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SUSTAINABLE STRATEGIES ON IRRIGATION MANAGEMENT FOR IRRIGATED MAIN FIELD CROPS (WINTER WHEAT, COTTON, CORN) IN GAP REGION OF TURKEY

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Abstract

To get an appropriate yield and production for winter wheat, it must be irrigated. Cotton and corn must be almost irrigated in the regions grown. Amount of irrigation water of 4000-4500 m^3 ha^{-1} need for optimum wheat production. More than 50% of the country's cotton production is in Southeastern Anatolia Region of Turkey and cotton need amount of irrigation water approximately 10000 m^3 ha^{-1} for an appropriate production using surface irrigation methods. However, the amount of irrigation water of 5 000-6 000 m^3 ha^{-1} is enough if modern irrigation technologies such as drip irrigation are used. Similarly, amount of irrigation water more than 10000 m^3 ha^{-1} has been used for corn production under the surface irrigation conditions and it is possible to save nearly 40-50% of water using drip irrigation method in the same region. One of the most important ways of ensuring sustainability of irrigated agriculture is to use micro irrigation, and it may help in saving significant amount of water and increase the quality and quantity of produce. Thus, it is possible to achieve both higher water productivity and higher yield by means of drip irrigation.

Key words*: cotton, corn, irrigation, sustainability, winter wheat.*

INTRODUCTION

Water scarcity is becoming a significant problem to the sustainability of irrigated agriculture. This issue is of primary interest especially in arid, semi-arid and developing countries where increasing population and standards of living, economic and social development. Thus, the use of water requires careful and continuous assessment of models and strategies and sustainability for water resources.

There are gloabally competitons among sectors used water, agricultural, domestic and industrial use.

This situation has raised the interest of consumers and governments to adopt water conservation practices and to limit environmental charges. We have to consider and/or focus on increasing the efficiency of water use in the the agricultural systems since agricultural sector is the major consumer of water resources because it uses more than 70% of global water resources. Thus, we have to find or/and use ways of efficiently use of water for irrigated agriculture. Efficient irrigation management also contributes to the reduction of environmental impact and sustainable use of resources. On the other hand, excessive irrigation results in low water use efficiency, leaching, and runoff of water, fertilizers, and other agrochemicals, contributing to make the agriculture an important source of non-point source pollution. However, irrigation management involves some technical, socio-economic and environmental issues. Management decisions directly affect the whole chain of water delivery and its application to the fields. Hence, irrigation practices affect quantatities and qualitatives of crops in agricultural production.

The sustainability of irrigation involves many variants and constraints like availability of water as a resource, ecological balance, socio-cultural impacts, and climate change effects.

Considering irrigated agriculture consuming water much more compared to other sectors, we can improve irrigation efficiency by some adopting practices such as deficit irrigation, appropriate irrigation scheduling, installing more efficient irrigation systems and conservation tillage.

Irrigation is vital important input to grow some main crops and increase yield and crop production in Southeastern Anatolia Region of Turkey since it has climate characteristics. Thus, irrigation might increase the yield from 100% up to 500% depending on soil and

climatic conditions, agricultural practices and technologies and farmer conditions.
Total cultivated agricultural area in Turkey is 23.7 million ha. The ratio of the main field crops used in Turkey are 32% wheat (7.7 million ha), 2.9% corn (0.68 million ha) and 1.7% cotton (0.416 million ha).
Water is the main limiting factor affecting agricultural production in arid and semiarid regions in the nearly whole areas of Turkey. The winter wheat are grown the all regions of Turkey. However, to get an appropriate yield and production, it should be irrigated. Cotton and corn must be almost irrigated in the regions grown.
In this article, it is discussed and given sustainable strategies on irrigation management for irrigated main field crops (winter wheat, cotton, corn) in Southeastern Anatolia Region of Turkey

WINTER WHEAT

Wheat is the most important world crop grown on more of the world's area than any other crop in terms of feeding of human. Turkey is in arid and semi-arid region, wheat production depends strongly on annual rainfall and irrigation. The effects of rainfall amount and distribution, temperature, nitrogen and irrigation according to growing stages of wheat on yield were not independent from each other.
Yields and quality are changing by regions and by fields due to irrigation and precipitation differences. If well-distributed rains in the spring resulted in high yields beyond farmers' expectations, favorable weather conditions had contributed to wheat yields (Karabina, 2017).
Insufficient rainfall especially in the late spring period limits wheat production in the Mediterranean countries. Western Turkey will have constraints in wheat production in future due to water deficits in spring and summer due to the expected climatic changes (Erekul et al., 2012).
Rosenzweig (1991) stated that higher temperature was the major cause of yield reductions because shorter crop life cycles occurred with corresponding decreases in grain filling.
The principle climatic factors affecting crop production are precipitation, temperature length of growing season light and wind.
On the other hand, increasing temperature due to climatic change would speed development rate and reduce the phenological period. Significant reduction in grain yield as a result of the drought after flowering stage was found (Gevrek and Atasoy, 2012). The negative effect of early drought (before milk stage) on grain yield was more significant than that of late drought (after milk stage) (Ozturtk, 1999).
In the study area, Southeastern Anatolia Region of Turkey, seasonal water consumption of winter wheat is about 750 mm and amount of irrigation water requirement is about 450 mm. The critical stages of wheat for irrigation are sowing, booting, heading and milk formation. In general, rainfall is appropriate during sowing and booting stages except occurring extreme drought conditions. The two stages, heading and milk formation depending on climatic conditions are significantly important water demand thus; these two stages must be irrigated but irrigated primarily.
As the economic maximum fertilizer nitrogen, the rates of 70 kg N/ha under non-irrigation conditions and 150-170 kg N/ha under irrigated (one at the beginning of heading and one at the beginning of milk stages) conditions can be recommended. However, in case of drought occurrence, the rate of 120- 130 kg N/ha may be used under irrigated conditions. Drought or limitation of the rainfall limits use of nitrogen and its positive effects on grain yield (Cetin, 1993a; Cetin and Ogretir, 2000).

COTTON

Cotton is an important cultivation to the general economy because it provides fiber for textiles. Southeastern Anatolia Region is one of the most important cotton-producing areas in Turkey, accounting for more than 50% the country's cotton production. Cotton is, thus, one of the main crops grown in irrigated fields in this area. Cotton crop can grow method irrigation in this region since climatic conditions, dry and arid conditions.
Most of the cotton fields in the area are irrigated by surface irrigation. However, the use of drip irrigation and fertirrigation for cotton has increased enormously as a result of government subsidies. Drip irrigation and fertirrigation techniques are more and complex

compared with conventional applications such as surface irrigation and fertilizing. (Cetin et al., 2015).

Three stages of cotton crop, vegetative stage (sowing-flowering) (I), flowering-ball formation (II), ball formation-opening of balls (about 10-15%) are significantly important in terms of irrigation and water consumptive use. If deficit irrigation is considered, it should not be applied at the stages of II and III. However, it should apply at the only stage of sowing-flowering if it is needed (Kara and Gunduz, 1998).

Comparing to different irrigation methods on cotton yield, drip irrigation produced 21% more seed-cotton than the furrow method. Hence, drip irrigation resulted in not only higher cotton yield but also considerable water savings. At the same time, the highest IWUE was recorded in drip-irrigated plots. Thus, use of drip irrigation increased not only yield but also saving water (30-40%) compared to conventional irrigation (surface-furrow irrigation) (Çetin, 1993b).

Sprinkler irrigation increase the shedding reaction of cotton compared to furrow and drip irrigation, thus, if cotton irrigated by sprinkler during the noon time, the yield can lower since increasing shedding. Three main reason for higher shedding ratio with the sprinkler method may be attributed to moisture stress in the soil profile under the extreme climatic such as very low relative humidity (33%) with high temperature up to 46.8^{o}C (Cetin and Bilgel, 2002).

On the other hand, nitrogen fertirrigation by drip irrigation should apply with one-fifth of the total amount of N during sowing through the soil and equal applications of the remaining N every two irrigations (10 days). For this, one-fifth of the total N should be applied to the soil at sowing, and the remaining N should be applied in equal doses (an average of 7 fertigations) every two irrigations (10 days) by fertirrigation.

CORN

The areas grown and cultivated corn in Turkey is 68% of grains and 32% silage (Özden, 2017). The production and cultivated areas of corn have increased depending on increasing irrigation lands.

Corn as a second crop in the Southeastern Region of Turkey are more suitable and appropriate because of climatic conditions and long growing season. However, corn growth needs more amount of irrigation water compared to the other regions of Turkey. Because of high temperature (up to 46.8^{o}C) and very low relative humidity (~15%) cause much more water consumption. For this, corn needs about 1000 mm (or 10000 m^{3}/ha) of irrigation water if the surface irrigation (furrow method) is used.

Corn is grown under irrigated conditions and, therefore, requires higher amounts of irrigation water compared to the other field crops (Musick et al., 1990; Cetin, 1996).

Highest average corn grain yield (11920 kg/ha) was obtained from the full irrigation treatment with six-day irrigation interval.

Irrigation intervals did not affect corn yields; however, deficit irrigation affected crop yields by reducing seed mass and the seed number.

Deficit irrigation generally reduced corn yields. Irrigating at less than 100% of pan evaporation may not produce enough leaching for a salt balance in the root zone since the average annual rainfall in the project area is only 38 mm. Thus, deficit irrigation of corn with a trickle system is not recommended for the region. The trickle system permitted precise control of irrigation applications. With proper management, trickle irrigation can avoid some application losses, which are inevitable with sprinkler and surface methods.

Water savings in the vicinity of 50% could be possible with trickle systems under proper management (Yazar et al., 2002).

The trickle irrigation systems can be used successfully for irrigation of corn under the climatic conditions of the GAP area in Turkey. However, a final decision on using trickle systems for irrigating corn in this region should be made after a thorough economic analysis Each 6 day interval and water irrigation need about 581 mm and yield 11.9 t/ha (Yazar et al., 2002).

The optimum level of irrigation was 100% Class A pan evaporation for optimum dry matter of silage corn.

When calculating the amount of irrigation water for the drip-irrigated silage corn production, an optimum wetted area must be

considered. In this study, an appropriate value was 0.65. Thus, the requirement of irrigation water was 447 mm in average value. Similarly, the optimum nitrogen frequency was application of one-fifth of the total amount of N fertilizer at the sowing date, with the remaining N applied at each irrigation cycle for 5 days based on 240 kg ha^{-1} N. (Yolcu and Cetin, 2015).

CONCLUSIONS

Considering sustainability of irrigation and optimum use of water resources, drip irrigation is more adapted to climate change. It certainly does reduce evaporative losses, and reduces fertilizer use when liquid fertilizer is added to the mix and delivered precisely to the root of the plant (fertirrigation). Thus, the use of micro irrigation system will save significant amount of water compared to traditional method of irrigation such as level borders and furrows. Large-scale adoption of drip irrigation for cotton and corn can, thus, serve as successful examples for efficient use of water.

Micro-irrigation has been particularly successful for not only horticultural, ornamental and landscape applications but also field crops. Thus, it could be applied to a wide range of climatic conditions from humid to arid and semi-arid regions and all topographic conditions. Its advantages with respect to water and energy savings, increased yields, improved fertilizer application, reduced the rate of salinization, eliminated wood and diseases, and reduced labor, are well recognized.

On the other hand, having the highest water use efficiency does not mean that net returns will be highest. As more water is applied per land area, crop yields generally increase, but each increase in yield is less than for the previous unit of water applied.

Converting to drip can be expensive because it requires water in pressurized pipes (rather than open, gravity-fed canals) or requires a large storage pond on each farm and energy. However, Ministry of Food, Agriculture and Livestock in Turkey is subsidized as 50% of total investment of drip irrigation for farmers

As a result, it is possible to save nearly 40-50% of water using drip irrigation method in the region. One of the most important ways of ensuring sustainability of irrigated agriculture is to use micro irrigation, and it may help in saving significant amount of water and increase the quality and quantity of produce. Thus, it is possible to achieve both higher water productivity and higher yield by means of drip irrigation.

Considering sustainability of irrigation, physical productivity (water use efficiency) and economical productivity (net return per unit area and per unit volumetric water) of irrigation water should be evaluated and taken into account together with them.

The farmers should be, thus, used yield-response curve pertaining each soil and climatic conditions to get an economical yield for any crop.

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