



Role of Climate Change in Growth and Development

(*Deepak Kumar, Rakesh Kumar and R.S. Bochalya)

Sher-e-Kashmir University of Agricultural Sciences and Technology Jammu, SKUAST,
Jammu, UT of J & K-180009

* pandeyagronomy@gmail.com

India with diverse soil and climate comprising several agro-ecological regions provides ample opportunity to grow a variety of horticultural crops which form a significant part of total agricultural produce in the country comprising of fruits, vegetables, root and tuber crops, flowers and other ornamentals, medicinal and aromatic plants, spices, condiments, plantation crops and mushrooms.

India with more than 28.2 million tonnes of fruits and 66 million tonnes of vegetables is the second largest producer of fruits and vegetables in the world next only to Brazil and China. Addressing problems of climate change is more challenging in horticulture crops compared to annual food crops. The issues of climate change and solution to the problems arising out of it requires thorough analysis, advance planning and improved management. The crop productivity is subjected to number of stresses and potential yields are seldom achieved with stress.

The present challenges like global climate change, water and soil pollution, less water availability, urbanization etc adds up to the situation. In combination with elevated temperatures, decreased precipitation could cause reduction in availability of irrigation water and increase in evapotranspiration, leading to severe crop water-stress conditions. Fruits, vegetables, flowers, medicinal plants and tubers are grown from tropical to temperate, some horticultural crops like spices and plantation crops are location specific. Climate change poses serious challenges to human and places unprecedented pressure on the sustainability of horticulture industry.

Climate change

- Change of climate which is attributed directly / indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”.
- Due to natural process or external forcing , (UNFCCC-United nation framework convention on climate change.)
- Recent report of the IPCC & a few other global studies a probability of 10-40 % loss in crop production in India. (Parry et al, 2004)
- The established commercial varieties of fruits, vegetables and flowers will perform poorly.

Factors responsible for climate change

- Increase in average temperature,
- Increases in atmospheric CO₂ concentration,
- Changes in rainfall pattern

Drought

- Drought is a shortage of water for essential needs, which for agricultural purposes relates to plant growth
- Less rain or breaks in monsoon rainfall results in moderate to severe moisture stress.
- Root and shoot development, Flowering, Pollination and fertilization all are affected by severe drought condition.

High rainfall

- Excess water in the soil can injure flood prone plants, due to lack of oxygen.
- 10-15 % of the crop damage due to heavy rainfall.
- So there was sharp rise in the prices
(Samra *et al.*, 2006)
- High absorption there is build-up of high turgor pressure in the region of cell elongation which causes maximum swelling of the cells.
- Growth cracks occur as bursting heads of cabbage and cracked fruits of tomato and roots of carrot and sweet potato.

Edmond, *et al.* (1978)

Temperature

- Excessively high temperatures, denaturation of enzymes & proteins.
- Excessively low temperatures can also cause limiting effects on plant growth and development.
- Increased temperature can cause plants to close their stomata
- Reducing photosynthesis and ultimately damaging the crop
- Fruit mineral production and composition could be affected
- Pollination will be affected.
- Floral abortions, flower and fruit drop will be occurred frequently.
- Eg: Floral abortion will occur in capsicum when temperatures exceed 30°C.
- Earlier and quicker ripening
- Eg. with a 2°C temperature increase, some apple varieties could mature up to 3 weeks earlier
- Reduced frosts will weaken vernalisation, potentially reducing yields in some crops
- Anthocyanin production is reduced,
- Similarly, in capsicum red colour development during ripening is inhibited above 27°C.
- Inducing delayed bud break.
- Effect of high temperature some disease also developed in some plants.

Influence of elevated Carbon dioxide

- Photosynthetic metabolism due to increase in CO₂, & will be able to accumulate more biomass.
- It will alter the quality of the produce.
- The WUE was almost doubled.

Relative Humidity

- RH directly influences the water relations of plant,
- Indirectly affects leaf growth, photosynthesis, pollination, occurrence of diseases and finally economic yield.
- When RH is low, transpiration increases,
- Causing water deficits in the plant.
- Water deficits cause closure of stomata and blocking entry of carbon dioxide.
- At high RH pollen may not be dispersed from the anthers

Impact of Climate Change in Indian Horticulture

Effect of fruit crop

India is the second largest producer of Fruits after China, with a production of 44.04 million tonnes of fruits from an area of 3.72 million hectares. A large variety of fruits are grown in India, of which mango, banana, citrus, guava, grape, pineapple and apple are the major ones. Due to rise in temperature, crops will develop more rapidly and mature earlier. For example, Citrus, grapes, melons etc. will mature earlier by about 15 days. Strawberries will produce more runners at the expense of fruits.

The climate change increases the atmospheric temperature and change of rainfall pattern, as a result, banana cultivation may suffer from high temperature, soil moisture stress or flooding / water logging. High temperature and moisture stress also increase sunburn and cracking in apples, apricot and cherries and increase in temperature at maturity will lead to fruit cracking and

burning in litchi (Kumar and Kumar 2007).

List of some variety tolerant abiotic stress:

S. No	Crop	Variety	Tolerant
1	Pomegrante	Ruby	Drought tolerant
2	Annona	Arka Sahan	Drought tolerant
3	Mango	Bappakai	Salinity tolerant
4	Grape (rootstock)	Dogridge	Salinity tolerant

Source: Bose and Mitra (1996)

Effect of vegetables crop

- High temperatures can cause reduced fruit set, produced smaller and lower quality of tomato fruits
- Bud drop, abnormal flower development, poor pollen production, ovule abortion, reduced carbohydrate availability, and other reproductive abnormalities.
(Erickson and Markhart 2002)
- The severity of flooding symptoms rapid wilting and death of tomato plants.
(Kuo et al. 1982)
- Ozone has adverse effect on vegetable production in terms of reducing growth, yield and quality.
- Risk of the air pollution is more when vegetable crops grown close to the densely populated areas.
- A recent study indicated that the ambient air pollution significantly decreased the yield upto more than 50 percent incase of Brassica oleracia, Lactuca sativa and Raphanus sativus.
- Many vegetable crops namely tomato, water melon, potato, squash, soyabeans, cantaloupe, peas, carrot, beet, turnip, etc are more susceptible to air pollution damage.
- Yield of vegetable can be reduced by 5-15 percent when daily ozone concentrations reach to greater than 50 ppb (Raj Narayan 2009).

Table 2. List of some abiotic stresses vegetable crops

Sl. No.	Tolerant	Crop
1	Drought tolerant	Chilli, melons, tomato, onion
2	Heat tolerant	Peas, tomato, beans, <i>Capsicum</i>
3	Salinity tolerant	melons, peas, onion
4	Flooding/ excess moisture tolerant	tomato, onion, chilli

Source: Rai and Yadav (2005)

Table 3. List of some variety and advanced line tolerant to abiotic stress.

Sl. No.	Tolerant	Crop	Variety	Advanced Line
1	Drought/rainfed	Tomato	Arka Vikas	RF- 4A
		Onion	Arka Kalyan	MST-42 and MST-46
		Chilli	Arka Lohit	IIHR Sel.-132
2	Photo insensitive	Dolichos	Arka Jay, Arka Vijay, arka Sambram, Arka Amogh, Arka Soumya	IIHR-16-2
		Cow pea	Arka garima, Arka Suman, Arka Samrudhi	
3	High temperature	Capsicum		IIHR Sel.-3
		French bean		IIHR-19-1
		Peas		IIHR-1 and IIHR-8
		Cauliflower		IIHR 316-1 and IIHR-371-1

Source: Hazra and Som (1999) and Rai and Yadav (2005)

Effect on plantation crops

- High temperature ($>34^{\circ}\text{C}$) and low relative humidity ($<20\%$) during afternoon causes drying of flowers, resulting in yield reduction(50-60%).
(Directorate of Cashew Research, Puttur)
- Consecutive drought here reduced the coconut production by about three lakh nuts/year for four years. Productivity loss was to the tune of about 3500nuts/hectare/year in India.
- Apart from drought other natural calamities like cyclone etc have impacted the crop production and productivity.
- In coconut, arecanut and cocoa increased CO_2 led to higher biomass production. But a slight decline in biomass production was apparent at elevated air temperature. All three crops responded differentially under elevated air temperature. In coconut, net photosynthesis rate has reduced but increased that of arecanut and cocoa.
- TDM was slightly decreased in all three crops.

Effect on spice crops

Seed Spices are winter season crops and commonly grown in arid and semi arid track of Rajasthan and Gujarat requiring certain period of low temperature for optimum vegetative growth. Heavy losses have been observed due to combined effect of chilling and frost injury. Cumin, coriander, nigella, ajowan are the crops which are very sensitive to frost.

- Fennel and fenugreek are also affected by frost but growth stage plays an important role. So far no efforts have been made to identify the source of resistance against low temperature injury in available germplasm of seed spices crops.

In general due to increase in maximum and minimum day temperature and decreasing the annual rainfall the productivity showed decreasing trend in most of the black pepper growing areas of India.

- In black pepper, Accs 1380(IC 316801), 1387(IC 316803), 1410(IC 316817), 1423(IC 316825) and 1430(IC 316832) were identified as relatively tolerant to drought.
- In cardamom, RR1(IC 349591), CL-893 (IC 349537), Green Gold (IC 349550) were found relatively tolerant under Kerala, India condition.

Effect on flower crops

Melting of ice cap in the Himalayan regions will reduce the chilling requirement for the flowering of many of the ornamental plants like Rhododendron, Orchid, Tulipa, Alstromerea, Magnolia, Saussurea, Impatiens, Narcissus etc. Some of them will fail to bloom or flower with less abundance while others will be threatened. Commercial production of flowers particularly grown under open field conditions will be severely affected leading to poor flowering, improper floral development and colour.

- Chrysanthemum is a short day plant. So flowering round the year in open field condition is not possible.
- Low temperatures shut down flowering in Jasmine (<190C) and lead to reduction in flower size.
- Flowers do not open up fully in tropical orchids wherever temperatures below 150C.
- High temperature leads to flower bud drop and unmarketable spikes in tropical orchids when temperature remains > 350 C.

Solutions

- Where markets will allow select varieties for resistance to water-logging and heat stress
- Manage groundwater abstraction near coastal areas to reduce risk of saltwater being drawn into aquifers

Conclusion

In view of these problems, horticulturists will have to play a significant role in the climate change scenario and proper strategies have to be envisaged for saving horticulture. The most effective way is to adopt conservation agriculture, using renewable energy, forest and water conservation, reforestation etc.

- To sustain the productivity modification of present horticultural practices and greater use of green house technology are some of the solutions to minimize the effect of climate change.
- Development of new cultivars of horticultural crops tolerant to high temperature, resistant to pests and diseases, short duration and producing good yield under stress conditions, as well as adoption of hi-tech horticulture and judicious management of land use resources will be the main strategies to meet these challenge.

