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Impact of Climate Change on Horticultural Crops

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Climate change means a long-term shifts in temperatures and weather patterns. These changes may be natural aur due to human activities. Since 1800s, human activities have been the main cause of climate change, primarily due to burning fossil fuels like coal, oil and gas. Global mean temperatures increased by 0.74˚C during last 100 years and best estimates predict that to increase global annual mean temperatures in the range of 1.8-4˚C during the year 2100; resulted to increase variability in rainfall and enhance frequency of extreme weather events such as heat waves, cold waves, droughts and floods. According to IPCC report it has been projected that; there is a probability of 10–40 % loss in crop production in India by 2080-2100 due to global warming. Quality and yield of the any crop is only possible through its optimum climatic requirements. The shifted climatic parameters affect the crop physiology, floral biology, biotic stresses like disease-pest incidence etc. and ultimately resulted to the reduction of yield and quality of horticultural crops. Unexpected change in climate adversely affects the fruit production, blossoming, pollination, fruit quality, yield and occurrence of different diseases and pests.

Impact on fruit crops

Weather condition during flowering and pollination determine the production quantity and quality. Mild winter temperature followed by warmer spring advanced bud burst exposing bud to frost damage in almond and apricot. In mango, low temperature (4-11°C), high relative humidity and cloudy weather in January delayed panicle emergence, low temperature during inflorescence development reduce number of perfect flowers. In citrus, untimely winter rains promotes vegetative flushes instead of flowering flushes, while dry spell during flower emergence and fruit set affect initation and pest incidence(Psylla). Apple productivity declined upto 1500m msl to the tune of 40-50 per cent due to warmer climate resulting in lack of chilling requirement during winters and warmer summers in lower elevations resulting into shifting of apple to higher elevations (2700m msl). Although increased CO_2 concentrations has positive impact in some fruit crops. Plants with C_3 photosynthetic metabolism benefit due to increased CO_2 concentrations and will become able to accumulate more biomass. Controlled environment studies indicate that elevated CO_2 at 550ppm improved the bulb size and yield of onion. CO_2 elevated at 550-700 ppm increased the growth of coconut seedling by 20-30%.

Temperature change include rise in temperature and cold waves. Cold waves have shown significant impact on crop production in northern India. Cold waves during Dec2002-jan2003, cause a considerable damage to mango, guava, papaya.(Samra and Singh, 2003). Even though elvated CO_2 has positive impact, these may be nullified by increased temperature and less water availability decreased the production under current level of management. In black pepper, it was observed that increased rainfall during dec- jan decrease the productivity while march – April rainfall increased the productivity. Pollination will be

affected adversely because of the higher temperature. Abortions of flower and fruit drop will occur frequently at extremely higher temperatures that usually result in reduction in fruit quality. High temperatures also reduce colour development. Incidence of several physiological disorder of fruit crop more pronounced e.g. Spongy tissue of mango, fruit cracking, black spot in custard apple, etc. Specific chilling requirements of pome and stone fruits will be affected hence dormancy breaking will be earlier. Optimal disease development occurs at 10-31°C and 60-90 per cent RH.

Name of Fruit Crops	Effect of High Temperature
Apple	Sunburn
Apple cv. Jonagold	Bitterpit
Apricot	Reduction in the no. of buds, flowers and fruits
Avocado	Reduced fruit set
Cherry	Accelerated pollen tube growth
Citrus	Poor colour development
Mango	Spongy tissues and fruit cracking
Pineapple	Sun Scald

Effect of low temperature on fruit crops

Name of Fruit Crops	Effect of low Temperature
Almond	Pollination & fertilization is highly reduced
Aonla	oozing of water from fruits
Banana	Below 10°C leads to impedance of inflorescence and malformation of bunches.
Ber	fruits are shrivelled, brown and turn black
Citrus	Drying up of fruits and twigs
Mango	Floral induction
Pomegranate	Hardening of fruits

Effect of It is reported that high humidity (85-90 per cent), moderate temperatures (maximum temperature of 25-26°C and minimum of 18-20°C) provided a good condition for the initiation of disease (Chhata *et al.*, 2006).

- **Rainfall**: Pre-monsoon showers destroy the complete crops of fruits like grapes and dates. Rain during flowering wash out the pollen from the stigma of flower resulted in poor or no fruit set. Mango production loss 80-90 per cent was reported in Gujarat due to unseasonal rain followed heavy dew attack during the blossoming season; which reduced fruit set, increased fruit drop at pea stage and also increased the heavy incidence of sooty mould and powdery mildew in mango (Varu *et al*., 2015).
- **Effect of Relative Humidity:** Fluctuation in relative humidity can cause the poor fruit set and an excessive drop of the fruits in oranges, mandarins and most of the subtropical and temperate fruit crops. Low and high humidity affects fruit set as it may cause poor pollen germination owing to drying or desiccation of stigmatic fluid. The intensity of relative humidity was also found higher resulted in the higher infestation of mango hopper and powdery mildew.
- **Effect of Frost:** Spring frosts are primarily harmful to the plants in a temperate climate that can destroy the blossoms thereby affecting the fruit-set. Damage caused to the plant parts near the ground level since it is the coldest place. The bark of the young trees is killed and cracked open and the inner-sap carrying tissues are shattered through freezing.

- **Effect of Hails:** Very harmful if it occurs at any time between flowering and fruit development stage. In temperate fruit orchards, hail destroys all the flower buds and injures almost all the developing fruits. On fruits, there is the development of ugly spots.
- **CO_2:** Rising distinct CO_2 level and climate change may also influence secondarily on crops through effects on pests and disease. Indications suggest that pests, such as aphids and weevil larvae, respond positively to elevated CO_2 and changing climatic parameters also increased the threat of new incursion.
- **Effect on different fruit crops:** In mango high humidity, rainfall and frost during flowering are harmful. Water stress increases fruit drop incidence. Early flowering under the subtropics causes low fruit set due to prevailing low night temperatures. The high temperature in combination with low humidity and high winds affects the growth of the trees adversely. Dry weather before blossoming is conducive for prolific flowering. A Higher temperature during fruit development hastens fruit maturity and improves fruit size and quality. When temperatures exceed 35°C may cause sun burning when fruits are in the maturity stage. While in hot and dry climate reduce the risk of fungal diseases like anthracnose and powdery mildew in mango because the sunlight, low humidity and temperature extremes (below 18°C or greater than 35°C) rapidly inactivate spores (Alphonso *et al.*, 2014). Air pollution also significantly decreased the yield of many fruit crop and increase of certain physiological disorders like black tip of mango.

- The young plants of litchi require protection from frost and hot desiccating winds otherwise their growth and survival is affected. Bearing litchi trees are affected by hot winds causing fruit skin cracking and sunburn. The observed temperature trends in the region of litchi production (Bihar) showed a general increase in temperature in the order of 2-3 °C during the base period of 50 years. The occurrence of physiological disorders and reappearance of pest are very much dependent on the temperature and humidity variations in the atmosphere.
- It has been observed that red colour development on the peel of guava requires cool nights during fruit maturation. Varieties like Apple Colour, which have attractive apple skin colour under sub-tropical conditions of North India, have red spots on the skin under tropical South Indian conditions.
- In tropical areas, due to high respiration rates at high temperature, citrus fruit mature quickly and do not have enough time to accumulate high TSS, and acidity declines rapidly so that the soluble solids/acid ratio increases sharply, and the fruit quickly become insipid and dry. Citrus is grown from sea level up to an altitude of 2100 m but for optimal growth, a temperature range from 2° to 30 °C is ideal. A long period below 0 °C injurious to the trees and growth diminishes below 13°C. However, individual species and varieties decrease in susceptibility to low temperatures in the following sequence: grapefruit, sweet orange, mandarin, lemon/lime and trifoliate orange.
- In papaya, higher temperatures have resulted in flower drops in female and hermaphrodite plants as well as sex changes in hermaphrodite and male plants. The promotion of stigma and stamen sterility in papaya is mainly because of higher temperatures. It has also been noticed that if flowering takes place under extremely low temperature conditions, flower drop is quite common.
- In grapes, degree-days are important in determining the timing of various phenological events where a temperature regime of 10°C and temperatures between 28-32°C are most congenial. Downy mildew is found worldwide wherever grapes are grown, occurring primarily where warm, humid conditions exist during the growing season. All common cultivated and wild species of the grape as well as a few hosts outside the *vitis* species are susceptible to this disease (Pearson and Goheen, 1988). Unseasonal rains coupled with

higher temperatures during vegetative phases in grapes will result in damage due to this disease.

- Lychee and longan require a warm sub-tropical to tropical climate that is cool but also frost-free or with only very slight winter frosts not below -4°C, and with high summer heat, rainfall, and humidity. Like the lychee, longan is adapted to a sub-tropical environment with warm, humid summers and cool, dry winters. Nevertheless, it does not tolerate temperatures below 0°C, and temperatures of -2 to -3°C can cause severe damage or death to young trees. Rambutan is adapted to warm tropical climates, around 22–30 ° C, and is sensitive to temperatures below 10°C. It is grown commercially within 12–15°C latitude of the equator.
- Sharma *et al.* (2013) gathered the meteorological data gathered from RHRS for the period 2001-2015, years like 2001, 2005, 2006 and 2011 showed a much lesser yield of Royal Delicious variety due to the warmer climate. In 2004, excessive rainfall destroyed maximum plants of Royal Delicious. As per the annual average temperature data, there is an annual increase of annual temperature with a difference of 0.84°C with 21.10°C in 2008 to 21.03°C in 2009. 2004 received unexpected rainfall and 2014 experienced severe drought, which declined the production. In 2011, productivity was nil because of pest attacks on the majority of apple plants. Researchers at DOH, Mashobra also reported that winter temperatures and precipitation, especially in the form of snow, are critical for inducing dormancy, bud break and ensuring flowering in apples.
- Less than 1,000 chilling hours, results in a poor fruit set which consequently leads to poor yield. Also, trend analysis indicated that snowfall is decreasing in the study area, which finds the support of observation made by researchers in 2014, who reported the decrease in snowfall at the rate of 82.7 mm/annum in Himachal Pradesh. Thus, because of the unsuitable climate, the apple cultivation area is shifting to higher elevation, which is abruptly affecting the production trend (Chand *et al.*, 2016) did trend analysis of last five years of Kullu valley and predicted that the climatic conditions for apple cultivation would be unfavorable in coming years due to reduced chill units in the mid-hill sub-humid zone of valley as a result of the increase in surface air temperature. This may lead to a shift in apple belt to the higher altitude.
- Through a questionnaire survey by Basannagari *et al*. (2013) at low hills, 72 per cent of farmers believed that the increase in temperature was responsible for the decline in fruit size and so that the quality. At mid hills apple scab and at low hills pest attack on apple crops are considered as the indicators of climate change. Along the altitudinal gradient, the majority of respondents reported that there was an increase in atmospheric temperature. About 24 per cent of farmers at low hills perceived hailstorm as the major deterrent for apple farming whereas 35 per cent farmers at high hills and 30 per cent at mid hills perceived frost as a major cause for damaging apple farming. The growers reported many indicators of climate change that impact apple farming along with the altitudinal inclination.
- In conclusion, particularly climate-sensitive crops may be significantly impacted by expected climate change. Early and delayed flowering are expected to be a defining property of fruit production, effecting fruit-bud differentiation. Particularly, changes in precipitation patterns will have an impact on most locations, increasing the danger of drought. Under this scenario, the effects would be severe for the regions that produce fruit crops. The hazards of abnormal blooming, fruit set, and reduced yield will mostly affect well-known traditional fruit growing regions. There is also a risk that untimely rains may degrade fruit quality and lead to a build up of disease and pests. Since fruit crops need to be planted as soon as possible, it would be ideal to gather multiple locational datasets on the phenology of trees along with meteorological records. For the purpose of improving

our capacity to adapt to climate change, more research should be conducted in breeding, photosynthesis, biological nitrogen fixation, stress resistance, protected horticulture, and precision horticulture.

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