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REVIEW PAPER

Effect of Climate Changing on Horticultural Crops in India – A Review

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ABSTRACT

The impact of global warming is now visible in many parts of the India. Uneven change in climate patterns, induced by accelerated warming, has started to affect a catchment-specific hydrologic cycle. Increased temperatures lead to a high rate of evaporation and dry conditions in some areas of the India especially in North Western India. Scientists believe that rapid warming in the last several decades is mostly due to man-induced changes in the atmosphere, on top of some natural variations. Climate change such as temperature, and has been affected all cultural crop and results greater impact on productivity and quality of horticultural crops. Hence, to maintain the sustainability of crops need to minimize the effect of climate on horticultural crops by various hi-tech horticulture and management method. At higher levels of warming, estimated monetary impacts generally become negative, and studies, allowing for disastrous possibilities, can reach high negative outcomes. Moreover, the perennial plants (mostly fruit plants) are at more risk than annuals or seasonal.

Keywords *Climate, Fruit crops, Temperature, Global Warming*

India is a country having diverse climate which provides different agro-ecological regions with specific characteristics. Due to this diversified climate it has many opportunities' to grow different variety and horticultural crops. It is estimated that all the horticulture crops put together cover nearly23.2 million hectares area with an annual production of 305(Horticulture Statistical Year Book, 2017). Hence, to maintain the sustainability of crops need to minimize the effect of climate on horticulture crops by various hi-tech horticulture and management methods. Export of medicinal plants, fruits and vegetables have also exhibited rising trend. Horticultural crops play a unique role in India's economy by improving the income of the rural people. Cultivation of these crops is labor intensive and as such they generate lot of employment opportunities for the rural population. Fruits and vegetables are also rich source of vitamins, minerals, proteins, and carbohydrates etc. which are essential in human nutrition. Hence, these are referred to as protective foods and assumed great importance in nutritional security of the people. Thus, cultivation of horticultural crops plays a vital role in the prosperity of a nation and is directly linked with the health and happiness of the people. The knowledge about the impact of climate change on horticultural crops is limited. 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. Climate change is predicted to cause an increase in average air temperature of between 1.4^{0}C and 5.8^{0}C, increases in atmospheric CO_2 concentration, and significant changes in rainfall pattern (Houghton *et al.*. 2001). Impact of climate change on four sectors of the economy, namely Agriculture, Water, Natural Ecosystems and Biodiversity and Health in four climate sensitive regions of India, namely the Himalayan region, the Western Ghats, the Coastal Area and the North-East Region. 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. Vegetable production is threatened by increasing soil salinity particularly in irrigated croplands which provide 40% of the world's food (Datta, 2013). Fruits, vegetables, flowers, medicinal plants and tubers are grown from tropical to temperate, some horticultural crops like spices and plantation crops are location specific. In order to sustain our horticultural production with present day challenges we have to manage the manage, precipitation etc. The nature and magnitudes of stress vary. Climate change poses serious challenges to human and places unprecedented pressure on the sustainability of horticulture industry. Therefore, the development of horticultural crops that can withstand stress will be the single most important step we may take to adapt the changes we have faced today and will face in the future.

Effect of Climate Change

The consequences of such rapid change are - global warming, change of seasonal pattern, excessive rain, melting of ice cap, flood, rising sea level, drought, etc. leading to

extremity of all kinds. Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor vernalization. Western Ghats and surrounding regions may be deprived of normal precipitation due to abnormal monsoon. Vulnerability, rarity and rapid extinction of plant species will be among the other consequences. Plains of India will face similar kind of problems. Nobel Laureate Pachauri said, total agricultural land will shrink and the available land may not remain suitable for the present crops for too long. Farmers have to explore options of changing crops suitable to weather. The per capita availability of fresh water in India is a expected to drop from around 1900 m^3 currently to 1000 m^3 by 2025 due to a combination of population and climate change (Rehman *et al.*, 2015). He also pointed out that climatic changes could lead to major food security issues for a country like India.

Climate Change and its Impact on Horticultural Crops

Two major parameters of climate change that has far reaching implications on agriculture in general and horticulture in particular are more erratic rainfall patterns and unpredictable high temperature spells will consequently reduce crop productivity. Latitudinal and altitudinal shifts in ecological and agro-economic zones, land degradation, extreme geophysical events, reduced water availability, rise in sea level and salinization are postulated (FAO, 2004).

The climate change will have many impacts on horticulture and a few examples are given below.

1. A study conducted at IISR, Calicut using GIS models have shown that many areas presently suitable for spices would become unsuitable in another 25 years. There would be new areas which are presently unsuitable, become highly suitable for cultivation of spices. This will be applicable in other horticultural crops.
2. Production timing will change due to rise in temperature. Due to rise in temperature, photoperiods may not show much variation. As a result, photosensitive crop will mature faster.
3. The winter regime and chilling duration will reduce in temperate regions affecting the temperate crops.
4. Pollination will be affected adversely because of higher temperature. Floral abortions, flower and fruit drop will be occurred frequently.
5. The requirement of annual irrigation will increase and heat unit requirement will be achieved in much lesser time.
6. Higher temperatures will reduce tuber initiation process in potato, reduced quality in tomatoes and pollination in many crops. In case of crucifers, it may lead to bolting; anthocyanin production may be affected in apples and capsicum. Tip burn and blossom end rot will be the common phenomenon in tomatoes.(Hrebar and Vedrih, 2013)
7. Coastal regions can expect much faster percolation of sea water in inland water tables causing more salinity.

Effect of Climate Change on Fruit Crops

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. Specific chilling requirements of pome and stone fruits will be affected hence dormancy breaking will be earlier. Delay in monsoon, dry spells of rains, and untimely rains during water stress period, supra-optimal temperatures during flowering and fruit growth, hailstorms are some of the most commonly encountered climatic conditions experienced by the citrus growers over the past decade or So. Similarly, in arid region date palm like fruit crops need heat summation units. Due to pre-monsoon and rains at flowering time are some most common 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). Air pollution also significantly reduced the yield of several horticultural crops and increase the intensity of certain physiological disorders like black tip of mango which is induced by coal fume gases, sulphur dioxide, ethylene, carbon mono-oxide and fluoride. Leaf production increases by one leaf per month for every 3.3 to 3.7^{o}C rise in minimum or mean temperature from 10-20 ^{o}C or 13.5 to 25 ^{o}C respectively.

Higher temperature (31-32^{o}C), in general, increases the rate of plant maturity in annual species, thus shortening the growth stages, during which developing fruits and suckers absorb photosynthetic products. The temperature below 10^{o}C leads to impedance of inflorescence and malformations of bunches. Chilling symptoms on leaves are not seen immediately but it may take 2 to 4 days to appear (Morinaga, 2007).

The production of apple has gradually increased but the productivity has fallen from 10.8 to 5.8 t/ha (Awasthi *et al.*, 2001). The reasons attributed to it are climate variability, soil, crop improvement etc. Among all the productivity reducing factors, climate is difficult to manage. The changes in climate in the form of erratic precipitation, increase in temperature, lesser days serving as the chilling period have

started affecting the mountain agricultural production systems and ultimately the food security of the people.

Rai *et al.* (2015) reported insufficient chilling greatly influences flower initiation fruit coloration with deteriorating in fruit texture and taste. Further, high temperature and moisture stress is increasing the sunburn and cracking in apple, apricot and cherries in higher altitudes.

Immediately after the frost period, the survey was conducted in the Bikaner and adjoining areas in order to assess the effect of frost on the survival and severity of damage on arid fruit crops. Study revealed that the crops could be classified on the basis of severity of damage into four groups *viz*. severely affected which included crops such as aonla, gonad, phalsa, moringa, ber, Ficus sp. etc. It was also observed that few crops such as pomegranate was moderately affected, sapota and bael less affected and crops such as date palm was unaffected by the frost.

Effect of Climate Change on Vegetable Crops

India is the second largest producer of vegetables in the world (ranks next to China) and accounts for about 15% of the world's production of vegetables. The current production level is over 90 MT and the total area under vegetable cultivation is around 6.2 million hectares which is about 3% of the total area under cultivation in the country. Environmental stress is the primary cause of crop losses worldwide, reducing average yields for most major crops by more than 50% (Bray *et al.*, 2000). Climatic changes will influence the severity of environmental stress imposed on vegetable crops. The response of plants to environmental stresses depends on the plant developmental stage and the length and severity of the stress (Bray, 2002). Plants may respond similarly to avoid one or more stresses through morphological or biochemical mechanisms (Capiati *et al.*. 2006). Environmental interactions may make the stress response of plants more complex or influence the degree of impact of climate change.

High temperatures can cause significant losses in tomato productivity due to reduced fruit set, and smaller and lower quality fruits. Pre-anthesis temperature stress is associated with developmental changes in the anthers, particularly irregularities in the epidermis and endothesium, lack of opening of the stromium, and poor pollen formation (Sato and Thomas 2002). Hazra *et al.* (2007) reported that symptoms causing fruit set failure at high temperatures in tomato s includes bud drop, abnormal flower development, poor pollen production, dehiscence, and viability, ovule abortion and poor viability, reduced carbohydrate availability, and other reproductive abnormalities. In pepper, high temperature exposure at the pre-anthesis stage did not affect pistil or stamen viability, but high post-pollination temperatures inhibited fruit set, suggesting that fertilization is sensitive to high temperature stress (Erickson and Markhart, 2002). Plant sensitivity to salt stress is reflected in loss of turgor, growth reduction, wilting, leaf curling and epinasty, leaf abscission, decreased photosynthesis, respiratory changes, loss of cellular integrity, tissue necrosis, and potentially death of the plant.

During the last 40-50 years, air pollution level increasing at an alarming rate in the developing countries and causing potential threat to the crop production. Sulphar dioxide, nitrogen oxide, hydrofluride, ozone and acid rain are the primary air pollutant. 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).

Effect of Climate Change on Plantation Crops

Consecutive drought here reduced the coconut production by about three lakh nuts/year for four years. Productivity loss was to the tune of about 3500 nuts/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. However, TDM was slightly decreased in all three crops.

Studies conducted on "Impact of climate change in cashew" at Directorate of Cashew Research, Puttur, India indicated that the rainfed cashew crop is highly sensitive to changes in climate and weather vagaries, particularly during reproductive phase. Cashew requires relatively dry atmosphere and mild winter (15-20^{0}C) coupled with moderate dew during night for profuse flowering. High temperature (>34.4^{0}C) and low relative humidity (<20%) during afternoon causes drying of flowers, resulting in yield reduction. Unseasonal rains and heavy dew during flowering and fruiting period aggravated the incidence of pests and diseases. All these situations resulted in reduction yield upto 50 to 65%.

Effect of Climate Change on Spice 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. Kashmir's prized saffron crops have suffered a 40% drop in production, one of the three places in world - besides Iran and Spain - most famous for its saffron, water shortages are straining the crops. Some of the saffron farmers who traditionally relied on rainwater are now looking at irrigation measures to save their rare and labour intensive crop.

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. Incidence of frost causing serious loss in yield almost reaches up to zero. 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.

Effect of Climate Change 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. Plant species requiring high humidity and water may find them under difficult conditions for survival. Plains of India will also have similar kind of problems and will be affected either by drought or excessive rains, floods and seasonal variations. 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 (<19^{0}C) and lead to reduction in flower size. Flowers do not open up fully in tropical orchids wherever temperatures below 15^{0}C. High temperature leads to flower bud drop and unmarketable spikes in tropical orchids when temperature remains > 35^0 C.

Spring bulbs brought indoors and kept in warm temperature after flowering will not bloom again. Such bulbs left in the winter ground under historical changes. Such imposed temperature regimes very precise, there are sharp differences in temperature requirement (Rea and Eccel, 2006).

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.

LITERATURE CITED

Annon 2017. HORTICULTURE - Statistical Year Book India 2017 The Ministry of Statistics and Programme Implementation, Govt of India.

Awasthi RP, Verma HS, Sharma RD, Bhardwaj SP and Bhardwaj SV 2001. Causes of low productivity in apple orchards and suggested remedial measures: Productivity of temperate fruits. Jindal, K.K. and Gautam, D.R. (Eds), 1-8.

Bose TK and Mitra SK 1996, Fruits: Tropical and Subtropical. Nayaprakash, Kolkata, India.

Bray EA 2002. Abscisic acid regulation of gene expression during water-deficit stress in the era of the Arabidopsis genome. *Plant Cell Environ* . **25**: 153-161.

Bray EA, Bailey-Serres J and Weretilnyk E 2000. Responses to abiotic stresses: Biochemistry and molecular biology of plants. Gruissem, W., Buchannan, B. and Jones, R. (eds). ASPP, Rockville, MD 1158-1249.

Capiati DA, País SM and Téllez-Iñón MT 2006. Wounding increases salt tolerance in tomato plants: evidence on the participation of calmodulin-like activities in cross-tolerance signaling. *Journal of Experimental Botany*. **57**: 2391-2400.

Datta, S. 2013. Impact of Climate Change In Indian Horticulture - A Review. International Journal of Science, *Environment and Technology*, **2** (4) : 661– 671

Drew MC 1979. Plant responses to anaerobic conditions in soil and solution culture. *Curr. Adv. Plant Sci*. **36**: 1-14.

Erickson AN and Markhart AH 2002. Flower developmental stage and organ sensitivity of bell pepper (*Capsicum annuum* L.) to elevated temperature. *Plant Cell Environ*. 25:123-130.

FAO 2004. Impact of climate change on agriculture in Asia and the Pacific. Twenty-seventh FAO Regional Conference for Asia and the Pacific. Beijing, China, 17-21 May 2004.

Hazra P and Som MG (1999) Technology for Vegetable Production and Improvement. Naya Prokash, Kolkata, India.

Hazra P, Samsul HA, Sikder D and Peter KV 2007. Breeding tomato (*Lycopersicon esculentum* Mill) resistant to high temperature stress. *International Journal of Plant Breeding*. **1**(1).

Houghton J, Ding Y, Griggs D, Noguer M and Van der Linden P 2001. Climate Change 2001: The Scientific Basis. Published for the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York. 881p.

Janez H. and Rajko, V. 201. Impacts of climate change on fruit physiology and quality. Proceedings . 50th Croatian and 10th International Symposium on Agriculture . Opatija . Croatia (42–45)

Kumar, R. and Kumar, K.K. 2007. Managing physiological disorders in litchi. *Indian Horticulture*. 52 (1): 22-24.

Kuo D.G, Tsay J.S., Chen, B.W. and Lin, P.Y. 1982. Screening for flooding tolerance in the genus Lycopersicon. *Hort Science*. **17**(1): 6-78.

Morinaga, K. 2009. Impact of Climate Change on Horticulture Industry and Technological Countermeasures in Japan. NARO International Symposium, on Impact of global warming on food and agriculture -Frontiers of developing technological countermeasures- 61-63.

Rai, N. and Yadav, D. S. 2005. Advances in Vegetable production. Researchco Book centre, New Delhi, India.

Rai, R., Soni Joshi, Sumana Roy, Omveer Singh, Malay Samir and Anil Chandra 2015. Implications of Changing Climate on Productivity of Temperate Fruit Crops with Special Reference to Apple. *Journal of Horticulture*. **2** (2) : 135-141

Raj N. 2009. Air pollution–A threat in vegetable production. In: Sulladmath, U.V. and Swamy, K.R.M. International Conference on Horticulture (ICH-2009) Horticulture for Livelihood Security and Economic Growth, 158-159.

Rehman, Munib Ur, Gh Hassan Rather , Yasmeen Gull , Mohmad Ramzan Mir ,Mohd Maqbool Mir , Umar Iqbal Waida , and Khalid Rehman Hakeem. 2015. Effect of Climate Change on Horticultural Crops. *Crop Production and Global Environmental Issues* .211-238.

Sato Peet, M.M and Thomas, J.F. 2002. Determining critical pre- and post-anthesis periods and physiological process in *Lycopersicon esculentum* Mill. exposed to moderately elevated temperature. *Journal of Experimental Botany*, **53** (371) -1187–1195.

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