IMPACT ON HORTICULTURE IN INDIA DUE TO CLIMATE CHANGE

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Abstract: Global warming and climate change is the greatest concern of mankind in 21st century. The established commercial varieties of fruits, vegetables and flowers will perform poorly in an unpredictable manner due to aberration of climate. Commercial production of horticultural plants particularly grown under open field conditions will be severely affected. Due to high temperature, physiological disorder of horticultural crops will be more pronounced eg. Spongy tissue of mango, fruit cracking of litchi, flower and fruit abscission in solanaceous vegetables, etc. Air pollution also significantly decreased the yield of several horticultural crops and increases the intensity of certain physiological disorder like black tip of mango. Hence there is a need to protect these valuable crops for sustainability against the climate change scenario. 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 greenhouse 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 natural resources will be the main strategies to meet this challenge.

Keywords: Climate, disorder, horticultural crop, India, yield.

Introduction: 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. It is estimated that all the horticulture crops put together cover nearly 11.6 million hectares area with an annual production of 91 million tonnes. Though, these crops occupy hardly 8% of the cropped area in India, with approximately 30% contribution in agricultural GDP.

Export of medicinal plants, fruits and vegetables have also exhibited rising trend. 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 and it provide the employment opportunities for the rural population. 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 China.

However, per capita consumption of fruits and vegetables in India is only around 46kg and 130g against a minimum of about 92g and 300g respectively recommended by Indian Council of Medical Research. 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 1.40C and 5.80C, 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. 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 have packages to manage abiotic stresses. 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.

Consequences: 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. He also pointed out that climatic changes could lead to major food security issues for a country like India.

Climate Change and Impact on Fruit Crops: India is the second largest producer of Fruits after China, with a production of 81.20 million tonnes of fruits from an area of 4.02 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. Specific chilling requirements of pome and stone fruits will be affected hence dormancy breaking will be earlier. 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 monooxide and fluoride. Leaf production increases by one leaf per month for every 3.3 to 3.7 oC rise in minimum or mean temperature from 10-20 oC or 13.5 to 25 oC respectively. Higher temperature (31-32 oC), 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 oC 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.

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.

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.

Climate change and impact 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 et al. 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). Most of the vegetable crops are highly sensitive to flooding and genetic variation with respect to this character is limited. Flooded crops especially in tomato plants accumulate endogenous ethylene that causes damage to the plants (Drew 1979). Under low oxygen levels stimulate an increased production of an ethylene precursor, 1-aminocyclopropane-1-carboxylic acid (ACC), in the roots. The severity of flooding symptoms increases with rising temperatures; rapid wilting and death of tomato plants is usually observed following a short period of flooding at high temperatures (Kuo et al. 1982). 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 Raphanussativus. 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 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 0C) and lead to reduction in flower size. Flowers do not open up fully in tropical orchids wherever temperatures below 15 0C. High temperature leads to flower bud drop and unmarketable spikes in tropical orchids when temperature remains > 35 0C.

Effect 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 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.

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 (15-200C) coupled with moderate dew during night for profuse flowering. High temperature (>34.4 0C) 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 up to 50 to 65%.

Effect 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.

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.

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