Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2019; SP2: 744-748

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# Climate change on crop production

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**Abstract**

Climate change has a serious impact on the availability of various resources on the earth especially water, which sustains life on this planet and directly impact food production across the globe. Increase in the mean seasonal temperature can reduce the duration of many crops and reduce the yield throughout the 21stcentury. The average temperature change is predicted to be 2.33°C to 4.78°C with a doubling in $CO_2$ concentrations. The heat waves will lead to increased variability in summer monsoon precipitation, which will result in drastic effects on the agriculture sector in India. Food production systems are extremely sensitive to climate changes like changes in temperature and precipitation, which may lead to outbreaks of pests and diseases thereby reducing harvest ultimately affecting the food security of the country. Bio-technology has to develop crop varieties are specialized to coping with the effect of climate change. Improved management of inputs and shifts in farm practices significant worth emphasising for the sustainable development. The genetic diversity in crops provides a platform to identify suitable thermal and drought tolerant cultivars for sustained productivity, identification of suitable agronomic management practices, an overall assessment of soil health and the possible alterations in soil physical, chemical and biological characters need to be looked for climate change

**Keywords:** Climate change, Agriculture productivity crop and management

## Introduction

Climate change is defined as the average weather or more rigorously as the stastical description in terms of the mean and variability quantities over a period of time from months to thousand or million years. Climate change refers to a statistically significant variation either the mean stage of the climate or in its variability persisting for an extended period. Climate change caused by the accumulation of greenhouse gases in the lower atmosphere. The global concentration of these gases is increasing, mainly due to human activities, such as the combustion of fossil fuels (which release carbon dioxide) and deforestation (because forests remove carbon from the atmosphere). The atmospheric concentration of carbon dioxide, the main greenhouse gas, has increased by 30 per cent since preindustrial times.

It is estimated that global mean surface temperature will rise by 1.5° to 3.5° C by 2100. This rate of warming is significant. Large changes in precipitation, both increases and decreases, are forecast, largely in the tropics. Climate change is very likely to affect the frequency and intensity of weather events, such as storms and floods, around the world. Climate change will also cause sea level rise due to the thermal expansion of the oceans and the melting of the mountain glaciers. Global mean sea level is anticipated to rise by 15 to 95 centimetres by 2100. Sea level rise will increase vulnerability to coastal flooding and storm surges. The faster the climate changes, the greater will be the risk of damage to the environment. Climatic zones (and thus ecosystems and agricultural zones) could shift toward the poles by 150 to 550 kilometres by 2100. Many ecosystems may decline or fragment, and individual species may become extinct. The *IPCC Second Assessment* report concludes that climate change has probably already begun

Indian agriculture consumes about 80-85 per cent of the nation's available water (Mall *et al.*, 2005) [15]. The quantity of water required for agriculture has increased progressively through the years and more areas were brought under irrigation. Surface water and groundwater resources have play significant role in irrigation and also in attaining self-sufficiency in food production during the past three decadesIn India, average food consumption at present is 550 g per capita per day, whereas in China and USA are 980 and 2850 g, respectively (Mall *et al.*, 2005 and Mall *et al.*, 2006) [15, 16]. The country faces major challenges to increase its food production to the tune of 300 m.t. by 2020 in order to feed its ever growing population which is likely to reach 1.30 billion by the year 2020. To meet the demand for food from this increased population, the country's farmers need to produce 50 per cent more grain by 2020 (Agarwal and kalra, 1995)

The total gross irrigated area has more than quadrupled from 22.6 million ha in 1950–51 to

99.1 million ha in 2011-2012. Although, agriculture contributes 14% in the Gross Domestic Product (GDP) in India, 64 per cent of the population depends on agriculture for their livelihood (Anderson and Domsch, 1986) [3]. Over the years, demand for water has increased due to urbanization, increasing population, rapid industrialization and other developmental initiatives. In addition, changes in cropping and land-use patterns, over-exploitation of groundwater and changes in irrigation and drainage have modified the hydrologic cycle in many climate regions and river basins of India (Agarwal and Mall 2002).

Water quality and quantity are serious constraints for agriculture in most parts of India. Therefore, assessment of the availability of water resources is future national requirement and expected impact of climate change and its variability is critical for relevant national and regional long-term development strategies for sustainable development (Rana and Ranbir Singh, 2009) [18].

**Climatic Changes in India**

The climatic disasters *viz*, floods, drought, typhoon, acid rain, elevated $Co_2$ El-nino and La nina, cyclones and anticyclones and excessive or defective insolation. India is a disaster prone area, with the statistics of 27 out of 35 states being disaster prone (Rao *et al.,* 1999) [19]. The process of global warming has led to an increase in the frequency and intensity of these climatic disasters. According to surveys, in the year 2007-2008, India ranked the third highest in the world regarding the number of significant disasters, with 18 such events in one year, resulting in the death of 1103 people due to these catastrophes (Joshi *et al.,* 2011) [13].

Rising Temperatures on the Tibetan Plateau are causing the melting of the Himalayan glaciers, reducing the water flow in the rivers Ganges, Brahmaputra, Yamuna, and other major rivers, on which the livelihoods of hundreds of thousands of farmers depend (Asha *et al.*, 2012) [4]. According to the The Indira Gandhi Institute of Development Research, if the process of global warming continues to increase, resulting climatic disasters would cause a decrease in India's GDP to decline by about 9 per cent, with a decrease by 40 per cent of the production of the major crops (Bhatia, *et al.,* 2008) [5]. A temperature increase of 2 °C in India is projected to displace seven million people, with a submersion of the major cities of India like Mumbai and Chennai (IPCC 2007) [12].

**Floods**

India is the most flood distressed state in the world after Bangladesh, accounting for 1/ 5th of the global deaths every year with 30 million people displaced from their homes yearly. Approximately 40 million hectares of the land is vulnerable to floods, with eight million hectares affected by it (Demeke *et al.,* 2011) [7]. Unprecedented floods take place every year at one place or the other, with the most vulnerable states of India being Uttar Pradesh, Bihar, Assam, West Bengal, Gujarat, Orissa, Andhra Pradesh, Madhya Pradesh, Maharashtra, Punjab and Jammu and Kashmir (Joshi *et al.,* 2011) [13]

**Droughts**

India depends heavily on prolonged and optimum monsoons for its agricultural productivity, failure of which results in the decreased crop productivity, leading to droughts. Of the total agricultural land in India, about 68 per cent is prone to drought of which 33 per cent is chronically drought prone, receiving rainfall of less than 750 mm per year. This is particularly the states of Maharashtra, Gujarat, Rajasthan, Karnataka, Andhra Pradesh and Orissa (Gupta *et al.,* 2011). According to researches, global warming will lead to exacerbation of the droughts, cutting down the water availability in the plains of Uttra Pradesh and Bihar (Geethalakshmi *et al.,* 2011) [9].

**Cyclones and Anticyclones**

As a result of climate change, the average number of Category 4 and 5 hurricanes per year has increased over the past 30 years. India has an 800 km coastline, and is therefore very susceptible to cyclonic activity. Cyclones have been observed to be more frequent in the Bay of Bengal than the Arabian Sea. Consequently the states of West Bengal, Orissa, Andhra Pradesh, and Tamil Nadu along the Bay of Bengal are the most affected (Rao *et al.,* 1995) [20] The notable cyclones in Indian history include the 1737 Calcutta cyclone, 1970 Bhola cyclone, and Cyclone 05B, which affected more than a million people. (Demeke, *et al.,* 2011) [7]. The more serious cyclonic storms usually in the Bay of Bengal and Arabian sea in the transition month (April to May and October to November). Anticyclones are opposite to cyclonic characteristic and are composed of subsiding air. The anticyclones that forms in the upper atmosphere over western Rajasthan is one of the reason for not getting enough rain during the rainy season of June to September (Singh, 1998) [22]

**Temperature Extremes**

High-frequency extreme temperature events such as heat waves, cold waves, and the number of days exceeding various temperature thresholds. The number of days in the exceeding thresholds of 0°C and 32.2°C (90°F) indicate that for the 1910–1998 period there has been a slight decrease in the number of days below freezing (Evens and Hart 1999). Apparent temperature, which combines temperature and humidity effects on the human body, is another important measure, particularly for human health due to increases in water vapor and precipitable water vapor (Yoshimura *et al.,* 1999).

Venkateshwaralu, (2010) indicated that increasing trend in maximum temperature was noticed south zone followed by central east and west zone. Minimum temperature showed increasing trend in central and east zone followed by north zone south zone and least in west zone. Decreasing trend in minimum temperature was seen in west zone followed by north and south zone. Deka and Nath (2008) reported that annual mean minimum temperature showed a net increase in Jorha region of Assam during the last decade (1991-2000) when compared to previous two decades (1970-1990).

**Elevated $CO_2$**

Increased $CO_2$ lead to higher biomass in plantation crops such as coconut, arecanut and cocoa while reduced stomatal conductance, stomatal density and leaf surface wax leading to increased water use efficiency. Increased $CO_2$ level in the atmosphere caused marginal decline in seed protein content of greengram, chickpea and wheat (Singh *et al.,* 2008) [23]. Due to elevated $CO_2$, oil percent increased (5 and 15%), but protein percent decreased by 3 per cent in sunflower (Sharma *et al*., 2000).

**Acid Rain**

Acid rain is a mixing of ran in the air with pollutant gases released from burning of fossil fuels in power stations, factories and automobiles and bringing about the dilute sulphuric acid or nitrate acid or both together in the atmospheric (Mishra and Pande, 2008) [17]. Acid rain significantly affect the soil fertility, destroy the mineral elements and other nutrients of the soil. In plants acid rain retard the rate of photosynthesis, growth of roots and nutrients.

**EL-Nino and LA Nina**

El –nino is a spanish word meaning child Christ. It is used because El -nino occurs during Christmas time. A strong El Nino in 1972 and 1982 combined with effects of over fishing. It is due to decrease in atmosphere pressure over the south east pacific ocean and Indosenia and increase in Australia. La Nina is opposite to El Nino when the waters of eastern Pacific are abnormally cold. It is associated with more rainfall over eastern Indonesia, North Australia and India. El nina events are used in forecasting monsoon rainfall with the help of long range weather forecasting (Kumar *et al.*, 2002).

**Forest Fire out Breaks**

The main cause of forest fire are lightening, self-combustion and human activity. Fire inducing weather conditions are lack of rainfall, high temperature low humidity and wind speed. The types of trees and their moisture content and stage of foliage contribute forest fire. (Shukla *et al.*, 2002) [24].

**Agricultural productivity and food security**

Medium-term climate change predictions have projected the likely reduction in crop yields due to climate change at between 4.5 and 9 per cent by 2039. The long run predictions paint a scarier picture with the crop yields anticipated to fall by 25 per or more by 2099. With 27.5 per cent of the population still below the poverty line, reducing vulnerability to the impacts of climate change is essential. Indian food production must increase by 5 million metric tons per year to keep pace with population increase and ensure food security (Hundal and Kaur 1996) [11]

**Crop and land management practices to mitigate the climate change**

**1. Agronomy management**

Improved agronomic practices that increase yields and generate higher inputs of carbon residue lead to increased soil carbon storage. Using improved crop varieties; extending crop rotations, notably those with perennial crops that allocate more carbon below ground and avoiding or reducing use of bare (unplanted) fallow. Crop rotations with legume crops, which reduce reliance on external N inputs. Another group of agronomic practices are those that provide temporary vegetative cover between successive agricultural crops, or between rows of tree. These ‘catch’ or ‘cover’ crops add carbon to soils and extract plant-available N unused by the preceding crop and reducing $N_2O$ emissions.

**2. Nutrient management**

Nitrogen applied in fertilizers, manures, bio solids, and other N sources is not always used efficiently by crops. The surplus N is particularly susceptible to emission of $N_2O$. Consequently, improving N use efficiency can reduce $N_2O$ emissions and indirectly reduce GHG emissions from N fertilizer manufacture. By reducing leaching and volatile losses, improved efficiency of N use can also reduce off-site $N_2O$ emissions. Practices that improve N use efficiency include, adjusting application rates based on precise estimation of crop needs and using slow or controlled release fertilizer forms.

**3. Tillage / Residue management**

Advances in weed control methods and farm machinery now allow many crops to be grown with minimal tillage (reduced tillage) or without tillage (no-till). Since soil disturbance tends to stimulate soil carbon losses through enhanced decomposition and erosion. Reduced or no-till agriculture often results in soil carbon gain. The effect of reduced tillage on $N_2O$ emissions may depend on soil and climatic conditions.

**4. Water management**

Effective irrigation measures can enhance carbon storage in soils through enhanced yields and residue returns. Drainage of croplands lands in humid regions can promote productivity and perhaps also suppress $N_2O$ emissions by improving aeration.

**5. Rice management**

Cultivated wetland rice soils emit significant quantities of methane. Emissions during the growing season can be reduced by various practices. Draining wetland rice once or several times during the growing season reduces $CH_4$ emissions. Rice cultivars with low exudation rates could offer an important methane mitigation option. In the off-rice season, methane emissions can be reduced by improved water management, by keeping the soil as dry as possible and avoiding water logging.

**6. Agro-forestry**

Agro-forestry is grows trees for timber, firewood, or other tree products. It includes shelter belts and riparian zones/buffer strips with woody species. The standing stock of carbon above ground is usually higher than the equivalent land use without trees, and planting trees may also increase soil carbon sequestration.

**7. Land cover (use) change**

The conversion can occur over the entire land area, or in localized spots, such as grassed waterways, field margins, or shelterbelts. Such land cover change often increases carbon storage. Compared to cultivated lands, grasslands may also have reduced $N_2O$ emissions from lower N inputs, and higher rates of $CH_4$ oxidation. Planting trees can also reduce emissions. It is usually an option only on surplus agricultural land or on croplands of marginal productivity.

**8. Transgenic crops and climate change**

Genetic engineering for improving traits such as heat tolerance, water productivity and better use of nutrients that may enhance crop adaptation to the changing climate. Transgenic or genetically modified (GM) crops with enhanced environmental stress tolerance are likely to require substantial advances in biosafety assessment and regulatory approval that are very different first generation of commercial transgenic crops.

**9. Livestock and to climate change**

There will be significant impacts on livestock and livestock-based systems as the climate changes. Local breeds – which appear to better than exotic germplasm for coping with climate change – and community based, participatory breeding could assist in adapting livestock to global warming and drought (CGIAR, 2009). In this approach, the entire community herd is regarded as a single breeding pool for genetically enhancing target traits such as milk yield or growth rate. Likewise, shrub and other species adapted to drought- and heat-prone environments will help in replanting grazing lands whereas fodder banks with legumes such as *Stylosanthes* may ensure feed availability during scarcity periods due to drought.

## Conclusion

Agriculture sector is the most sensitive sector to the climate changes because the climate of a region/country determines the nature and characteristics of vegetation and crops. Increase in the mean seasonal temperature can reduce the duration of many crops and hence reduce final yield. Food production systems are extremely sensitive to climate changes like changes in temperature and precipitation, which may lead to outbreaks of pests and diseases thereby reducing harvest ultimately affecting the food security of the country. Bio-technology has to develop crop varieties are specialised to coping with the effect of climate change. Improved management of inputs and shifts in farm practices are significant worth emphasising for the sustainable development. The vast genetic diversity in crops provides a platform to identify suitable thermal and drought tolerant cultivars for sustained productivity, identification of suitable agronomic management practices, assessment of soil health and the possible alterations in soil physical, chemical and biological characters need to be looked for climate change. There is an urgent need for coordinated efforts to strengthen there search to assess the impact of climate change on agriculture, forests, animal husbandry, aquatic life and other living beings. Coping with the impact of climate change on agriculture will require careful management of resources like soil, water and biodiversity, India will need to act at the global, regional, national and local levels.

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