CLIMATE CHANGE IMPACTS ON CROP PRODUCTION IN TURKEY

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Abstract

Global warming of concern is widely recognized as a main environmental issue by scientific community and the predictions are claimed that total increase in temperature will be 3.2˚C at the end of the present century. Countries across the globe are doing their own action plan to adapt and mitigate climate change taking into account their domestic capabilities. Turkey has been also started to face significant consequences of climate change and implanted her own actions plans. Sustainable agricultural production and food security is one of the major challenges. However, assessment of effects of climate changes on agriculture is usually concerned in a general overview and impacts of the change on particular products are missing for Turkey. Wheat, barley, maize, sunflower and cotton are the largest field crops grown in Turkey. This paper focuses on complex effects of global climate change on these main field crops in Turkey considering physiological functions to address crop development, yield and production.

Key words: climate change, crop production, Turkey

Although climate change and global warming were concerned as a serious environmental problem by scientists in early 1970's, the predictions had started earlier, about 120 years ago (Weart S.R., 2008). Today, long-term records of NASA reveal that the global average surface temperature has increased 0.8˚C in only last three decades (Lynch P., 2012). Thus global warming of concern is widely recognized as a main environmental issue by scientific community and the predictions are claimed that total increase in temperature will be 3.2˚C at the end of the present century (Solomon S. *et al*, 2007). Global warming, the most obvious and harmful consequence of all human activities, affects most seriously the agricultural production. The estimations demonstrated that, globally, climate-induced reduction in agricultural productivity amounts to 16% (20% in Turkey) by the 2080s (Cline W.R., 2007). However the United Nations of Food and Agricultural Organization estimates that food demand of world population will increase 70% in next 40 years and the increase will be more pronounced in developing countries (FAO, 2006).

Wheat, barley, maize, sunflower and cotton are the largest field crops grown in Turkey. And the proportion of these major crops to total harvested area is more than 72%. Different aspects of climate change such as elevated carbon dioxide, higher temperature and precipitation pattern have different impacts on physiology, development and yield of these agricultural products. Wheat and barley (C_3 species) and maize (C_4 species) have a different response to increasing carbon dioxide concentration while winter and summer crops possess a different adapting capacity to climate change. On the other hand, change in climate may have more profound effect on yield in South than North Regions of Turkey.

EFFECTS OF CLIMATE CHANGE IN TURKEY

Turkey's climate can be generally characterized as warm or hot in summer and cold or very cold in winter period. However, coastal areas of Turkey are much milder than inner lands (MSO, 2016). Therefore west and southern coastal Anatolia have a Mediterranean climate whereas plateau in the center has a steppe climate (large temperature difference in day and night). On the other hand, along the coast of the Black Sea Region has a continental climate. Effects of climate change are expected to vary region to region in Turkey because of these distinct climate zones.

Most of the climate change scenarios have agreed that temperature increase will be reach 5℃ for general in Turkey. And annual precipitation will decrease 30% in west and south regions while increase 20% in north regions (*figure 1*). Fujihara

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Y. *et al* (2008) investigated potential effects of climate change in Seyhan River Basin in South Part of Turkey where one of the most productive agricultural lands are located. They predicted about 160 mm reduction in annual precipitation which leads to water scarcity with increasing water demand in the basin.

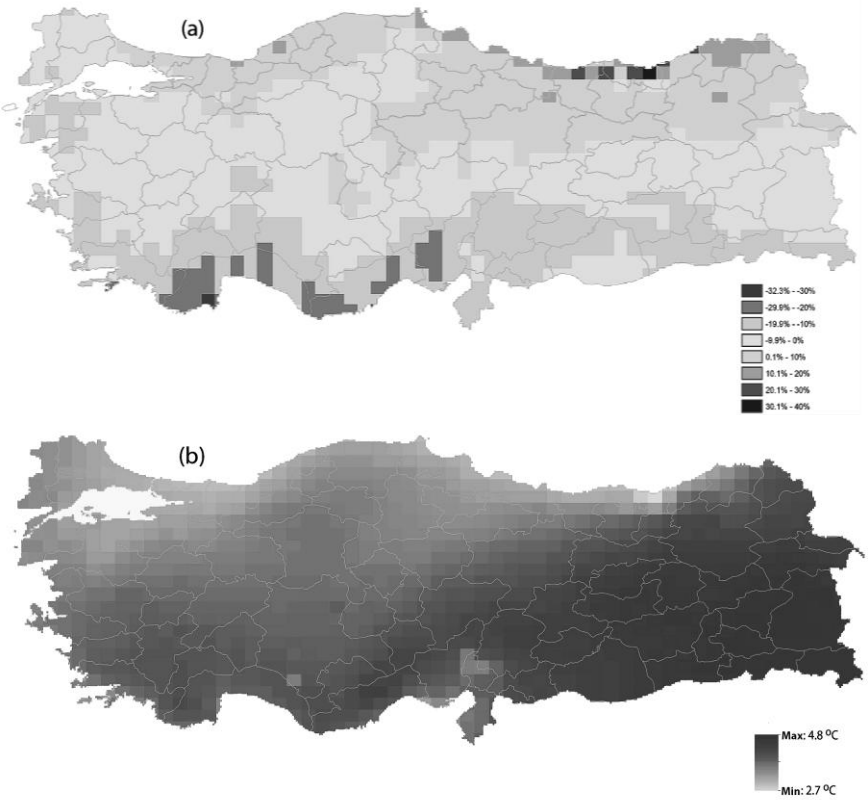

Figure 1 **Simulation maps of ECHAM5 global climate change model A2 for changes in precipitation (a) and temperature (b). Data is calculated based on the changes between 1961-1990 records and 2070-2099 scenarios (Şen, 2013; Önol and Semazzi, 2009)**

Underground water level has decreased more than 20 meters over the last 20 years in Konya which is located on the high plains of Central Anatolia. According to the projections of Köken E. *et al* (2015), temperature will increase about 1.5-3℃ and precipitation will decrease 25-50% in the basin. GAP-Şanlıurfa basin has experienced 17 abnormal to exceptional dry years since 1951 (Aydoğdu M.H. and Yenigün K., 2016). Conventional arid agricultural systems are being rapidly transformed to irrigated system in the basin situated Southeastern Turkey during last few decades (Özdoğan M. *et al*, 2006). On the other hand, more than 10% decrease in precipitation and 4-5℃ increase in temperature are expected for the basin until end of the present century (*figure 1*).

Climate scenarios estimate 2-4℃ increasing in temperature for The North Coastal Regions of Turkey. However, they also predict 200-300 mm increase in precipitation over Northeast part whereas not significant change is expected for Northwest part of the region (Terzioğlu S. *et al*, 2015). Projections for the end of 21st century suggest that reduction in annual precipitation will reach 50% in Gediz and Greater Menderes Basin in the Aegean coastline (TMEU, 2012).

To assess response of main crops to future environmental conditions, the distinct variations in impacts of climate change across Turkey should be considered.

EFFECTS OF CLIMATE CHANGE ON CROP PRODUCTION

Average production amount of wheat considering last 5 years is 17.4 million ton in Turkey (TUIK, 2016). Most of the wheat is produced in center of the Turkey around Konya Basin (*figure 2*). Although top producing city is Konya (1.5 mil. ton), wheat is generally grown in all around Turkey.

Konya and central part of Turkey where have already lowest precipitation receiving region (Dursun S. *et al*, 2012), is one of the most sensitive region in terms of climate change impacts on crop production. Especially wheat production is very depending on total rain amount and distribution during growth period. More than 70% of the precipitation receives during autumn and winter period whereas limited rainfall between April and

June frequently causes drought stress in wheat (Soylu S., Sade B., 2012). Though water scarcity might be experienced during all growth stages of wheat due to unfavorable rainfall distributions, effects of drought markedly increase in post-anthesis and grain filling stages (Ozturk A., 1999). These crucial stages of wheat growth are considered as a most important period regarding to yield formation (Acevedo *et al*, 1999). Drought-inhibited reduction in post-anthesis photosynthesis and remobilization of dry matters to the grain lead to significant decrease in grain yield (Patla J.A. *et al, 1994;* Ercoli L. *et al*, 2008). Generally, 10 mm decrease in total rain amount causes 13.4 kg/ha yield reduction in the region (Soylu S. and Sade B., 2012).

Wheat is more often grown in arid and semi-arid regions of Turkey under rain-fed conditions thus water scarcity due to climate change can be expected as a main limiting factor in production. On the other hand, Tonkaz *et al* (2010) reported that 6°C increase in both maximum and minimum air temperature lead 30% decrease in wheat yield. They also revealed that every 40 ppm increase in CO_2 level cause 150 kg/ha increase in grain yield.

Impacts of climate change are expected to intensify in the next decades and drought events will more frequent and severe especially wheat production lands in Turkey. Therefore sustainability of production in rain-fed agricultural systems is not high in the region. Implementing higher grain yield strategies under drought conditions concerns two main approaches: (*i*) breeding tolerant and high yielding genotypes, (*ii*) improving agronomic water use efficiency (Fischer R.A., 1999). Early-maturing wheat genotypes also might avoid late-season drought stress in rain-fed wheat production system. Improved water management systems considering critical development stages of wheat (before stem elongation and booting stage) must be implemented in irrigated wheat lands.

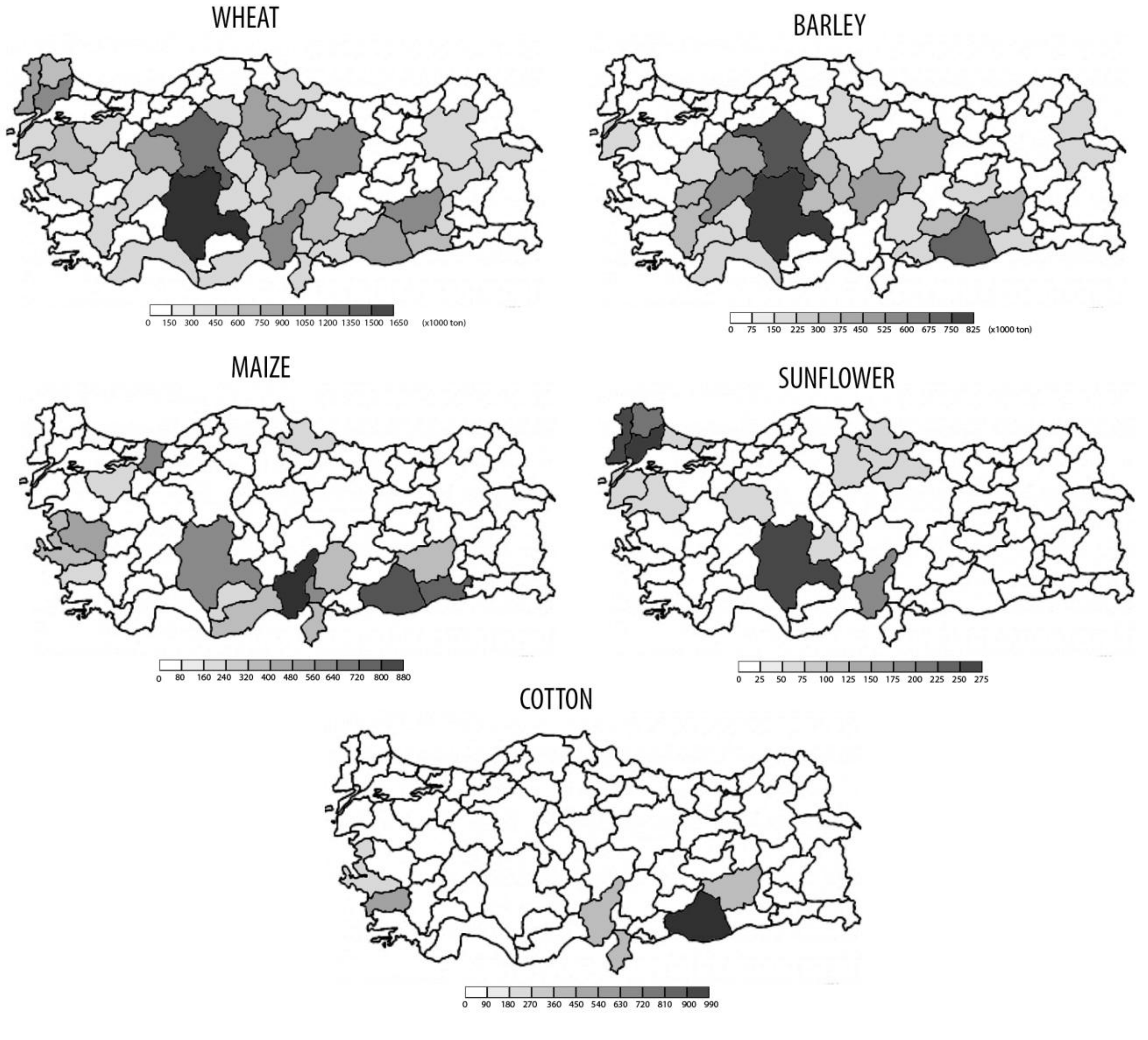

Figure 2 **Distribution of wheat, barley, maize, sunflower and cotton production in Turkey. Cities are colored based on average annual production amounts between 2011 and 2015**

Turkey produces about 6.8 million tons of barley per year (*figure 2*). And similar distribution of barley cultivation areas with wheat can be seen in *figure 1*. Barley is relatively more tolerant to insufficient lands than wheat (Li C. *et al*, 1970). Soylu and Sade (2012) observed lower reduction in barley yield than wheat yield during dry years in the central part of Turkey. And they suggested that better adaptation of barley plants to dry periods was mostly based on earlier maturation and avoidance of plants from drier months after May. However, the advantage of barley in years which dry and warmer conditions are experienced at the end of the season is not observed if the stress conditions occur during earlier growth stages. Although barley might be suggested for the lands where wheat production would be not possible as a result of climate change in near future, breeding tolerant varieties and increase agronomic water use efficiency seems one of the best solutions.

Maize production has not a wide distribution throughout the country as wheat and barley cultivated lands (*figure 1*). Totally 5.4 million tons of maize grain is produced per year in Turkey. And most of the producers are situated in South and Southeastern and Coastal West parts of Turkey (*figure 1*). These lands have generally Mediterranean type climate conditions. Climate change projections suggested approximately 3℃ increase in average temperature and 10-30% decrease in annual precipitation in these regions (*figure 1*). Yan W. and Hunt L.A. (1999) have described that photosynthesis is restricted and maize growth inhibited under higher than maximum of 41℃ air temperature. Over 40℃ has already often experienced during summer period especially in Şanliurfa Basin (Southeast part of Turkey). Frequently, maize plants are subjected to heat stress during reproductive stages and grain yield significantly reduces. Maize cultivars which have a short vegetation period has an advantage to avoid heat stress during these critical stages, however they have lower yield potential. Early sowing might be another option. Since maize plant sensitive to chilling stress during initial stages of the development, new cultivars may be suggested to develop to early sowing.

Impacts of rising atmospheric CO_2 concentration result of the climate change is expected to be not a significant on maize plant because it has C_4 carbon fixation properties (Lobell D.B. *et al*, 2011). Water use efficiency of C_4 plants such as maize is already about double that of C_3 plants (Huang R. *et al*, 2006). However, water use efficiency in maize production could be increased by better water management using with new irrigation and agronomic techniques.

Sunflower is main oil plant in Turkey and annual production is about 1.3 million tons based on last 5 years data (*figure 2*). Northwest part of Anatolia was the main sunflower cultivated regions until last decade. But the production has rapidly increased in the center of the Anatolia since Turkeys rising need to plant oils. On the contrary to Thrace Region in the Northwest, sunflower is mostly grown in irrigated lands of Konya basin in the Center of the country. Therefore water scarcity, exacerbated by climate change will be a great risk for sunflower production in the region. Groundwater level has already started to decrease 0.7 m per year in some locations in the basin (Doğdu M.Ş. *et al*, 2007).

Water requirement of sunflower is about 450-500 mm during growing season in Konya (Soylu S. and Sade B., 2012). Improving water use efficiency in sunflower cultivation should be considered for a sustainable production in the region. Elevated atmospheric CO_2 concentration due to climate change is predicted to enhance water use efficiency in sunflower (Harrison P.A. and Butterfield R.E., 1996). But, improved agronomic managements are still needed to implement to reduce irrigation amounts.

Most of the predictions revealed that climate change shortens the length of the sunflower growing period (Harrison and Butterfield, 1996). This impact would be more drastic in the center of the Anatolia than in Northwest regions in terms of future projections (*figure 1*). Existing cultivars may not become convenient in the future.

Turkey produces about 2.3 million tons of cotton (*figure 2*). Approximately half of the cotton cultivated lands locate in Southeast of Anatolia around Şanlıurfa-Harran Basin. Cotton production has drastically increased in the basin last decades because of the ultrastructural improvement in water sources by a national project (GAP). However, excessive increase in irrigated lands would be not sustainable in terms of the water resource management in the future. One of the reasons of increasing water use in Şanlıurfa-Harran Basin is being widespread of cotton production lands (Özdoğan M. *et al*, 2006). Bayder A. and Kanber R. (2012) suggested that better soil-water management, using drip irrigation system, higher sowing density and developing tolerant varieties could be a part of the solutions for sustainable cotton production.

The mean air temperature higher than 35℃ during day time restricts photosynthesis whereas higher than 25℃ during night time lead higher respiration resulting higher assimilate lose in cotton plant (Bange M. *et al*, 2007). Harran Basin has already often faced with more than 35℃ during

June to September (MSO, 2016). High temperatures have negative effects on cotton yield especially during flowering and early ball development (Oosterhuis D.M., 2013). Early sowing might be one of the possible options to avoid heat stress during these critical stages. Impacts of climate change can be expected to be more pronounced for cotton cultivated lands in Southwest of Turkey. Therefore improving heat tolerant varieties and efficient water management applications should be adapted primarily for the region.

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