Successive waves of climate change taking toll on ecosystems across the world

OKESH CHHABRA , Department of PDP , Graphic Era Hill University, Dehradun, Uttarakhand, India 248002,

Abstract

"a change that is ascribed directly or indirectly to human activity that modifies the chemical makeup of the world's atmosphere and that is in addition to natural climatic variability seen over similar time periods," as defined by the United Nations Framework Convention on Climate Change (UNFCCC). Temperature rise, precipitation shifts, and more frequent occurrences of heat waves, cold snaps, frosty days, droughts, floods, and other severe weather events are all predicted as a result of climate change. Climate change poses a significant threat to several aspects of plant life, including vegetative development, blooming, fruiting, and the quality of fruit. Crop production is predicted to decrease as a result of two primary aspects of climate change: more variable rainfall patterns and unexpected high temperature spells.

Keywords: climate change, composition, global atmosphere, vegetative growth, temperature, cold waves, frost days, erratic rainfall

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Introduction

One of the many unfavourable consequences of climate change is the alteration of natural vegetation and ecosystem. Phenological shifts have been well reported as one of climate change's most pervasive consequences. As a result of climate change, the ratio of vegetative to reproductive stages is shifting.

"Important pollinator species, such as bees, moths, and butterflies", are suffering drastic declines in population size, geographic range, and pollination activities, according to scientific studies. "Many physiological diseases, such as spongy tissue and black tip in mangoes, cracking of fruit, granulation in citrus, etc., were more common as temperatures rose during fruit development." As a result of climate change, the ecology of certain pests that feed on specific crops is shifting. Rising temperatures and humidity levels are creating an alarming situation with fruit flies in guava, calamansi, citrus, etc.

"Warm and humid conditions are also favorable for pests like:

1. Beetles
2. Bugs
3. Other sucking pests
4. Diseases like mildew, blight, etc"

"The key to keeping yields stable should be the development of new cultivars with greater yield potential and resilience to many stressors (drought, flood, salt)." One goal of breeding projects should be to increase heat stress resistance in the germplasm of economically significant tropical and subtropical fruit crops. Some approaches to reducing the effects of climate change include developing location-specific conservation of water and soil models, following a protocol for organic agriculture, engaging in conservation horticulture, creating rootstocks that are resistant to biotic and abiotic stresses, and so on.

Impacts of Climate Change on Various Aspects of Cultivation

The effects of climate change may be seen in many forms. They are elaborated upon as follows:

(i) Impact on dormancy and chilling requirement : To prevent damage to its delicate tissues from unfavourable environmental conditions, plants employ the dormancy process. Several temperate fruit crops may need to make adjustments to their adaptation in the near future as a result of fast climate change, and this might cause serious production issues. For many fruit and nut trees to be grown commercially, a certain amount of winter chilling is necessary. This amount of chilling is different for each variety of tree. On temperate fruit trees, the bud-break and growth rhythm is disrupted when cooling is lacking, as under mild winter circumstances. Overwinter cold needs of temperate tree fruits may change as a result of climate change, necessitating the introduction of new cultivars or species. This procedure causes harvesting crops of varied sizes and stages of ripeness, which may drastically lower production and quality. The chilling impact necessary for the blossoming of many horticultural crops, such apples, cherries, etc., will be diminished when the Himalayan ice cover melts. There are now extremely few areas with safe chilling levels for cultivars with chilling needs exceeding 1000 chilling hours, such as apples, cherries, and pears, and modelling findings estimate that nearly none will remain by mid-century.

(ii) Impact on pollination

Reduced numbers of pollinating insects may be directly attributed to the current climate crisis. A lack of fertilisation, and thus, a failure to set fruit, occurs when temperatures are either too cold or too hot. When harvesting cross-pollinated fruits like walnuts and pistachios, inadequate cooling may diminish pollination and thus lower crop yields. Temperatures between 20 and 25 °C are ideal for pollination and fertilisation of temperate fruits such as apple, pear, plum, cherry, etc. Pollination of sour cherries in the USA is known to be negatively impacted by cold temperatures and wet or foggy weather.

(iii) Impact on pest and disease incidence : Modifying host resistance and the physiology of host-pathogen interactions, climate change affects the timing and progression of pathogen growth. "Climate change lead to:

- Changes in geographical distribution
- Changes in population growth rates
- Increased overwintering
- Increase in the number of generation
- Extension of developmental seasons
- Changes in crop-pest synchrony of phenology
    - Changes in interspecific interactions of insects
    - Increased risk of invasion by migrant pests" (Parmesan, 2007)

(iv) Impact on Fruit Quality: "A rise in temperature of 0.7-1.0 °C has the potential to alter the region now suited for the high-quality production of Dashehari or Alphonso kinds of mango."
Rise in temperature by 0.2 °C may result into dramatic reduction areas suitable for development of red colour on guava (Rajan, 2008).
Mandarin exposed to direct sunlight (35 °C) is 2.5 times firmer than those on the shaded side (20 °C).

(v) Impact on Post-harvest quality : According to Moretti et al., temperature variation can directly affect crop photosynthesis, and a rise in global temperature can be expected to have significant impact on the postharvest quality by altering important quality parameters such as:

- sugars synthesis
- Peel colour
- Insistence
- Antioxidant compounds

Grapes had higher sugar content and lower levels of tartaric acid when grown under high temperatures.

Steps towards Mitigating the Impact of Climate Change

(i) Dormancy avoidance: The methods which can prevent the plants from entering into dormancy condition helps in bud burst without requiring chilling temperature. Griesbach observed that dormancy can be induced artificially by defoliating the trees just after the harvesting. The defoliation of the trees enables them to resume their annual crop cycle without chilling requirements and this type of practice has made the production of temperate fruits possible in countries like India and Kenya. Bud break in case of apple, Japanese plum,apricot, and pear can be broken artificially by a sequence of treatment like desiccating the trees followed by manual defoliation of the tree, renewed irrigation, and rest-breaking treatments.

(ii) Manipulation of the chilling requirement of temperate fruit trees: Once the tree cultivars are selected and planted in the orchard, it is required that they remain in production for decades. The need to anticipate and adapt to climatic changes is very much urgent for growers of tree crops.
Even the already established commercial varieties of fruits might perform poorly in an unpredictable manner due to

aberration of climate. This has led to the development of cultural, mechanical and chemical practices to alleviate the problem associated with insufficient chilling.

(iii) Low chill cultivars: This is the most feasible solution to the problem of insufficient chilling. However, it is very difficult to breed low chill cultivars. Modern biotechnological aspects in mapping the genetic determinism of chilling are required to boost the breeding process with a view to develop appropriate cultivars for all major fruits within a reasonable time span.

Re-evaluation of the fruit varieties as per the indicated climate changes is imperative for planning a new orchard. Introduction and adaptation of low chilling cultivars of crops like apple, peach, pear and plum in certain areas of lower hills and North Indian plains where they could be grown commercially. The low chill cultivars of some temperate fruits are listed below (Rai et al.).

(iv) Heat treatment: In temperate areas, temperature is often believed to be the most influential element on the phonological stages of fruit trees. Heat promotes biological changes, which in turn lengthen the growth season and affect the phonological stages of individual plants. Some types of plants have been discovered to have heat shock proteins (HSPs), and in some instances, the HSP levels even increased after being chilled. In order to induce bud break in the floral buds of Japanese Pear 'Nijisseiki,' researchers Tamura et al. observed that trees accumulated nine heat shock proteins after being subjected to a short-term high temperature treatment (45 °C for 4 hours). A similar effect was seen when pear plants were subjected to 45 °C water for three hours, prompting bud explosion. During six hours on a single day or over the course of two days in July, October, and November, Chandler demonstrated that apple trees will bud burst if exposed to temperatures between 44 and 46 degrees Celsius.

(v) Evaporative cooling: Cooling effect of the buds during the endodormancy stage is another method for inducing bud burst. In mild winters, evaporative cooling may increase the number of cooling hours needed for successful bud burst by lowering the bud temperature. The flowering of 'Flordagold' peaches and 'Sungold' nectarines was sped up by seven days when they were sprinkled with water and provide cooling effect during the rest time. Dormex and evaporative cooling using intermittent overhead sprinklers were shown to have a synergistic impact on budbreak and yield, as reported by Allan et al. Uzun and Caglar used evaporative cooling, in which water was sprinkled on fruit buds to chill them, to postpone flowering in pistachio. Israel has used overhead watering to effectively chill buds during the day's warmest hours.

(vi) Chemically induced violation of the cooling-off period: Deciduous fruits and nut trees often have delayed and inconsistent blossoming and foliation due to insufficient cooling throughout the winter months. Rest of it may be cracked with the use of chemicals like DNOC oil or cyanamide under the right circumstances. Cutting et al. found that treating 'Granny Smith' apples with hydrogen cyanamide or

DNOC oil accelerated bud-break by 3 and 4 weeks, respectively. Mineral oil (4-6%) with DNBP (dinitro-butyl-phenol) from 0.13% to 0.2% was used on apple trees by Petri, who observed a 40% increase in lateral bud break rate when using Mineral oil (4%).

Conclusions

Future food production is unclear due to global warming and changed precipitation, despite the increasing levels of carbon dioxide in the atmosphere. Future food security may be affected by the current lack of data on the actual effects of pests and illnesses in a hanging climate. “Changes in temperature and precipitation patterns have a negative impact on both crop yield and fruit quality. Climate change will make the situation more worse by reducing plant variety and making once habitable areas uninhabitable”. As climate change is expected to occur in the near future, efforts should be made to adjust the chilling needs of temperate fruit crops in preparation. Adaptation and mitigation strategies should be quantified in a strategy based on strategic scientific evaluation of such risks to global fruit production.

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