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WATER SAVING OPPORTUNITIES FOR SUSTAINMENT OF IRRIGATED AGRICULTURE: FIELD IRRIGATION IN TURKEY

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ABSTRACT - Water scarcity has been a major concern in Turkey since the 1960's. Agriculture is the major water consuming sector with an average of 70% of the country's total water consumption. Many studies have been conducted to ensure more efficient use of water for sustainable agricultural development through better management of the irrigation schemes by the local authorities and Water Users Organizations (WUOs).

Irrigated agriculture is the most effective means for making rapid increases in crop production. The results from all research activities on irrigation in Turkey have been collected in last 10-15 years and statistical aspects of the collected results are presented to supply information and knowledge on irrigation science and assessment of past and existing experiences and identifications of relevant gaps and problems in Turkey. Also, overviews of some scientific results are on main irrigation topics such as crop-water-atmosphere relationships, irrigation scheduling techniques, comparison of irrigation methods for some main crops, and irrigation system performances are presented.

Efforts were carried out to collect the results of all research activities on both irrigation and water saving opportunities to sustain irrigated agriculture in Turkey, however, published data and other activities on all studies could not be obtained due to the deficiencies in the archives system. Therefore, assessment of all the conducted studies is limited. Statistical aspects of the collected results for the last 10-15 years are presented to give information in experiences on irrigation science and assessment of past and existing experiences and identifications of relevant gaps and problems in Turkey.

Keywords: Water saving, Field Irrigation.

INTRODUCTION

Irrigated agriculture is the most effective means for making rapid increases in crop production. Improvements in irrigation can results in higher levels of living in low income nations because they have approximately 80% of the world's irrigated land. The introduction of irrigation is one of the turning points of the human history in that the man who learned to use the seeds and to place it into the soil had acquired the insight that greater yield would be obtained by irrigation. Water management in agriculture is the process by which water is manipulated and used in production of food and fiber.

There is no doubt that for developing countries of the Mediterranean region, with erratic rainfall pattern, efficient control and management of water use has to be an essential requirement for this continued development. Without proper water management, self efficiency in food and energy will continue to be a mirage for most of these countries. Due to increasing of population which leads to growing demand for water resources, and pollution that reduces fresh water yield, most of the Mediterranean Countries have serious water scarcity problems for agricultural production and urban/industrial consumption. Scarcity of water and reliability of its supply are major constraint for agriculture development in those countries.

In the developing countries of Mediterranean, the major challenge facing water planners and managers at the end of 20 century is that while physical availability of water is fixed, its demand will continue to increase steadily in the foreseeable future. Accordingly, the problem is how to balance demand and supply of water under those difficult conditions. In addition, the issue of potential climatic change due to global warming and what its impacts could be on natural resources including water, are basically unknown factors at present (Hamdy and Lacirignola, 1999).

Today, agriculture is the main consumer of freshwater in the Mediterranean countries and the drawn backing for agriculture is about 80% of the total freshwater sources. Even though in the world which has an urban/industrial culture today, agriculture still continues to be the biggest consumer of water. For this reason, water saving opportunities should be considered within this domain. Prospective of water saving in agriculture ranges from genetics to agronomic, engineering, and different management options, including the use of non-conventional water resources.

Irrigation has a vital role for increasing and stabilizing agricultural production in Turkey because of scarcity and unreliability of rainfall conditions prevailing during growing season in most part of the country. The 36.5% of the total land (77.95 Mha) in Turkey is suitable for agriculture (28.05 Mha). Of the total irrigable area (25.85 Mha) 16.6% is being irrigated (4.3 mha) while 65% is not. Only 16% of total water resources are used for irrigation and other purposes. Economically viable irrigation is possible for only 8.5 million hectares.

The annual potential rivers are calculated as 186 billion cubic meters and a certain level of runoff is to be allocated for water requirements of neighboring countries. The amount of flow that can be used for consumptive purposes is estimated to be around 95 billion cubic meters. Together with the 13.66 billion cubic meters of useable ground water resources total available water resource of Turkey is around 108.66 billion cubic meters. Today, Turkey can not use soil and water resources effectively, due to personnel, coordination, political and economics problems.

However, during the next 20-30 years, Turkey will want to irrigate all the irrigable lands and the population will reach 80 million by 2010 and 90 million in 2025; if 400 kg of grains for one person, the total grain demand will be around 32 million tons by 2010 and 36 million tons by 2030 (Hamdy, 1998). To meet this demand, the irrigation area should be increased. It should be up to 4.77 million ha by 2010 (a net increase of 0.47 million ha more than the current), and 5.4 million ha by 2025 (a net increase of 1.1 million ha more than the current). This will cause the agricultural water consumption to increase dramatically. Currently in Turkey, about 31 500 km^3 of water is used by agriculture, in which 70 per cent, that is, about 22 050 km^3 is for the grain production (SPO, 2001). As a result of these, sustainable quantities of freshwater supplies will be diverted from agriculture to industry and households in the country. Irrigated agriculture will face two problems of water shortage and reducing financial resources in this time. Despite these problems, irrigated agriculture has not only to supply the other sectors with their water demands, but has also to provide 70-75% of the additional food grain requirements to the increased population. This will not be possible without the implementation of demand water management in all sectors, and in particularly, the agricultural one. There is a great need to find appropriate ways to achieve greater efficiency, better saving in water losses, and an equitable distribution in irrigation sector. This will require a wider range of alternative approaches than before considered to be developed, tested and implemented with greater imagination and flexibility on the part of irrigation policy makers, managers, and planners.

In this report, water scarcity and possible water saving in Turkey are discussed and some scientific results on water saving opportunities taken some experiments carried out in the different regions and crops.

CLIMATE, SOIL AND WATER RESOURCES IN TURKEY

Climate

Turkey forms an elongated rectangle roughly 1,700 kilometers in an east-west direction and 1,000 kilometers north to south. Anatolia, except for its eastern parts, is surrounded by seas and has a total coastline of over 10,000 km, including Thrace and islands. Turkey is a bridge between Europe and Asia, with about 3 percent of its land in Europe and the rest in Asia.

Turkey is under the effect of both maritime and continental weather patterns, which cause extreme geo-climatic diversity when combined with a highly varied topography. The Mediterranean type of climate with hot, dry summers and mild winters prevails in the Southern coastal region and the Aegean region (Western Anatolia). The Black Sea region receives rain throughout the year and lives both mild summers and winters. Central Anatolia is a vast high plateau with an average altitude of 1,000 meters above sea level and a semi-arid continental climate, i.e. hot and dry summers. Southeastern Anatolia region has arid climate which is characterized by hot and dry summers and mild winters.

The average annual temperature are 18-20 ^{o}C on the south coast, 14-15^{o}C for the west coast, and finally in the interior regions, depending on the location of the place from the mean sea level, fluctuates between 4 to 19 ^{0}C. The annual average precipitation is 643 mm, but it varies from 250 mm in the central part to 3000 mm in the Eastern Black Sea region. Seventy-five percent of annual rainfall is received in the winter season. Except for the coastal areas, Thrace and Eastern Anatolia, annual rainfall is less than 500 mm; therefore irrigation is of paramount importance.

Generally, agricultural production is adversely affected by the shortage and inconsistency of the rainfall during the growing season. Solar energy makes it possible to grow arid and semi-arid crops like bananas and citrus. Moreover, it is possible to have 2-3 crops from irrigated areas by allowing

270-day crop growing seasons. However, some crops may be harvested before maturation, particularly in Eastern Anatolia with its 60-90 growing days. The southeast region records very low humidity levels. The coastal regions have quite high levels being in line with precipitation rates. Inevitably, the topographical features are main factors shaping the distribution. The highest average speed of wind is measured in the Çanakkale province, located on the northwest Aegean coast. Moreover, a speed of about 136 km per hour is detected in the provinces of Ankara, Kırşehir and İskenderun. The long-term annual evaporation rates indicate a high rate particularly in the southeast region, which receives almost no rainfall during the summer and reaches more than 2000 mm per year in Southeastern region.

Soil and Water Resources

Soil Potential: Turkey occupies a total area of about 78 million ha, of which about 1.1 million is inland lakes. The total arable lands are almost 28 million ha, and almost 26 million ha of arable lands is irrigable and 2 million ha is non-irrigable land. The irrigated area is 4.3 million ha. The area which would be economically feasible to irrigation by surface methods is estimated to be totally 8.5 million ha by DSI (State Hydraulics Works) (Table 1).

Table 1. The Distribution of Irrigable Land in Turkey (DSİ, 2001)

Land	Area Million ha	%
Irrigable Land	26.00	
Economically Irrigable Land	8.50	33
With Surface Water Resources	7.90	93
With Ground Water Resources	0.60	7
Equipped with Irrigation	4.30	51
Surface Water	3.80	90
Ground Water	0.40	10
To be Irrigated in the Next Future	4.20	49
Surface Water	4.00	96
Ground Water	0.15	4

Irrigated lands developed by DSI in the different region in Turkey are given in Table 2. Today, 17 % of total irrigable lands are developed for irrigation by different agencies including DSI being the first, KHGM (General Directorate of Village Affair), and Private Publics Organizations. Before two years ago, for the Irrigation Master Plan of Turkey, 227 projects covering a gross irrigable area of 2.94 million ha have been analyzed. 139 of these covering a gross irrigable area of 2.07 million ha, or 70 % of the total area reviewed, have an IRR of 8% or more. If that same percentage is applied to the area still to be developed, a potential additional irrigable area of 3.2 million ha will be added.

Table 2. Irrigated Lands in The Different Region In Turkey (DİE, 1995)

Regions	Irrigable Lands 1000 ha	Irrigated Lands[1] ha	Irrigated Lands %	Irrigable Lands %
Marmara	4,615	418,902	9.8	9.1
Aegean	1,797	656,390	15.4	36.5
Mediterranean	3,633	813,048	19.1	22.4
Southeastern	4,895	476,239	11.2	9.7
East Anatolia	1,073	600,404	14.1	56.0
Black Sea	1,236	390,599	9.2	31.6
Central Anatolia	8,386	905,603	21.2	10.8
Total	25,635	4,261,185		

[1] Total irrigated areas developed by DSI, KHGM, and PO. The values of 1995 year are updated for 2004.

Tables 1 and 2 show that Turkey can not use soil resources effectively due to personnel, coordination, political and economical reasons. Irrigated lands in the regions vary from a maximum value of 21.2 % for irrigated lands in Central Anatolia to a minimum of 9.2 % in Black Sea region. Mediterranean region follows Central Anatolia with 19.1 % of the irrigated lands.

The maximum irrigable lands of 8.386 million ha are placed in the Central Anatolia region, a minimum of 1.073 million ha is in East Anatolia due to their topographic properties. The ratios of irrigated lands to total irrigable areas for regions vary between 56% in the East Anatolia and falls to 9.1% in the Marmara region. Central Anatolia region, which has maximum irrigable area, however, is the one region which has small ratio. The irrigated areas in Southeastern Anatolia region is rapidly expanded at the last decade since some irrigation structures in Southeastern Anatolia Project have started to operate in some places in this region.

Water Potential: The average annual precipitation of the country is 642.6 mm, which corresponds to a water potential of 501 km^3 per year. Runoff amounts to 238 mm, an average rate of 37 %, and the remaining 63% is lost to evapotranspiration. A certain amount of the runoff is allocated to meet the water rights and requirements of the neighboring countries. The amount of surface water, which is utilized for consumptive purposes, is in the range of 95 km^3 per year. According to the studies based on groundwater resources, the total safe yield of groundwater resources is estimated to be 11.6 km^3. Thus, total potential available water resources from surface flow and groundwater would amount to 106.6 km^3 per year (Table3).

Table 3. Water Potential (DSI, 2001)

Average Annual Precipitation, mm	643
Water Potential from Precipitation, km^3	501.0
Surface Water Potential, km^3	
Annual Flow	186.05
Runoff Coefficient	0.37
Utilizable potential	95.00
Actual Annual Potential	31.49
Groundwater Reserves, km^3	
Surfaced Annual Reserve of Groundwater	12.3
Annual Water Reserved by the SHW	9.0

In order to regulate the whole surface waters in the country, the construction of 662 dams is required. Today, total dams and HEPP under operation are 504 which are suite to the rules of International Commission of Large Dams, ICOLD. Almost 100 dams and HEPP are under construction. Thus, it is obvious that the possibilities mentioned above require great amounts of investment and a long period of construction. The water supplies from these dams would be regulated to achieve the following objectives: irrigation of 6,609,382 ha; drainage of 135 801 ha, flood control of 636,794 ha; conveyance of 7,726 km^3 of water to urban areas and generation of 121,484 MKwh of electric power by the hydroelectric power plants with a total electricity capacity of 34,484 MW.

Water Scarcity in Turkey

Water consumption increased slightly during the last decade depending on the development of soil and water resources, expanding of urban population and development of industrial sector. Total water consumption rose to 42.0 km^3 by the end of 2000 as a result of numerous projects developed by various agencies, including the DSI who is, in charge of developing water resources. Breakdown of the total figure is as follows: Irrigation (31.5 km^3, 75%); drinking water (6.4 km^3, 15%); and for industrial purposes; 4.1 km^3, 10% (Table 4). Sectarian breakdown of utilized surface water resources is as follows: Irrigation (82 %), drinking-use (10 %) and industrial purposes (8 %). Corresponding percentages for the utilization of groundwater are 39, 37 and 24, respectively.

Table 4. Actual Water Consumption in the last decade of 1990-2000 (SPO, 2001)

Year	Total water consumption km^3	Potential use (%)	Water Consumption by Sectors, km^3					
			Irrigation		Drinking-Use		Industrial	
			Volume	%	Volume	%	Volume	%
1990	30.6	28	22,016	72	5,141	17	3,443	11
1992	31.6	29	22,939	73	5,195	16	3,466	11
1998	38.9	35	29,200	75	5,700	15	4,000	10
2000	42.0	38	31,500	75	6,400	15	4,100	10

Water amount utilized for irrigation is calculated and given in Table 5. Industrial and urban consumptions are not considered in the calculation. Average steady flow for whole Turkey is estimated as 1.1 L s^{-1} ha^{-1} using steady flow values from irrigation systems placed at the different regions. All plants grown in the different regions are assumed to be irrigated 120 days per year.

Turkey has approximately 26 Mha irrigable lands in spite of the water resources to be allocated for irrigation are not seem to be enough to irrigation of all the lands. It is estimated that in Table 5, only 8.5 Mha areas can be irrigated with present water resources. It is clear that water resources in Turkey are considerably limited. When all irrigable lands are opened to irrigation, roughly 200 km^3 water deficits can be expected. Water is a constraint to agricultural productivity in comparison with the extent of existing irrigable land resources, especially for Mediterranean, Central and Southeast Anatolia regions, which are arid and semi-arid regions.

Table 5. Net Water Requirements of the Average Crops Pattern Grown on the Irrigated and to be Irrigated Areas

Lands, ha	Average Steady Flow L s^{-1} ha^{-1}	Average Irrigation Season, day	Net Water Requirement, km^3 year^{-1}
4,261,185 (being irrigated)	1.1	120	49.0
8,500,000 (to be irrigated)	1.1	120	96.0
25,635,000 (to be irrigated in future)	1.1	120	296.5

In Turkey, as in several Mediterranean countries, the dominant fact which will be strongly evident over the next few decades is the structural imbalance between constantly increasing demand for water to meet the needs and the natural available water resources. This imbalance will appear around the year 2000 and beyond. In foreseen future, in Turkey, excessive reduction in water withdrawals per capita will create notable competition and conflicts among users in the various sectors, in the irrigation and domestic sectors in particularly. Priorities will be given to satisfy the drinking water demands to the expenses of the available water allocated for the irrigation sector with the consequence of less irrigated surface and more land degradation.

POSSIBLE WATER SAVING IN TURKEY

There is a high opportunity for saving significant volumes of water losses through a better use of technical and economical tools, as well as, the institutional and human resources capacities Turkey already has. It is possible to reduce losses and leaks in drinking water in industry; through recycling it is visible to reduce the water consumption. However, in spite of the water saving could be achieved in both drinking and industrial sectors, yet, the most beneficial saving in terms of volume would be in irrigation sector.

In Turkey, where more than 72% of its water resources are allocated to agriculture, major efforts should be directed to increase the efficiency in the field, as the opportunity of water saving is notable higher compared to other water use sectors. For instance, in the irrigation sector, the reduction of conveyance losses and the improvement of irrigation efficiency can provide too much water saving.

In this section, some summarized results, which showed the water saving approaches and total saved water amount are given. The results are taken from experiments carried out in the different regions and different topics. These are the new mechanisms which are to protect the resource and allocating diminishing water supplies to increasing and competing uses.

Deficit Irrigation

Generally, irrigation and irrigation water requirement of crops were determined without any consideration of likely water limitation of available water supplies. In arid and semi-arid regions, because of increasing allocations of water for municipal and industrial use, major changes came about in water use under irrigated agriculture. New innovations had to be tested and adapted to increase effective use of decreasing water allocations for agricultural use (Hanks, 1983).

Research effort has focused on developing new techniques to receive high returns from restricted supply of water. Among the techniques of increasing effective use of water, deficit evapotranspiration should also be used. Deficit irrigation can be used either through agronomic practices or through changing management schemes to decrease crop evapotranspiration (Kanber et al., 1993). The end result is so called ‘‘deficit irrigation’’ (Vaux and Pruitt, 1983). To save irrigation water, crops are exposed to water stress either throughout the whole growth season or at certain growth stages. With this application, water sawing is obtained without significant yield decrease and also irrigated area can be increased without additional water supply available (Merriam, 1965). Deficit irrigation is promoted widely and used for some crops in Turkey. Experiments on the deficit irrigation of crops are being considered with different ways: 1) To spread of water deficiencies equally through the growing season. For this reason, different approaches are being consedered such as to use different soil depth for wetting, to decrease irrigation water as control treatment, to use different plant-pan coefficients, to use different irrigation intervals, to use different furrow spacing in surface, lateral and trickle spacings in drip irrigation systems, and to use line source sprinkler irrigation technique. In some deficit irrigation experiments crops are exposed to water stress at the different growth stages. This technique is named as omitted irrigation. In the all deficit irrigation experiments, yield response factors (Ky) given by Stewars Equation are worked to be calculated. Yield response factors for some maih crops are given in the Table 6.

Table 6. The Empirical Yield Response Factors for Some Main Crops

Crops	Ky Values, Growth stage / Irrigation Method	Region	Sources
Cotton	0.76 (flowering-yield formation) 0.99 (seasonal, Furrow) 0.93 (seasonal, furrow) 0.86 (seasonal, drip) 0.72 (sprinkler, sprinkler) 1.22 (sprinkler, Seasonal)	Çukurova Çukurova Harran	Baştuğ, 1987 Yavuz, 1993 Kanber et al., 1991
Pistachio	0.62 (Seasonal, Ponded) 0.77 (seasonal, drip)	Şanlıurfa Gaziantep	Kanber et al.,1993 Aydın, 2004
Maize	0.98 (Seasonal, Furrow) 0.85 (seasonal, sprinkler) 0.69 (Vegetative) 1.03 Tasseing) 1.00 (Milk stage) 0.66 (Ripening) 1.14 (Seasonal, surface)	Tarsus Tarsus Tharece	Kanber et al., 1990 Köksal, 1995 Çakır, 1999
Wheat	0.87 (Seasonal, surface) 1.14 (seasonal, sprinkler) 0.76 (Seasonal, surface) 0.32 (seasonal, surface)	Southeast Southeast Centre Anatolia East Anatolia	Karaata, 1987 Sezen, 2000 Madanoğlu, 1977 Sevim, 1988
Sunflower	0.62 (Seasonal, surface)	Tharece	Karaata, 1991
Bean	1.3 (Seasonal, Sprinkler)	Centre Anatolia	Bahçeci, 1995
Soybean	1.1 (seasonal, sprinkler)	Souteast	Kara, 1995

Water saving with deficit irrigation approach is used in the different ways in the some experiments. For instance, in some studies, different irrigation season lengths are use while in others evapotranspiration losses are prevented by chemical applications.

Different irrigation season lengths were used for cotton under Seyhan Plain conditions (Kanber et al., 1994). In this study, different irrigation interval, first and last irrigation times are considered. According to results, different yield reductions and irrigation water savings were obtained depended on irrigation season lengths. When the last irrigation was applied at the ball diameter was 1-2 cm, the maximum water saving was measured 46-62 percent.

In some places where the evaporation losses are very high, chemicals were applied to reduce evapotranspiration of cotton. In this study, the effects of irrigation intervals and antitranspirant doses on evapotranspiration, yield, and water use efficiency of cotton were investigated on the field plots in Harran Plain for 4 years (Kanber et al., 1992). Different irrigation intervals (I_1: 7, I_2: 14, and I_3: 21 days) and four antitranspirant doses (D_0: 0; D_1: 40 g/ha; D_2: 80 g/ha; and D_3: 160 g/ha) were tested. The antitranspirant that contains N, N, N-tributtill-3- (trifluoromethyl) benzene methananium chloride as the effective substance was used in sub-plots of the experiment. The antitranspirant application was done in the two times in which the reddish color on the main stem of cotton 5-7 cm reach to the top bud (as the first application) and at the 5-7th days of ball formation (as the second application) during the growing season. The irrigation programs were begun after the first application of antitranspirant and 90 cm soil depth was wetted in irrigation events.

Results show that the frequent irrigation increased evapotranspiration (ET) and net irrigation water requirement (IR). The maximum ET and IR values were found to be 1670 and 1555 mm, respectively in treatment I_1 (Table 7). The highest WUE values, although not statistically significant, were obtained from I_2 as 2.41 and 2.69; and from D_1 as 2.34 and 2.60.

Table 7. Results from experiment of antitranspirant doses and irrigation program

Treat	No of Irr.	IR mm	ET mm	IWUE	TWUE	Yield* kg/da	Average Values No of irr.	IR	ET	IWUE	TWUE
I_1D_0	13	1555	1670	2.45	2.28	384a	8 (D_0)	1201(D_0)	1322(D_0)	2.51(D_0)	2.26(D_0)
I_1D_1	13	1555	1670	2.55	2.36	394a	8 (D_1)	1182(D_1)	1310(D_1)	2.60(D_1)	2.34(D_1)
I_1D_2	13	1555	1670	2.39	2.23	361a	8 (D_2)	1172(D_2)	1290(D_2)	2.54(D_2)	2.29(D_2)
I_1D_3	13	1555	1670	2.35	2.18	376a	8 (D_3)	1196(D_3)	1312(D_3)	2.49(D_3)	2.25(D_3)
I_2D_0	7	1113	1234	2.62	2.34	295b					
I_2D_1	7	1113	1234	2.76	2.48	302b					
I_2D_2	7	1113	1234	2.65	2.36	298b				2.44(I_1)	2.26(I_1)
I_2D_3	7	1113	1234	2.74	2.46	304b				2.69(I_2)	2.41(I_2)
										2.47(I_3)	2.18(I_3)
I_3D_0	5	894	1019	2.45	2.15	223c					
I_3D_1	5	894	1019	2.48	2.18	224c					
I_3D_2	5	894	1019	2.57	2.27	227c					
I_3D_3	5	894	1019	2.38	2.11	209c					

*20.94 and 9.77; the yield groups were statically obtained by the orthogonal comparison methods

The application of various antitranspirant doses had no significant effect both on seasonal ET and WUE values. The irrigation intervals have significant effect on the yield and quality of cotton. The maximum cotton yield was obtained from frequent irrigations. Frequent irrigation applications increased lint length, whereas, infrequent irrigations and antitranspirant doses resulted in shorter and thicker lint.

Use of Unconventional Water

Applying deficit irrigation programs including supplemental irrigation and to manage the irrigation systems according to deficit irrigation approach can be considered as best solution. However, this solution is very expensive and requires new approaches. On the other hand, to find new water resources for different purposes including irrigation is another possibility to solve the problems related with insufficient water resources. To use unconventional water such as brackish water (treated waste water, drainage water, ground water table), shallow ground water and saline water supplied from different resources is considered to be one of the best solutions. Table 8 shows the waste water amount in Turkey from urban and industrial consumption in 2001.

Table 8. Waste water amount from urban and industrial consumption in 2001 (DIE, 1995)[1]

Resources	Amount, km^3
Urban waste water	3.700
Industrial waste water	3.000

[1]The values of 1995 year are updated for 2004.

The use of drainage and saline water for irrigation seems to be an attractive alternative for solving water scarcity problem. Saline water is a potential source for irrigation. The use of saline water for irrigation increases the quantity of water available for agricultural production if the sustainable management strategies for their utilization are evolved. Such water occur extensively in the arid and semi arid parts of the Mediterranean, Central and Southeast Anatolia regions and are being used for irrigating some summer crops which are tolerant to salinity. Some times saline water is blended with fresh water with different quantity and used to irrigate the salt sensitivity crops. There are enough evidences taken from several studies carried out either in Turkey or in the other countries to show the potentiality of using water with saline up to 6 dS/m for major cereal crops (Hamdy, 2002). Unconventional water use for irrigation gradually increases in a lot of countries where irrigation is evitable but water resources are scarce.

Use waste water

Inspite of standards which are detaily prepared in Turkey, waste water is not widely used in irrigation except in a pilot project in the GAP areas and few small industries. Enough water is being supplied for irrigated areas therefore total irrigated areas did not reach to the marginal limit value for the water resources. Frankly, farmers still can find enough water for irrigation. The experiments on use of waste water for irrigation purpose are persisted (Sarikaya, 1994). A study using urban waste water treated by Çiğli purification plant for irrigating Menemen plain (Eagen Region) is been carried out for a long period. On the other side, in the GAP areas two experiments on use of waste water and drainage water for irrigation were carried out (Altınbilek and Akçakoca, 1997).

Bilgin et al. (1997) have carried out studied to determine the effects of Ankara stream-water which is polluted by wastes from urban and industrial consumptions on soil, plants (lettuce and broccoli) and environment. Moreover, they have examined that the chemical composition of stream water for such as heavy metals, microbiological pollution, etc, at time and places, where the samples were taken, dimensions. Experiment was conducted in the open areas and greenhouse conditions. According to results heavy metal concentrations of Ankara stream were found to be not hazardous level to plants and soils. However, microbiological pollution of the water was obtained to be too high. Irrigations caused to the yield decreases due to detergent content of the stream flow.

Use of drainage water

Yarpuzlu (1999) has studied in order to evaluate the response of cotton and wheat grown on a clay soil in a sequence to drainage water applications with different leaching fractions (5 treatments in 1991-1995; In 1996-1997, three different irrigation water sources (drainage canal water, collector water and Seyhan canal water with different leaching fractions were utilized) as well as salinity build-up in the soil profile was evaluated during each growing season in Tarsus plain. The results of the study showed that the effect of irrigation with different leaching fractions statistically were not important on the yield of wheat crop, and it is determined that the effect of different leaching fractions on cotton yield was statistically significant at the 99 signification level. Drainage water applications in the wheat sowing periods did not cause salt accumulations in the soil however, in the cotton sowing periods it did cause salt accumulations. In addition, after long years of winter rainfalls, these precipitations were effective for leaching the salt accumulations in the soil.

Bahçeci (1991) has examined to determine the effect of groundwater used in irrigation, the accumulation of salts, sodium and boron in the Konya-Yarma district soils for wheat and sugar beet crops. The trial was designed in randomized block with three replications. According to the results, the salt accumulation wasn't significant but both the boron amount in the soil has increased and the increasing amount of exchangeable sodium statistically was significant. The exchangeable sodium accumulation was taken into consideration as a trend function and $YB= 0.193+0.309X$ relationships obtained. This relationship showed that only 20 years later the amount of ESP with a 90 percent probability would be reached to 23 - 47 percents limits.

Bahçeci (1993) studied in order to explore the quality and the suitability of main drainage channel waters for irrigation of Konya. In the research, the drainage water of Alakova and Arapçayiri branches of the main drainage channel were tested. The results showed that drainage waters may cause salt and boron accumulations in the soil. Besides the study also determined that Keçeli branch of the main drainage channel in the region was polluted from urban areas and reuse of this drainage water may cause serious environmental problems.

Use of saline water

There are various studies regarding the use of saline water for irrigation purpose. In these studies, surface and pressurized irrigation methods are used with saline water which is diluted at different levels. Diluted-saline water is used with various irrigation systems such as drip, sprinkler and surface methods. In surface irrigation methods, different amount of irrigation water with different saline levels are directly applied to plots whereas in pressurized systems, different salinity levels of irrigation water were used with line source sprinkler and drip which had different line and trickle head spacing (Sönmez and Yurtseven, 1995). Line source sprinkler system and drip system which has different trickle intervals can be shown as examples (Kanber and Bahçeci, 1995; Ödemiş, 2001). The results on saline irrigation of some crops in Turkey are given in the Table 9 (Yurtseven et al., 1999a and b; Şener, 1993; Yurtseven et al., 1996; Yurtseven and Bozkurt, 1997; Çizikçi, 1998; Yurtseven and Baran, 2000; Yurtseven et al., 2001a and b; Yurtseven and Öztürk, 2001; Yurtseven et al., 2002). This table contains both threshold and zero yield values of crops.

Table 9. The Rersults of Saline Irrigation for Various Crops

Crops	Threshold Value, dS/m	Zero Yield Value, dS/m
Maize	0.81	4.0
Tomato	2.7	11.0
Pepper	1.8	7.0
Lettuce	1.5	7.0
Broccoli	3.5	9.0
Radish	1.5	7.0
Rape	2.3	9.0
Spanish	3.5	
Cotton	5.7	

The values in the Table 9 are close to values given in some literatures; however, some little differences may be reasoned by irrigation programs, soil properties and other factors.

Irrigation system performances

Several irrigation systems in different regions were evaluated to obtain their system performance (Benli et. al., 1987; Yavuz, 1993; Uçar, 1994; Kanber et al., 2001). Open channel systems, and pressurized systems (sprinkler and drip), were examined in these studies. Moreover, the irrigation systems, which convey irrigation water from earth dams constructed in the high plateaus, were worked for their performance. Results from different regions and systems are summarized in Tab. 10.

Table 10. Irrigation Efficiencies (Ea), Conveyance Efficiencies (Ec) and Distribution Efficiencies (CU) for Different Regions and Irrigation Systems

Regions	Trickle Irrigation			Sprinkler Irrigation			Surface Irrigation		
	Ea	Ec	CU	Ea	Ec	CU	Ea	Ec	CU
Mediterranean	95	-	97	75	-	85	55	65	40
Southeast	80		-	61		85	38-85	55	85
Central Anatolia	89			34		58-82	23-77	85	-
Black Sea	-			-			35-55		

According to the results referring to all relevant scientific studies, performance of irrigation schemes located in different regions of Turkey, overall, is not at acceptable levels. This inadequacy can be highly related to the infrastructure, management (agency, joint, and farmer), allocation and distribution procedures (demand vs supply), and the climate and socio-economic setting. In almost all systems, the whole area can not be irrigated for various reasons; such as, water scarcity, fallow land, socioeconomic reasons, and lack of infrastructure. On the other hand, there are considerable changes in the size of irrigated area and cropping pattern from year to year in all irrigation schemes, referring to all relevant studies. It can also be stated that efficient irrigation scheduling has still not achieved properly and this causes too low water application efficiencies with high water conveyance losses.

CONCLUSIONS

As the demand for the limited water resources continues to rise, the irrigation comes to be caught in the middle: on one side, with the development of the industry and agriculture and acceleration of the urbanization process, agriculture will have to give way for the industry and urban living; on the other side, in order to feed the increasing population, the new irrigation area must be expanded while the current irrigation area and guarantee rate are maintained, and more water will be needed. This determines that for a sustained development, Turkey's agriculture must stick to economy and efficiency.

As the irrigation water-using efficiency in Turkey is much lower than that in western countries, if the water-saving irrigation techniques are practiced generally, the potential to save water will be very prospective. To adopt canal lining or water pipes will increase the water delivery efficiency in a canal system; furrow and border irrigation for dry farmlands will improve the usage of field water; the sprinkling irrigation and micro irrigation will improve the usage of water at its delivery section and in the field, and improve the evapotranspiration environment and reduce evapotranspiration.

As a technical measure, the water-saving irrigation method is employed to make full use of irrigation water resources, improve water usage efficiency, and achieve high yield and efficiency in grain production. It is an integrated technical system, combining water-saving techniques concerning water resources, engineering, agriculture, management and other links. With it, the overall using rate of irrigation water resources will be improved, the grain production at unit area or total area will be heightened, and the sustained development of agriculture can be guaranteed.

Agriculture is the basis for the national economy, providing necessary agricultural products and industrial raw materials for the living of 72 million people. Because of the special topographic characteristics and climate of Turkey, its agriculture production mostly depends on irrigation, and appropriate irrigation measures will result in a stable and high yield. Due to the serious lack of water resources, the traditional irrigation methods cannot catch up. Hence, to practice water saving is a prerequisite for the sustained development of the national agriculture and national economy.

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