Procedures for Successful Agricultural Water Management in Water Poor Environments Under Climate Changes

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Abstract

The aim of the present study is to develop practical solutions for better agricultural water management especially for water scant climates. In some parts of the world such as Konya basin of Turkey, precipitation amount and its distribution are far from the expectations recently due to the some changes resulted from the climate changes. In accordance of our analysis, following recommendations may be addressed for minimizing negative effects of climate changes in water limited farmlands: crop patterns should be reorganized in accordance of current water supplies; water delivery systems should be converted pipe systems or at least line-canals for improvement conveyance efficiency; focusing on studies relevant to development of new crop types resisting for drought conditions; and innovative irrigation technologies such as trickle and sprinkler irrigation system can be used more.

Key Words: Climate change, crop pattern, agriculture, irrigation, water management

Introduction

Water is the most, vital, important element for agro-production. There is no doubt that if there is no adequate water within root zone, yields and quality will reduce. As known that precipitation is not uniformly distributed worldwide; some parts having much or enough water while other parts exposing water shortage conditions. In recent, precipitation amount and its pattern are highly affected from the climate changes. In water scant environments, water deficiency in root zone depth is met by the artificially water addition as called irrigation.

It is impossible to met whole food requirement of the human being without irrigation. As a result, irrigation is necessarily prerequisites for increasing crop yield or income of farmers particularly in water-starved ecology (Yavuz *et al.* 2015 a,b).

There are two basic irrigation techniques namely surface and pressurized irrigation systems. In region where water resources are plenty, surface irrigation systems can be preferred. In such irrigation systems, common problem is poor water distribution over or through soil profile. In pressurized irrigation systems, drip and sprinkler systems, better uniform water distribution is present.

As it expected that fresh water resources have used mostly in irrigation such as it accounts of more than 60% in Georgia (Braneon and Georgakakos, 2011), and more than such amount in Konya Closed Basin of Turkey. Sprinkler irrigation system has used in large scale at Konya

Basin of Turkey. That system has used irrigation of some field crops such as sugar beet, wheat, barley, dry bean and some vegetables such as carrot in region. Drip irrigation system has been used for irrigation of maize crops, pepper, tomato plants and so on. The reasons of preference of pressurized irrigation systems are well adaptation for more crops and greater water saving by comparison to surface irrigation systems. Hayaloğlu (2018) emphasized that climate change is possibly one of the most serious problems worldwide even in some parts of Turkey for those days and agricultural sector is possibly in top rank affecting from climate change. It has resulted reductions in both yield and quality of products. Following recommendations for sustainable agriculture can be made: focusing on development of new crop cultivars best suited regions; uses of modern irrigation systems resulting more water saving; and conservation of fertile soils.

Groundwater resources are also highly affected from climate change and they have to be used at irrigation in surface water shortage climates such as in Konya basin of Turkey. Intensive use of groundwater supplies are at present in regions and have caused both depletion of groundwater level gradually and increasing energy cost of irrigation (Yavuz *et al.* 2016). Two important climate components playing very important role in agricultural activities are temperature and precipitation. Global warming or climate change affects available water resources. The worldwide shares of land size and agro-production obtaining from the irrigated agriculture are as about 20% and 40%, respectively. In order to meet food supplies of nations in future, irrigated lands should be widen. It is necessary to enhance irrigation efficiency to put more areas into production by using same amount water (Doll, 2002).

The level of climate change effects on agricultural activities varies for the development status of countries and is high in developing countries such as India since economy highly dependent on agriculture (Nelson *et al.* 2009).

De Wrachein and Goli (2015) stated that sizes of lands having irrigation and rain-fed farming are almost 270 and 130 million ha in worldwide, respectively. In general, 1.1 million irrigation areas are far from correct irrigation water management although it has resulted about 45% of food demand of the world. The contributions of irrigation areas to the income of the farmers and employment rate are about 40% and 30%, respectively. The amount of water withdrawn for irrigation purpose is about 70% as an average in the world. The rain-fed farming has contribution about 15% food productions with 130 million ha area. Şen (2013) proposed some information about agricultural status of Turkey. In accordance of his report, agriculture is the first rank and economy relies on agriculture in most. Turkey has many advantages for growing of various field crops, vegetables, and fruit plants. The wheat, barley and rye are best suited at Middle Anatolian region of Turkey so such region has known as cereal store of country. In general, rain-fed farming is little so most of the agro-production has obtained from irrigated lands in Turkey. He reported that climate change has impacts on population density, industry, agriculture, and mainly on water supplies. According to his projections, outcomes of climate change will be as follows: temperature will increase through year, but the increase will be more especially in summer; the rainfall amount will reduce in southern parts and very little increase at northern part; water stress will increase all sectors, and; the possibility of landslide will be more in northern part. As a result, agriculture will be affected a lot from the climate

change. The studies should focus on the advance or early planting date, adapting new crop cultivars tolerating drought conditions and changing the crop patterns in accordance of current water supplies.

Climate Change and Irrigation Water Use

In irrigation program, one of the most important issues is correct determination of the crop water use or evapotranspiration. Evapotranspiration, crop water requirement, can be affected by different parameters such as atmospheric conditions including air temperature, relative humidity, wind speed, and altitude as well as crop characteristics such as crop cultivar, growth stages with ground cover, and root length so on.

Hargreaves *et al.* (1993) reported that there are three possible ways namely climate, crop and soil moisture monitoring at root zone during crop growth season for determination of evapotranspiration.

The climate change has direct effect on agro-production. Some regions will suffer from the insufficient water supplies resulting from low amount and uneven distribution of rainfall, and some parts will have over crop damages due to over rainfall within short period. In Turkey, hail is common problem in field crop production areas of Konya Closed Basin. This year, 2019 June, we have witnessed field crops damages associated by dangerous hail.

Although there are various reasons behind the low crop yield, and atmospheric conditions have the most impact on crop production. Those also affect the time of the sowing, selection of suitable crop cultivars, fertilizer management, soil tillage, crop protection ways and time, and event irrigation water management. The irrigation methods are important but agricultural water management is the most important factors affecting agricultural production especially in water poor environments. In those regions of the world, irrigation is necessarily prerequisites for meeting the food demand of world.

In recent years, due to the climate changes, it is almost impossible to grow crops without irrigation in Konya Basin of Turkey. Event, winter cereals are irrigated due to the partial drought within autumn or winter season. In recent years, studies have focused on efficient water using in irrigation. Deficit irrigation by drip irrigation system has applied in semi-arid research regions. In accordance of our findings, about up to 25% of deficit irrigation has led to not significant yield reduction in potato, maize and sugar beet so it may be suggested as one of practical solutions for sustainable use of current water supplies in agriculture for water shortage ecologies (Acar *et al.* 2014). It is clear that water saving should be started from irrigation firstly since as mentioned above fresh water resources have been used mostly in irrigation especially at water scant climates such as Konya region of Turkey.

The reasons of low crop yield differ depending on the places and types of the crops. In according to the general evaluation, the shares of those factors are as follows: disease attack as 40%, water deficiency as 30%, poor fertilizer management as 10%, preference of not suitable crop cultivars for region as 10% and use of conventional, old-fashion, technology in agricultural activities as 10% (Shestra and Shestra, 2017). Like the other parts of the world, the great portion

of water resources of Taiwan has been used for irrigation. The cultivated land of Taiwan is about 23%. The annual water consumption of Taiwan is about 17 064 million m^3 and 11 088 million m^3 (nearly 65%) has used in irrigation (Lee and Huang, 2014).

In different parts of the world, farming activities differ and are performed by policies of government. In Uzbekistan, government is strong authority for designing crop pattern for instance; farmlands of 60-70% must be used for cotton and wheat production. Farmers must plan planting date in accordance position of their farmlands for the irrigation networks. Water fee is based on crop types and can be estimated that around 0.4 USD per 1000 m^3 irrigation water. The water charge of 7 USD per 1000 m^3 irrigation water has resulted greater water savings in current water supplies. The overall irrigation efficiency is about 65% and is meant that around 35% of the irrigation water has lost by conveyance at irrigation networks and during the irrigation event (Bobojorow *et al.* 2016). Frisvold and Bai (2016) evaluated the irrigation system uses in western US during the periods 1979-2008. Lands with sprinkler irrigation systems increased from 36% to 54%, about 18% increment, in such period. The drip irrigated area raised from 1% to 7%. However, the land irrigated by surface or gravity irrigation systems reduced from 63% to 39%. Drip irrigation system has practiced for irrigation of mainly vegetables, vineyards, nuts and other perennial crops or plants in US. Among 17 western states of US, California is single maximum drip irrigation system applications as about 81% for citrus and private crops (Table 1).

Table 1. Irrigation methods in Western US (Frisvold and Bai, 2016)

Examined Years	Irrigation Systems Usage (%)		
	Surface	Sprinkler	Drip
1979	63	36	1
1995	52	40	3
1998	50	45	5
2000	48	46	7
2003	43	51	6
2005	44	50	7
2008	39	54	7

In Konya closed basin of Turkey, sprinkler irrigation is common irrigation method and has used for irrigation of wheat, sugar beet, potato, dry bean etc. In region, farmers have great experiences about irrigation technologies especially in pressurized systems such as sprinkler. Even, application efficiency of sprinkler irrigation systems is satisfactory and possibly greater than those most of the countries. The reasons behind those most farmers have obtained irrigation water from wells just close or within the irrigated lands so almost none water lost is present resulting from the conveyance and they manage the irrigation systems with an high efficiency. The modern irrigation technologies such as drip and center pivot or linear systems have also used in irrigation with an increase rate. They also have some alternatives in better irrigation water management by considering the future climate change effects on agricultural production.

Jägermeyr *et al.* (2015) reported to irrigation efficiency is low globally due to the water

losses during the conveyance systems and inefficient water management during the irrigation processes.

Table 2. Application efficiencies for irrigation systems (Jägermeyr *et al.* 2015)

Regions	Irrigation Technologies		
	Surface	Sprinkler	Drip
North America	53	77	86
South America	54	80	86
Europe	53	80	89
Central and East Asia	54	79	83
South Asia	48	83	90
World Average	52	78	88

Strategies for Efficient Water Use in Agriculture

In study performed by Alexandrow (2008), farmlands of low water consuming crops such as wheat and barley must be expanded instead of areas with high water consuming crops such as vegetables, paddy rice and maize for efficient water use in irrigation especially for water poor environments exposing from the negative effects of climate change. He added that the quality of infrastructures or irrigation networks is very important role to play in conveyance efficiency, and water loss during the water conveyance is about 70% in irrigation networks of Bulgaria. The drought resulting from the climate change has also direct effect on economical situation of countries e.g inflation rate reached up to 12.5% in December 2007 due to dry conditions in such year. He also suggested that to minimize negative impacts of climate change in agro-production, one of the practical and sustainable solutions is making progress in technological advents such as development of new crop cultivars having more productivity in dry or hot environments. In water management perspective, trainings of both farmers and water managers are viable solution for better agricultural water management in such regions. Preparing very simple and clear documents for farmers about efficient water use in agriculture are another suggestions to cope with drought. Beside those, adaptation of modern irrigation systems resulting high water savings such as drip and sprinkler irrigation techniques is strongly recommended for water shortage environments.

Similarly Akınnagbe and Irohibe (2014) reported that Africa is more vulnerable to impact of climate change and if this trend continues Africa will be warmer. They stressed following suggestions to cope with drought especially in Africa: creating crops varieties that are best suited for drought regions, crop diversifications, redesign of the crop patters with sowing date, soil moisture improvement practices, soil tillage systems resulting conservation of soil moisture

content within plant root zone depth, increasing irrigation efficiency by correct irrigation water management and planting of trees with intensely at the mountainous parts of the countries.

Conclusion

There is no doubt that climate change is reality in the world and each country has affected from that differently. Irrigation is the highest water user sector in world so water saving must be started at irrigation firstly. For sustainable irrigation especially in water poor environment, following suggestions should be considered: First, crop pattern should be reorganized in accordance of current water supplies. In Konya closed basin, the farmlands should be increased in the favors of some low water use crops such as wheat, chickpea, and squash so on. The amount of water application for wheat crop is almost one fourth of the sugar beet or maize crop in Konya plain of Turkey. Second, development of new crop cultivars having more tolerant for water stress conditions in root zone depth is a very useful practical solution for better use of water resources. Third, high water saving irrigation technologies such as sprinkler or drip irrigation system must be used widely with great care in water scant regions. In correct water management, drip irrigation will result at least 95% water application efficiency. The government should support the farmers using or would like to use that modern irrigation systems in water shortage regions. Finally, in field level, water fee should be allocated by using volumetric basis for better saving in irrigation. Water organizations and water users should be educated about efficient irrigation water management.

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