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Impact of Climate Change on Fruit Crops

*Dr. N.V.S. Supriya

Dr.YSR Horticultural University, Andhra Pradesh, India

*Corresponding Author's email: supriyanedunuri29@gmail.com

Climate plays a significant role in plant growth and productivity. The term “Climate Change” commonly refers to influences on climate resulting from human practices. An increase in the concentration of greenhouse gases in the atmosphere like carbon dioxide, nitrous oxide, ozone and methane may cause an impact in terms of increased temperature, more demand for water and an increase in biotic and abiotic stresses resulting largely from the burning of fossil fuels and deforestation, have led to an observed and projected warming of the earth known as the greenhouse effect. It has a direct impact on agriculture and horticulture. Due to climate change, low production of horticultural crops is featured. Recent climate changes have had widespread impacts on human and natural systems. The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85°C (0.65 to 1.06°C) over the period 1880 to 2012, for which multiple independently produced datasets exist. The total increase between the average of the 1850–1900 period and the 2003–2012 period is 0.78°C (0.72 to 0.85°C), based on the single longest dataset available.

Climate Change Implications in Fruit Crops

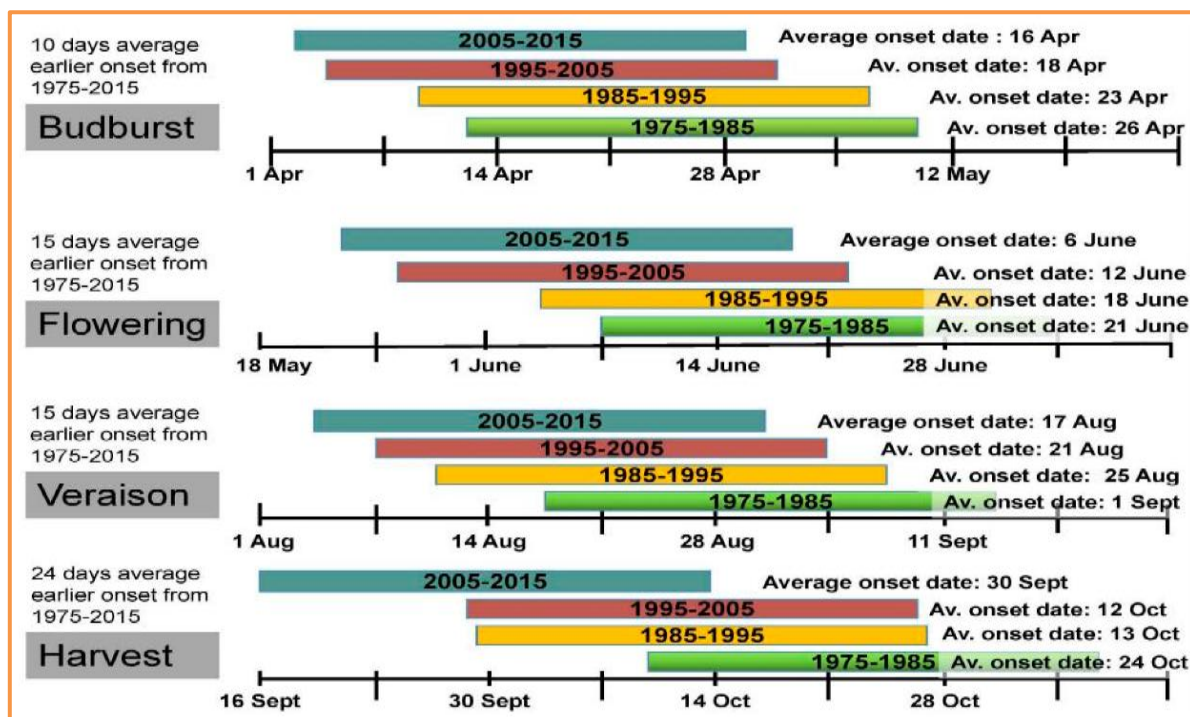
- Given that long generation species (perennial trees, shrubs, and herbs) would be less able to respond to new selective pressures than short generation species, fruit crops need to get special attention in the case of climate change. (Rosenheim *et al.* , 1991).
- In comparison to annuals, developing a new variety in fruit crops takes 15 to 20 years, making it more difficult for it to compete with obstacles brought on by climate change.
- Fruit crops are challenging to re-establish since they are high value crops that produce quality yield with increased productivity and necessitate the utmost caution in a changing climatic environment.
- Production of fruit crops is significantly impacted by climate, an important environmental variable.
- Poor fruit quality and low fruit production were the results of changes to plant physical characteristics like vigour, canopy development, and reproductive traits like fruiting ability and reduction in fruit size, as well as quality characteristics like less colour development, low juice content, decreased shelflife, and higher pest attack(Jangra*et al.*, 2013).
- The ability of temperate crops to adapt to sudden changes in the weather at a certain time of the growing season in any historically inhabited areas of temperate crops is at risk, and this could result in serious production issues in the near future (Ameglio *et al.*, 2004)
- In terms of the models used to predict how crops will respond to a changing climate, currently there are more than two dozen crop models available.
- The majority of these models consider crop response to only one climatic variable, such as CO₂ concentrations, temperature, or water stress, and they all generally agree on the general direction of the altered response but disagree on the magnitude of the changes predicted for the future.

- However, as was already indicated, the majorities of these techniques were developed for annual crops or were only tested on a few crops (Hoogenboom *et al.*, 2018).
- Due to anticipated changes in temperature and rainfall, changes in enterprise structure and location are likely to have an impact on tropical fruits and regions. In a changing climate, increased irrigation demand as well as altered irrigation scheme efficiency and water supply are likely to be important concerns for tropical fruit.
- The spread of current pests, illnesses, and weeds, as well as the increased threat of invasions into new crops, as well as the incidence of minor pests, diseases, and physiological conditions including sunburn, fruit cracking, and tipburn (Kumar *et al.*, 2007).
- In temperate fruit species, adequate cooling hours are crucial for healthy vegetative growth and fruiting. In temperate fruit crops, insufficient chilling hours results in inconsistent bud break and fruiting (Viti *et al.*, 2010).
- According to numerous recent modelling attempts that include long-term temperature measurements, a large portion of the recent trend of global warming can be linked to increasing minimum temperatures, which have augmented at a quicker rate than mean or maximum temperatures (Lobell *et al.*, 2007).
- Since their production depends on consistently cold temperatures during the growing season, perennial fruit trees are particularly susceptible to climate change.

Impact of Climate Change on Phenology of Fruit Crops

The shift in the time of plant growth activity, or change in phenology, is one of the well-known impacts of climate change. Fruit trees' vegetative and reproductive stages were altered due to climate change. Flowering is a critical stage in fruit development that has an effect on production and productivity. The flower primordia in pome fruits may totally or partially abscise in mild winters, (Brown *et al.*, 1952) producing smaller flower bud clusters that resemble leafy spurs. Climate change has resulted in alterations in flowering, fruiting, and eventually yield. The absence of early cold in December and January has a detrimental impact on the amount of chilling requirement. (Sharma, 2012) In apple, lack of chilling time led to incomplete blossoms and poor fruit set. (Jackson *et al.*, 1980) The blossoming and subsequently fruit set were both qualitatively and quantitatively affected by chilling hours. An increase of 0.45°C/decade (1973–2009) in early spring temperature led to an advance in apple and pear blooming by 1.6 days/decade. At various locations around the world, the following crops also had similar outcomes. In Alsace, France, an increase in the average growing temperature of 2–3°C (1964–2009) accelerated flowering, veraison, and harvest by 13–19 days in grape. Veraison for the cultivars "Riesling" and "Gewurtztraminer" will be advanced by up to 23 days by 2100. The peak flowering date of the cherry tree has shifted to early by 5.5 days in the past 25 years due to temperature fluctuations in February and March. There has been a 1.8°C increase in temperature during the past 25 years. Insufficient chilling requirements during warm seasons cause some phenological disturbances, including late flowering, prolonged flowering times, and a longer time between flowering and harvest in apple. A substantial correlation found between flowering progress and changes in maximum and minimum temperature over time in several sites throughout Iran (Kerman, Shiraz).²⁰ In citrus fruits, it was discovered that flowering advances at rates of 3.15–3.39 days/°C for Kerman and 4.3–4.47 days/°C for Shiraz. In Junagadh, India, flowering was delayed in the majority of mango varieties due to temperatures that were over the ideal day/night temperature range and in part because of cloudy weather. After flower initiation, hermaphrodite flowers were more closely associated with greater temperatures. Undeveloped pistils were a result of the warm (15.9°C) temperature, which is 3–5°C higher than typical.





Phenological shifts based on average onset dates for bud break, flowering, veraison and harvest of four grapevine varieties (“Pinot Gris”, “Pinot Noir”, “Riesling” and “Muller Thurgau”) grown in Hainfeld (Southwest Germany) from 1975 to 2015. (Venioset *et al.*, 2017)

Impact of Climate Change on Fruit Crop's Physiology

TEMPERATURE EFFECT

Temperature regulates the physiological functions of the plants. Imbalanced temperatures causes to following impacts. viz.,

1. Heat stress
2. Inadequate chilling for temperate crops
3. Disruption in pollination activity.

Heat stress increases evaporation, which leads to stomatal closure and a reduced influx of CO₂, which ultimately drives respiration and reduces photosynthesis.

Mango

- Mango has a vegetative tendency and when temperature rises it bears more number of leaves thus impacting the phenology of flowering.
- It may be noted that the hermaphrodite flowers (having both stamen and carpel) percentage in late emerging panicles was higher which also coincided with extreme temperatures (Balogoun *et al.*, 2016).
- In bearing or non-bearing trees of mango, scorching of leaves and the dying of twigs are the main symptoms of heat stroke.
- In mango, the major effects observed during climate change were multiplication of reproductive flushes, early flowering or delayed flowering, poor fruit set, reproductive buds transformation into vegetative ones, changes in the fruit maturity *etc* (Rajan *et al.*, 2011).

Banana

- In general, higher temperature of 31-32 °C increases the maturity rate in banana plant thus shortens the period of bunches development (Turner *et al.*, 2007).
- High temperature of more than 38 °C cause choking of bunches in banana (Stover, 1972).
- In Cavendish bananas, the development of the golden yellow color on leaves at high temperatures (Friend, 1981).

Grape

- Although the grape originated in temperate regions, advances in production method have enabled it to adjust to subtropical and tropical region. Availability of growing degree-

days (GDD)/temperature under climate change will lead to speeding up of the phenological processes (Wolfe *et al.*, 2005; Webb *et al.*, 2007).

- In grape vines, the development of **anthocyanin pigment is influenced by the day and night (15-20 °C)** temperatures with high variation.
- Extreme temperatures for prolonged periods in grapes usually **delays fruit ripening and decreases quality of fruit**(Kadir, 2005). Temperature fluctuations lead to changes in stages of growth and ultimately the maturation phase of the grapes. At the period of fruit growth, fruit firmness, TSS and dry weight percentage were negatively related with temperature and it also differ with cultivars (Hoppula *et al.*, 2006)
- No. of cluster/shoots increases with the increase in temperature but number of flower/cluster get reduced (Subedi, 2019) .

Papaya

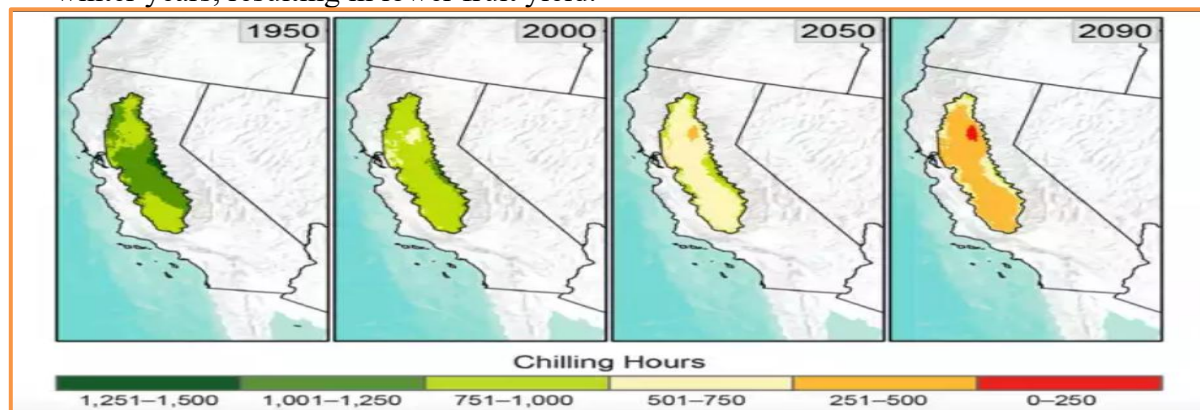
- Higher temperatures in papaya led to flower drop in female and hermaphrodite plants and also responsible for changes in sex in hermaphrodite plants.
- If flowering occurs under extremely low temperatures, flower drops in papaya are relatively normal (Reddy *et al.*, 2017) .

LOW TEMPERATURE

- Horticultural crops suffer a 10-100 percent return loss which depends on the crops and varieties because of the extremely cold waves (Hazarika, 2013).
- Potential flower buds have deeper dormancy than vegetative buds and the first stages of flower initiation seem to occur before the winter rest period (Reddy *et al.*, 2017).
- Inadequate chills can reduce pollination for cross-pollinated fruits such as pistachios and walnuts and thus reduces the crop yields.
- Optimum temperature in temperate fruits such as plum, apples, cherry, pears etc. for pollination and fertilization is between 20° and 25 °C. During pollination in USA in sour cherry conditions like foggy, rainy or low temperatures were found to have a negative impact (Haokip *et al.*, 2020).
- In longan fruit, overwinter develops problems like severe fruit drop, reduction in fruit size, and fruit cracking. In the young fruit phase, temperatures of less than 15°C reduce the potential and final size of fruit growth. Stressful colds or sudden changes in temperature cause severe fruit drop. Cold or dry weather during the young fruit stage is linked to extreme fruit cracking (Yang *et al.*, 2010).
- The low temperature in the case of mandarins has dual effects, inducing flowering as well as breaking bud dormancy.

Inadequate chilling for temperate crops

- According to National Climate Assessment 2014, chilling hours will decrease by 30 to 60 % by 2050 and by up to 80 % by 2100. The In peach cultivars, flowering, fruit set, yield and quality all were proved to be significantly influenced by warmer climatic conditions. Due to lack of chilling, peach tree develop irregular patterns of phonological stages including late flowering and prolonged flowering period. These traits are directly associated with chill accumulation in stone fruit species. Flower abortion occurs in warm winter years, resulting in lower fruit yield.



Carbon dioxide effect

- ✓ Increased CO₂ concentration affects a plant's physiological state. It performs a key role in photosynthesis, which produces the biomass of the plant. However, a rise in temperature and a shift in rainfall pattern may cancel out the positive effects.
- ✓ Increasing net photosynthetic rate in grapes while decreasing stomatal conductance in response to increasing CO₂ improves innate water use efficiency in Portugal (Pereira *et al.*, 2009) In general, they discovered that raising the atmospheric CO₂ level enhances the yield regardless of any good or negative impacts on grape maturity.
- ✓ Sour orange trees were particularly sensitive to the higher CO₂ levels even though they were well into middle-age reproductive maturity (17 years). At the time of final harvest, the root biomass, leaf biomass, branch biomass, fruit biomass and total biomass was significantly higher in the trees with CO₂ enrichment (350-650 ppm of CO₂) than that of the trees grown in ambient conditions (Kimball *et al.*, 2007).

Climate Change Impact on Quality

- ✓ Fruits quality parameters are of essential concern in order to fetch a lucrative price in export market.
- ✓ Changing climatic scenarios are impacting the ideal situations of proper pigmentation and secondary metabolites production which are of integral necessity to produce quality fruits.
- ✓ Temperature variability might also synergist to ideal conditions based on growing areas. Higher antioxidant activity was reported in 'Kent' strawberries under warm days (25°C) & warm nights (18–22°C).
- ✓ Changes in climate have also been recorded to have negative consequences such as earlier ripening by the end of this century in California which may result in lower quality grapes in the region.
- ✓ Incidental heat shocks (over 35°C) caused the loss of 50 % of the berries due to browning and berry burn.

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