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Climate Change and Adaptation Strategies in Agriculture

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ABSTRACT
Climate change is a fact that is happening in most regions of the world, the increase of greenhouse gases (mainly CO_2), temperature increase and precipitation fluctuations are among the components of climate change that are the result of agricultural products and in general, the production of the agriculture sector will undergo many changes in the future. It is important to know the effects of this phenomenon on agricultural crops and their effect on the yield of plants, as well as to identify strategies compatible with this phenomenon in the agriculture sector, especially the issues of water consumption, production and ensuring food security in every country. Among the methods adapted to climate change, changes in the type of product and the pattern of cultivation and production by creating cultivars resistant to environmental stresses (drought, salinity and heat). play an important role. In this article, by studying and summarizing reliable global and domestic sources, the effects of climate change on agricultural products from the aspects of thermal stress, increased water demand and the reaction of plants to CO_2, in general, the efficiency of water consumption and production in the agricultural sector are identified and discussed also the methods, compatible with a number of solutions in this field have been presented.

Keywords: Adaptation, Agriculture, Climate Change, Water

INTRODUCTION

In general, climate change is a long-period change in weather conditions (change in temperature, precipitation, wind and other indicators). The climate change may be natural anomalies or human activities, Climate change is an inescapable reality that is happening in different parts of the world, including landlocked countries like Afghanistan, this country has undergone changes. The climate change is the result of the complex interactions between the effective components such as the oceans, atmosphere, earth and environments. In general, any change and transformation in the nature of components or in the type of interaction between them can change in the climate of the earth. According to the definition presented, climate change means long-time stable change and transformation in the climate patterns of the earth (caused by changes in climatic components and the relationships between them), which can occur naturally or due to human activities (Shrestha *et al.*, 2018).

According to global models and studies, unfortunately, our country will become hotter and drier, the adverse effects of these changes in the agriculture sector are an increase in thermal stress and an increase in the water requirement of agricultural plants, which is the result of plants and a decrease in production agriculture and food security. Many types of plants grow in different climates, regions and soils of the country. Climatic weather characteristics such as temperature, rainfall, CO_2 and water availability directly affect the growth and health of plants as well as farm production. Also, the distribution of agricultural plants in a certain area is determined by climatic resources. Therefore, in regions with climate change, it is possible to take advantage of these changes by cultivating agricultural crops and even animal products. Basically, the effects of climate change on agriculture and the production of agricultural products should be viewed from the perspective of the reaction of agricultural plants to production and fertility. Meanwhile, plants' reactions to temperature, photosynthesis, and biomass production are caused by changes in the amount of CO_2 in the air, changes in water demand, in general, water consumption efficiency, water productivity, and production. (Hatfield *et al.*, 2008). According to the statement of the World Food Day (2016), there are seven areas related to agriculture and food production in which necessary changes related to adaptation to climate change should be made in order to provide food for the hungry. These seven areas are agricultural plants, horticulture, development of forest environment, management of sustainable animal production, management of food waste, sustainable management of natural resources and food systems. Climate change mitigation is related to the reduction of greenhouse gas emissions (mainly CO_2), while the objective of the mechanism is primarily to mitigate the unavoidable effects of climate change through a wide range of actions in a vulnerable system (Tol, 2002). In this article, it has been tried to express the effects of climate change on the physiological and morphological characteristics of plants and the relative solutions adopted for them.

MATERIALS AND METHOD

In this research, library studies, reports, statistics, articles and other reliable regional and global information sources have been used as a review. considering to seriousness of the climate change and the importance of adapting to it in agriculture, based on the results of domestic and international research, firstly, while defining the phenomenon of climate change and getting know it, the effects of this phenomenon on plant production are discussed, including the reaction of plants to temperature and its effect on the yield of plants, the effects of climate change on the increase in water demand. After that, the commitment of a solution compatible with this phenomenon in the agriculture sector is presented.

The effects of climate change from the point of view of temperature changes and its adverse effect on the yield of plants

plants have different critical temperature range required for their growth. There is a base temperature at which the plant starts to grow. At the optimal temperature, the growth of the plant is fast and maximum. Normally, with the increase in temperature, the growth of plant intensifies. this increase in growth continues until the optimal temperature of plant, which depends on the type of plant. If the temperature of the environment is higher than the normal temperature, the plant will face a decrease in growth. However, the reduction in field yield may not be due to temperature alone, as high heat is associated with reduced or absent rainfall in many climates (Ashraf et al., 2012).

In case of wheat and other grains, the grain filling period decreases significantly with an increase temperature. The optimal temperature for photosynthesis in wheat is between 20-30 degrees Celsius. Any increase in temperature above the desired level, which usually occurs during the wheat grain filling period, will shorten the grain filling period and ultimately reduce the yield. With the amount of daily photosynthesis of the plant, with the shortening of the seed filling period due to the increase in temperature, the yield of the product decreases in direct proportion. Based on the studies conducted in 9 sites in Europe, it has been determined that for every one-degree centigrade increase in heat, the yield of wheat decreases by 6% (Kochaki and Nasiri, 2017) by research the effect of climate change on wheat yield using the SUCROS simulation model and based on different climate change scenarios, forecasting the wheat yield for the target year of 2050 AD indicates that water wheat worked in the regions. Its production in Iran will decrease between 14 and 21 percent. In the mentioned research, preventing the reduction of wheat yield, changing the planting date and modifying wheat cultivars with higher resistance range to heat 2 to 4 degrees in the flowering stage have been introduced. Soleimani et al. (2011) researched the flowering behavior of saffron in response to the increase temperature in the development stages by conducting an experiment in a controlled environment. Their results showed that with increase temperature during, changes the flowering behavior of saffron occurred, so that flowering did not occur heat of 30 degrees Celsius regardless of the length. The findings of the mentioned research indicate that the length of the saffron growth period will increase by at least 32 and maximum 38 days for each degree of increase in the average temperature compared to the current conditions. Therefore, if global warming caused by climate change increase in the average air temperature by 1 to 2 degrees Celsius, depending on the intensity of the warming, this product will decrease in the saffron production areas.

The effects of climate change from the point of view of CO_2 and its effect on plant yield

The effect of CO_2 on the plant is mainly on the process of photosynthesis. This different effect depending on the type of plant in terms and place, in the group of C3 & C4 plants. Preliminary researches have shown that in the scenario of 2-field increase in the amount of CO_2 330-660ppm in C3 plants, the result will increase by 33%. This increasing effect was more on the yield and performance components such as increasing tilling and had less effect on the appearance quality of the grain. Field research on the effects of increasing CO_2 of plants also confirms the research conducted in closed space. In some field results, the response of plants to CO_2 is lower than previously reported cases. Table 1 shows the effects of doubling the amount of CO_2 on leaf photosynthesis, dry matter production, and evaporation and transpiration on different plants that were not under water stress.

Table 1- Percentage changes in leaf photosynthesis, total plant dry matter, grain yield, stomatal conductance and plant crown temperature or evaporation and transpiration in relation to the doubling of CO_2 concentration.

Plant	Changes in leaf photosynthesis	Changes in total dry matter of plant production	Changes in grain yield	Changes in stomata conductance	Temperature and transpiration
Corn	**3	4	4	34-	n.a.
Soybeans	29	37	34	40-	**12-
Wheat	35	27	31	33	*8-
Rice	36	30	30	n.a.	10-
Sorghum	**9	**3	8	**37-	**13-
Cotton	33	36	44	36-	8-
Beans	50	30	27	n.a.	n.a.

In the discussion of the effects of plant change and its production, different plant models are observed in scientific sources. Some of which have general and universal applications. Such as CERES-MAIZE, CERES-MAIZE and Aqua Crop models and a series have also been prepared in accordance with various researches and issues of the special effects of climate change on the growth of agricultural products and humidity, thermal stress, increase in CO_2, etc. That is, different plant models have the ability to predict the result of the plant in the reaction of the plant to the increase of CO_2 from past levels to current and future. In principle, the use of models is useful for understanding the effects of climate change (Karajeh and Steduto, 2014). Using plant models as an example, the yield of soybeans in the state of Iowa, America, increased by 9.1 percent during 2000, The amount of CO_2 has also increased from 315-370 ppm. Therefore, it has been concluded that part of the increase rate of soybean yield in this state was caused by global changes in CO_2 (Iglesias and Garroteb, 2015).

The effects of climate change on the effectiveness of water consumption in plants.

Water consumption through evaporation and transpiration of plants is a physical process, but it can also be affected by the physiological and morphological characteristics of the plant. One of the methods of calculating evaporation and transpiration is using the Penman-Mantit equation. Most of which can be affected by the parameters of climate change, i.e. heat, CO_2, and even the amount of ozone gas, and therefore, in total, these parameters can affect the amount of water consumption and the efficiency of water consumption in climate change conditions. These effects, for example, 1- direct effect on plant growth and leaf area. 2- Creating disturbances and influencing the opening of the leaf and as a result directing them and leaving the water loss from the plant in the form of steam. 3- Creating physical changes in the vapor pressure inside the leaves that affect the slope of the transpiration flow from the leaves.

An increase in the concentration of CO_2 the partial closing of plant stomata. which reduces water conductivity and reduces water losses in the form of steam from the leaves to atmosphere. According to the results of conducted research, on average, doubling the CO_2 from 340-680 ppm decreases the conductance of the apertures by 34%. this rate is different in C3 & C4 plants. increase in the concentration of CO_2 in the conditions of the field tests around 550 ppm has reduced the amount of water consumption by 2-13% depending on the type of plant (Hatfield *et al*., 2008).

Regardless of the positive effects of the increase in CO_2 for the water consumption efficiency of agricultural plants, the effect of climate change on the increase in plant water needs is high. Many studies have investigated the effect of climate change on the increase in water requirement of plants from regional and global dimensions. The results of these studies indicate that until 2070, the plant's pure water requirement will increase between 5 and 8 percent worldwide. Meanwhile, at the regional level, for example, in Southeast Asia, the results show an increase of up to 15% (Bates *et al.*, 2008). Other studies, while emphasizing the positive effects of the increase in CO_2 on the effectiveness of plant water consumption, have found that until 2080, the plant's water needs will increase by 20% globally, and these effects of increased water needs on developed areas. It will be more than the developing regions, because climate change, in addition to increasing the evaporation potential, will also increase the length of the period and the growing season of agricultural products in these regions. In the research, the effects of climate scenarios of heat and rainfall up to the horizon of 2100 AD on the water requirements of four major crops including wheat, barley, maize and potatoes in Iran have been investigated (Serafroz *et al*., 2014).

The amount of CO_2 in the atmosphere is also related to the water consumption of the plant. Increasing the concentration of atmospheric CO_2 on the yield of agricultural plants can be beneficial in terms of its effect on the consumption of water resources. Because the effectiveness of water consumption in plant leaves can increase due to the increase in stomata resistance of leaves in CO_2 conditions compared to light conditions. The results of many recent researches indicate that changes in temperature and precipitation in the coming decades will limit the effects of CO_2 on plants. Increase in temperature, evaporation and transpiration and increase in water stress during flowering may reduce and neutralize the effects of CO_2 on the plant by reducing the number of seeds formed (harvest index), seed size and product quality (Bates *et al*., 2008).

ADAPTATION METHODS TO CLIMATE CHANGE IN AGRICULTURE

Asian continent is the largest continent in the world, which is almost spread in four climatic regions (cold, dry and semi-arid, tropical and temperate). In this continent, climate change will affect various sectors, including water resources, agriculture, food security, ecosystems, biodiversity, and human health. In this continent, many environmental and development problems will be exacerbated by climate change. Based on the international information of the countries, the possible damage caused by climate change to developing countries in different economic sectors is presented in Table 2, as well as the range of activities and functions that can be used to adapt to climate change (Parry *et a.l*, 2004).

The results of research showed the adaptation of agriculture to climate change using the simulation model of different plant cultivars. Some varieties of the plant are less sensitive to its cultivation in different stages of the year. while other cultivars will have more yield potential under warmer conditions. Resistant cultivars are able to compensate the effects of yield reduction caused by climate change scenarios (Rosenzweig et al., 2004).

Based on the review of various scientific sources, the solutions to deal with the effects of climate change from the aspect of agricultural water management presented in Table 2. these solutions are potential and their selection and application depends on local conditions, they should become indigenous which is discussed in the next section.

Table 2- Compatible solutions in the agriculture sector in developing countries (FAO-OECD, 2012).

Compatible solutions are active and in progress	compatible solutions for the future
Water storage for irrigation (by creating a water dam). Changes in the application and consumption of chemical fertilizers. Attention to soil nutrition and its improvement. Changes in the planting time of agricultural crops. Use of new plant cultivars and varieties. Implementation of training programs for farmers in the management and protection of water, soil and plant resources.	Development of plants resistant / tolerant to drought, pests and diseases. Expansion of research and related studies. Water and soil management and better understanding of water and soil-plant-atmosphere relationship. Creating diversity in cultivated agricultural products. Creation and development of notification systems.

These solutions are mainly based on the results of field visits, experts' opinions, completing questionnaires and during a special research project entitled "Research of climate change on the agriculture sector from the perspective of water resources management".

Table 3- Adaptable solutions to climate change based on global scientific sources (Iglesias and Garroteb, 2015).

Compatible solution type	The title of the solution
Solutions related to water consumption of agricultural products.	Changing irrigation methods and developing pressurized irrigation systems. Construction of water storage dams. Preventing ineffective water losses or implementing new irrigation systems. Transporting water with a pipe from the water source to the place of consumption. Creating water supply networks. Development of micro irrigation methods (drip, etc.) Improving the activities of increasing moisture retention in the soil.

Agricultural and plant solutions	Creating suitable crop rotation with low water crops. Development of tillage cultivation and the use of cultivars resistant to drought and drought stress. Change in the planting date of some crops to take advantage of the winter rains. Development of treasury plant cultivation. Development of plants that are early maturing and tolerant to environmental stress. Development of greenhouse crops. Cultivation of plants with less water requirement and high economic value. Transferring some crops from fall to spring. The development of leguminous cultivation. Development of alternative crops in low water conditions. Development of seedling crops for oilseeds. More use of organic and biological fertilizers.
Mechanization agricultural solutions	Increasing accuracy in the consumption of production factors (fertilizers, pesticides, water, seeds, etc.) according to the needs of the farm and at the right time and using smart technology with the ability to change the amount of production factors according to the needs of the plant in any part of the farm. Improved plant growth and stability by increasing the accuracy of conventional machines to perform operations in the product production process. Fast and timely detection of the effects of climate change on plants during the growing season using air and non-destructive measurement tools for timely response.

CONCLUSION

In conclusion, it should be noted that the phenomenon of climate change is a complex phenomenon and the solutions presented in this article should be evaluated and localized on a local scale. Therefore, it is necessary to carry out small-scale assessments of climate change and adaptation to it. It is also necessary to expand the specific research and studies of climate change in the country and provide more local and specific results for this issue in the form of technical and promotional publications. The fields that need more attention to adapt to climate change in agriculture are:

- Increasing plant residues and soil organic matter.
- Maintaining soil moisture.
- Changing the pattern of cultivation and cultivation of drought-resistant crops with high economic value.
- Incorporating low-expected and new plants into the cultivation pattern in line with the sustainability of production and adapting to climate change.
- Expansion of cultivation in a controlled environment (greenhouse)
- Expanding cultivation of cultivars with a short growing period
- Adjusting the planting calendar of various agricultural products according to climatic conditions and soil resources.

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