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Importance of Pressurized Irrigation Systems in Arid Areas: A Case Study of Konya- Turkey

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Abstract: The average annual rainfall of Turkey is almost 643mm. However, it is almost 350-500mm in Central and South-East Anatolia Regions. The annual lowest rainfall occurs in Salt Lake as 250-300 mm and Karapınar Provinces of Konya in that both are arid areas of Turkey. In recently, rainfall is far from the average of long term annual meteorological records in Central. Water is vitally important for arid and semi-arid regions for higher crop yield. In such regions, it is almost impossible crop production without irrigation in summer season. In Konya Province of Turkey, every year, new irrigation wells are built for due to the insufficient surface water resources. Most of them were not legal so, the distance between wells is very low and every year groundwater level decreases. Surface irrigation methods are very widely used although irrigation efficiency is lower in Turkey. In some parts, pressurized irrigation methods have been used for sustainable irrigation and environment.

Keywords: *Central Anatolia, irrigation, semi-arid climate, water resources.*

Introduction

Turkey is situated in 36°-42° N latitude and 26°-45° E longitude so that it has a unique geographical and cultural position at the cross-road between Asia and Europe. Turkey has a total land area 77.8 $x10^6$ ha of which about 35.6% arable areas, 28% pasture-meadow, 30.2% forest and woodland and remaining surface water and residential area. Economically and physically irrigable arable land is almost 8.5 $x10^6$ ha.

Annual rainfall is almost 643mm with total available surface and groundwater potential almost 110 $x10^9$ m^3 in Turkey. Turkey is almost 1132 m above the sea level and higher than the average of 1050m in Asia and 330m in Europe. The elevation increases from West to East. There are number of natural lakes. The two largest fresh water resources namely Beyşehir and Eğirdir lakes are placed in Konya Plain and Isparta city in both that are situated in Central Anatolia Region. The climate is semi-arid and rainfall is higher in costal regions of Turkey (1000-2500 mm/year). The average annual rainfall is 500-1000 mm in Marmara, Aegean, high plateaus and mountains of East-Anatolia Regions of Turkey. However, it is almost 250-500mm in Central Anatolia and South-East Anatolia Regions. The lowest annual rainfall occurs in Salt Lake as 250-300mm (Çakmak *et al.* 2005) and Karapınar Provinces of Konya in that both are described as almost arid areas of Turkey.

In examine water resources of Turkey, annual water requirement of each person is 1700 m^3. This should be 10000 m^3 /year for classified as rich countries. According to this standard, Turkey can be acceptable as a water poor Country. Due to the lack of information about efficient water uses, future studies should be focused on water management and irrigation scheduling.

Evaluation of climate changes for Konya plain agriculture

Researchers are in agreement that the world's climate is steadily warming whether due to greenhouse gas emissions from industry and automobiles, or to natural variability (Perlman, 2001). Global warming will generally cause mild winters and dryer summers, although there will be differences between countries. During the winter, it may rain more, but in the summer, it

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may become hotter. Water resources would generally benefit from wetter winters but warmer summers with longer growing seasons and increased water evaporation rate would put greater pressure on them (Anonymous, 2008). Water is very important component for human life and all other living things.

Konya province has the almost 40% of ground water of Turkey, but water level depletion is almost 22-40m in last 20 years. The levels between fresh groundwater and Salt Lake reduced from 50 to 15m. If this continuous, the water may flows from Salt Lake to groundwater reservoirs so fresh water quality of wells will be reduce.

The climate changes have affected water resources capacity adversely. The greatest fresh water reservoir of Turkey is Beyşehir Lake and due to the in sufficient rainfall unwanted vegetation is present at sides of the lake. In Apa Dam, situated in Konya province, water potential in 2006 and 2007 July were measured as $51x10^6$ and $12.3x10^6$ m^3. The water potentials in Çavuşçu and Suğla Lakes at summer season reduced from 30.9×10^6 to 26.4×10^6 and from 70.7×10^6 to 62.5×10^6, respectively (Anonymous, 2007a).

According to the latest meteorological records, rainfall has reduced and distribution was far from uniform. Hotamış and Akgöl Lakes fully dried, and Meke, Akşehir, Ilgın and Eber Lakes are almost dry. Farmers in these regions believe that more water results in higher crop yield so in general they apply excess water by uses the surface irrigation methods to the crops. The possible reason may be that low water cost, poor experiences of irrigation schedules in pressurized irrigation methods.

Konya is the cereal store of Turkey but, if the water resources are used excessively, cereal production will be lower. There is estimation that, the yield lost can be 50% under poor water management conditions in which it may result in food crisis in Turkey. There are different kinds of cultivated crops such as cereals, sugar beet, various vegetables and fruit gardens in Konya Province. Cereals are mostly growth field crop and followed by sugar beet. In general, cereal and sugar beet have irrigated sprinkler systems since past, but trickle irrigation also is used for sugar beet. Vegetables are irrigated by surface, sprinkler and rarely drip system. According to the 1996 records, there are 135 407 sprinkler systems in Turkey (Anonymous, 1996). According to the long term observation in such region, the duration is higher in sprinkler irrigation in one set so, excessive water and energy is used. The source of energy used in sprinkler systems in Turkey is mainly petroleum products and is imported from the different countries where they are situated close to Turkey. This has increased the production cost of irrigated crops.

Although water resources are scant in Konya province, every year, new wells are built for obtaining more irrigation water. However, most of the wells are not legal and the distance between the wells are low, so there has been groundwater depletion (Acar *et al.* 2004).

In general, farmers in that region had to use groundwater intensely due to the absence of irrigation water in most irrigation season at irrigation canals. Gül *et al.* (2005) reported that due to the lower cost of diesel in arid region of Syria (average annual rainfall of 200-350mm) caused higher groundwater uses in irrigation of cereals. In such region, crop yield was increased, but groundwater level depleted. The other factor reduced the groundwater level was to cultivate the crops that were required higher irrigation water. Therefore, less water consumed or drought tolerant crops should be growth very much in areas where the water resources are limited.

Acar *et al.* (2004) determined the purposes of groundwater utilization by using the questionnaire technique in Konya Region. The result showed that surface water resources in irrigation periods were observed scarce so that the farmers preferred groundwater uses easy to obtain irrigation water from such wells for any time and obtaining higher crop yield due to the irrigation of crops on time. The irrigation number is very important factor affected the water resources sustainability. In general, it is higher than normal irrigation number in this region. The possible reason may be that in the past there were not water resources problems.

The irrigation number has varied even for same crops in Konya Province. Since, local farmers mostly do not know how to measure the soil moisture level and in general they decide the irrigation time by considering their experience. The time and the quantity of water in

irrigation are very important for irrigation schedules. The moisture content of soil should be measured and water should be applied up to reaching field capacity level of the soil. Applying the irrigation water amount lower or higher than the soil moisture level of field capacity may affect crop yield. Applying more water than field capacity increases the water losses so that irrigation efficiency reduces. Seasonal irrigation number for sugar beet and appetizer squash in sprinkler irrigation in Konya province were determined (Acar *et al.* 2004) and were between 7-13 and 6, respectively. According to the research, increases of irrigation number did not raise the crop yield remarkably.

One of the most important factors affecting the selection of irrigation method is system installation costs. To demonstrate trickle system cost, a case study was conducted by Acar *et al.* (2006) in Konya Region of Turkey. In 2005 record, the average installation costs of trickle irrigation system were found as 1340 € / ha, 2110 € / ha, 1260 € / ha, 2030 € / ha, 1300 € / ha, 1050 € / ha, 1140 € / ha, 1260 € / ha, and 2680 € / ha for tomato, corn, pepper, potato, water melon, vine yards, orchards, carrots and sugar beet, respectively depending on crops, emitter and lateral spacing, system design and pipe quality.

Importance of water and irrigation management

In last 10 years, rainfall is far from the average of long year's annual records in Central Konya. In Fig.1, long term annual rainfall is almost 321mm and there has been a fluctuation in last 5 years records. Therefore, water is vitally important in irrigation for these types of the arid and semi-arid regions.

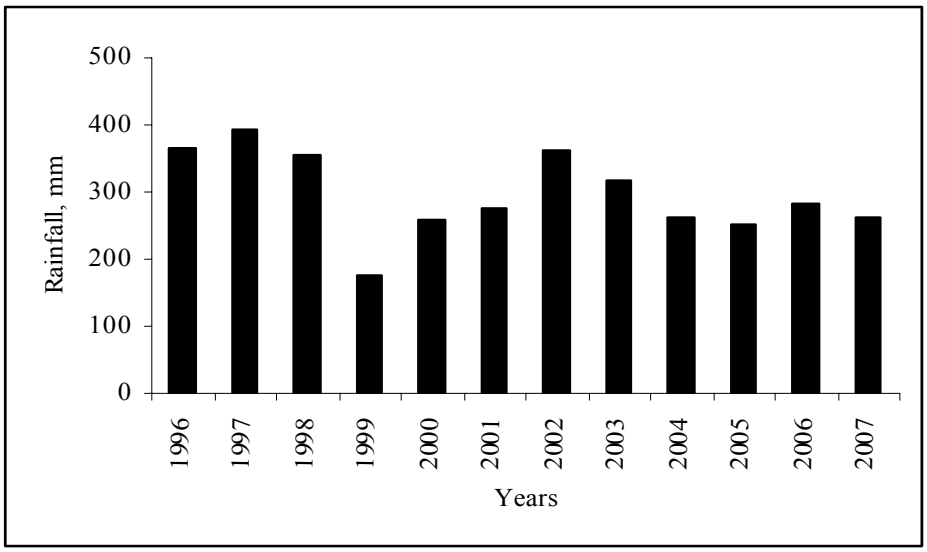

Figure 1. Average annual rainfall of Konya Province (Anonymous, 2007b).

It can be seen from Table that total annual water potential of Konya plain is 5.84 $x10^9$ m^3. Comparison to the water requirements of agricultural crops in Konya plain, Water resources are scant and these should be managed properly. Farmers in some parts of Konya Region like Çumra province have the greater experiences about irrigation and other agricultural activities than most other parts of Turkey. Water resources are mostly used in agriculture in Turkey. However, there is not serious government agricultural policy to force the farmers in efficient water uses subject. Therefore, most farmers even used trickle irrigation systems are senseless in irrigation schedules. Irrigation scheduling means that when and how much irrigation water will be applied? Therefore, in order to determine the irrigation time or irrigation intervals, soil water content should be measured correctly. If the soil content is not measured, it is impossible to schedule the irrigation in agriculture.

Table 1. Total water potential of Konya plain (Anonymous, 2002).

Water Resources	**Water Potential (10^9 m^3)**
Groundwater	0.920
Surface Water	2.400
Available Water Potential of Göksu River	0.500
Total Available Water	**3.820**
Possible Available Water Potential of Göksu River	2.020
TOTAL	**5.840**

Irrigation can be defined as the applying water of cultivated crops met with measured and controlled ways by during the insufficient rainfall period (Kara, 2005). In arid and semi-arid areas, agricultural production depends upon efficient irrigation (Vories & Von Bernuth, 1986). Due to the insufficient surface water resources during the most irrigation periods, groundwater has been used much higher in Konya region of Turkey.

Importance of pressurized irrigation systems for Konya plain

If the water necessary for plant growth is not applied uniformly, yields may be affected (Topak *et al.* 2005). In arid and semi-arid areas of the world, agricultural production mainly depends upon efficient irrigation. Sprinkler irrigation systems can yield irrigation efficiencies greater than 80% if adequately designed and managed (Keller and Bleisner, 1990). Portable sprinkler systems are more economical than solid set systems and may be adopted for different sizes of agricultural lands easily. They are one of the most popular systems to irrigate a wide range of field and orchard crops (Pereira, 1990). Average application efficiencies of sprinkler irrigation systems for two different areas of Konya - Çumra province were 76.17 % and 76.40 % (Topak *et al.* 2003). Some authors (Topak, 1996; Çakmak, 1994) had same conclusion for their former studies under sprinkler irrigation. Sprinkler irrigation system is mostly used and followed by furrow, border and trickle irrigation methods, respectively. The ratio of sprinkler irrigation use is almost 75 % and irrigation water is in general obtained from wells (Çiftçi *et al.* 1994) with costly, because it requires energy like electricity or petroleum. The electric energy may be preferred more by farmers due to the less expensive than petroleum and supplies regular pressure in systems. However, construction of electric units is very expensive so most farmers have to use petroleum.

Although, irrigation efficiency of trickle irrigation under good water management is higher than surface and sprinkler irrigations, it is still the least common method in Turkey. The possible reason may be that higher installation costs and requires technical experiences. Therefore, in recently, the area irrigated by trickle systems is getting increases due to the water scarcity in Konya regions.

Trickle irrigation is one of the best techniques to apply irrigation water for row crops (some vegetables or orchards), vine yards and trees. The irrigation water is controlled and applied frequently with small discharges. The basic concepts behind the successful use of trickle irrigation are that soil moisture remains relatively constant and air-moisture balance is always adequate. This causes higher and good quality production.

The most important factor affecting the irrigation efficiency for some parts of Konya province was education level of farmers (Direk *et al.* 2006). In Konya - Çumra region of Turkey, average farmer age was 47 years and almost they have interested in 27 years farming. The percentages of farmer's education levels were 58.6 % of primary, 20.7 % of secondary, 10.3 % high schools and 10.3 % of university, respectively. According to this, majority of farmers were graduated from the primary school and had no experiences about modern irrigation techniques or efficient water use.

Ideally, irrigation water should be applied with a uniform manner to the crops, but it is impossible to over come this in practice. Non-uniform water application results in deficit or excess irrigation especially surface irrigations.

The losses vary according to system design and water management. The run off losses for surface irrigation methods may be minimized by diverting the water stored lower end of field to the upper part of field. The leakage losses in unlined delivery systems or open fields' canals depend on the textural structures of canals, length of canal network with an average of 10%-15% (Solomon, 1988). These can be avoided by lining the canals or carrying water with pipe systems but, it is very costly.

The primary losses associated with sprinkler irrigation (other than those due to over watering) are evaporation from droplets and wet soil surfaces, transpiration from unwanted vegetation, wind drift, field border losses, leaks and system drainage (Keller and Bleisner, 1990; Li, 1998). Evaporation depends upon the frequency of irrigation intervals and size of the bare area between the crops. The allowable evaporation losses are 15 %-20% acceptable limit value (Solomon, 1988). Average evaporation loss in sprinkler systems was 12% for Konya Plain (Topak, 1996 ; Topak *et al.* 2005).

In absence of excess water application, the losses are very low in trickle irrigation systems. The reason that water is delivered through the pipe systems and only small part of the soil volume is wetted in this system. The conveyance losses are less than 1% under perfect management conditions.

Average irrigation efficiencies for trickle, sprinkler and surface irrigation methods in Konya province of Turkey were determined 80%-90%, 70%-80% and 40%-45%, respectively. In early 1985, installation of trickle irrigation systems was very costly. Nowadays, because of the high advent in plastic industry, installation costs are getting cheaper. However, farmers do not have enough information about the system costs. The possible reason may be that there is a poor coordination between trickle irrigation system producer, trader, irrigation engineers and farmers. The percentage of sprinkler and trickle irrigation is almost 10% in irrigated areas of Turkey and there is a great potentially use of these systems.

Bhardwaj *et al.* (1995) reported that the application efficiency was 44% greater in trickle irrigation than surface irrigation methods. Trickle irrigation was compared with furrow irrigation method (Hanson *et al.* 1997) by considering yield and the water saving in lettuce crop at Salinas Valley of California. The yield was almost same in both irrigation methods but, the water saving was 43%-74% higher in trickle than furrow irrigation.

Suggestions

Water resources are scant in Konya region of Turkey so these resources should be used efficiently in all sectors. Due to the absence of enough surface water resources in canals, farmers had to use ground water intensely without taking care of the distance of wells. Thus, there are plenty of wells. To obtain more water, depths of the wells have increased every year. These result in depletion in water levels of other wells. It is note that excess water application never result in higher crop yield. Excess water applications may result in lower yield due the unbalanced water-air ratios in soil profile. In addition, excess water application may lead some problems as follows: 1- loss of irrigation water or low irrigation efficiency, 2- depletion in groundwater levels, 3- excess energy uses in pressurized irrigation systems (sprinkler or trickle irrigation), 4-leaching of fertilizer through the lower part of crop root zone and contamination of groundwater via nitrate leaching. To sustain the water resources and environment, efficient irrigation methods such as sprinkler or drip systems should be widely used in arid and semi-arid regions under good management.

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