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# IMPACT OF CLIMATIC VARIABILITY ON FRUIT CROPS IN HIMACHAL PRADESH

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***Abstract***

*Climate is the long-term average weather. Climate change is a change of climate over comparable period of time that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere. The global mean temperature of the earth's surface has increased by about 0.74°C over last hundred years. 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. Himalayan ecosystem is predominantly sensitive to climate change. Himachal being a Himalayan state is nevertheless playing a major role in sustaining livelihood of many people. In Himachal Pradesh, evidences of global warming could be clearly deciphered by changes like receding snowfall, retreating glaciers and shifting of temperate fruit belt upward (upto 30km), adversely affecting productivity of many temperate crops, shifting and shortening of rabi season, forward and disrupted rainfall pattern. Twenty years ago snowfall was regular phenomenon in hills of Himachal Pradesh but in the last 20 years, only 2-3 instances of snowfall have been recorded. The incidence of pest and diseases with varying fruit crops (papaya, mango or apple) has been observed. It has been recorded that the average maximum temperature rose by 0.58oC from the year of 1963 to 2007, whereas, the average minimum temperature rose by 2.75°C. So, possible measures should be taken to adapt and mitigate with the changing climate of the state.*

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## Introduction

Climate change is one of the most leading environmental problems which is facing the modern world, and directly or ultimately to human action that changes the arrangement of the global atmosphere. The Earth's climate was although relatively stable for the past 10,000 years or so and it has always been changing, mainly due to natural causes such as volcanic activity, ocean currents, continental drifts or earths' tilt. But since the 1900s more rapid changes have been observed because of industrialization. It is widely accepted that human activities are now increasingly influencing changes in the global climate (Pachauri and Reisinger, 2007). Over the last 100 years, the global mean temperature has increased by 0.74°C and atmospheric CO2 concentration has increased from 280 ppm in 1750 to 368 ppm in 2000 (Watson 2001 ). Temperature is projected to increase by 3.4°C and CO2 concentration to increase to 1250 ppm by 2095, accompanied by much greater variability in climate and more extreme weather-related events (Pachauri and Reisinger, 2007). 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. Food production will be particularly sensitive to climate change, because crop yields depend directly on climatic conditions and could lead to food yields being reduced by as much as a third in the tropics and subtropics.

The Himalayan ecosystem is highly vulnerable to the stress caused by increased pressure of population, exploitation of natural resources and other related challenges. Climate change may adversely impact the Himalayan ecosystem due increased temperature, altered precipitation patterns, and drought. In the laps of Himalayas, Himachal Pradesh resides which has high dependency on climate sensitive sectors such as agriculture, horticulture and forest for livelihood. Rural population is dependent on agriculture and natural resources for livelihood. Nearly 63 percent of workers in the State are engaged in agriculture or horticulture for their day to day requirements.

## Impact of Climate Change in Himachal Pradesh

According to UNFCC "Climate change" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The signals of climate change have clearly indicated towards increasing temperature, reducing rainfall and snowfall and shrinking winter season (Bhagatet al., 2007). The agricultural and fruit crops in Himachal Pradesh are mainly dependent upon the snow fed gravity flow channels (kuhls) and fresh snowfall. Bhutiyaniet al. (2007) based on short term analysis observed that in different altitudinal zones in Himachal Pradesh , the rate of increase in maximum temperature at higher altitudes was more than that at the lower altitudes and in last century north western Himalayan region significantly higher than the global average. Therefore effect of climate change on horticulture is likely to increase the socio-economic vulnerability in the state.

There is rise in temperature in the N-W Himalayan Region by about 1.6°C in the last century. Due to climate variability, incidence of pest and disease are more severe. Temperate fruit belt has moved upwards by about 50-100kms. This has opened up new opportunities for high land farmers of Kinnaur and Lahul and Spiti but it also means that existing valleys of temperate fruits and vegetables are no longer the favorites. Farmers in these areas are looking for alternative options. Wheat and potato harvest was advanced by 15-20 days and the flowering of apple was early by 15 days. The optimum temperature for fruit blossom and fruit set is 24oC for apple, whereas state experienced above 26oC for 17 days.

The entire region recorded between 2.10C and 7.90C higher maximum temperature against the normal in March 2004 (Prasad and Rana, 2006). Awasthiet al. (2001) rightly pointed out that that although the production of apple was increasing but the productivity was falling. Based on ICAR recent findings, the apple belt is shifting upwards due to rise in temperature and decrease in chilling period. Due to this reason, the apple area between 1500-1800 msl is decreasing and increasing between 2200-3000 msl. As per study carried out by Verma (2009), in higher altitudes of Shimla Districts, the farmers have already started shifting from high chilling requirement crops to less chilling requirement crops such as kiwi, pomegranate and vegetables etc. Apple size has become less prominent; shape deterioration has been reported in Chamba District. At lower altitudes the shelf life of apple has decreased.Early fruiting in stone fruits due to warm & prolonged summers is recorded in State. Tropical trees are increased in some regions of Mandi as snowfall has declined and now mango crop flourishing well.

## Climatic variables affecting fruit production

### Temperature

Das (2012) stated clearly that "plants can grow only within certain limits of temperature". Global warming stimulates crop growth and, thus, shortens the time of fruit formation, and the number of fruits and seeds within may be reduced by the effects of high temperatures on reproduction, particularly the formation and function of pollen (Orduz-Rodriguez, 2012).

### High temperature

Grape vine temperatures if exceeds 35°C hinder fruit set, in cape gooseberry ≥30°C can inhibit flowering, in mango >35°C reduce the viability of pollen and fruit set (Fischer and Orduz-Rodriguez, 2012). Hot tissues are softer and lose their texture and, hence, resistance to attacks by pathogens and insects-pests; in addition, high temperatures cause the degradation of organic acids required primarily for the respiration of ripe fleshy fruits and make them insipid (Fischer and Orduz-Rodriguez, 2012).

### Low temperature-

Apple, pear, apricot, peaches, cherry or plum demands low temperatures to break bud dormancy. Cold waves during December 2002 – January 2003, caused considerable damage to fruit crops like mango, guava and papaya in India. Oranges develop white crystals clearly visible between the segment membranes due to freezing temperature. These are hesperidin, the principal flavone in citrus fruits, and although their presence sometimes causes alarm, they are completely nontoxic (Grierson and Hayward, 1959).

## Effect of Rainfall

Fruit are very demanding in water throughout plant reproductive stages starting from the flower formation until the filling of the fruit. In these species, water shortage stops growth and development, while heavy rains during flowering, fruit set or maturation are harmful for flowers and recently set fruits (Fischer and Orduz-Rodríguez, 2012). A prolonged rainy season or heavy rain after a long dry period can cause cracking of fleshy fruits, thus, water and nutrition have become of great interest to fruit growers (Fischer and Melgarejo, 2014). Therefore, the soil in orchards must be kept at a constant moisture level, slightly below field capacity, with optimum contents of calcium, boron, potassium and magnesium, maintaining nitrogen fertilization at the low average levels (Gordillo et al., 2004; Fischer, 2005).

## Effect of Wind and Hail

Thunder storms and their destructive winds are expected to become more frequent and severe as our climate changes. Longer hotter summers will generate warmer surface temperatures, causing the air to become more buoyant. Air, laden with moisture from increased.

## Effect of Solar Radiation

The visible solar radiation is essential as a source of energy for photosynthetic activity in plants (Koyama et al., 2012), with its key role as an energy source for biomass production and finally fruit crops yield. The plants would be severely affected in its photosynthetic efficiency when photoinhibition results from alterations in radiation levels or temperature (Rivas, 2008). However, in sensitive plants, prolonged UV-B radiation can prevent photosynthetic activity and plant growth by damaging DNA, proteins, membranes, and lipids (Hideget al., 2013).

## Impact of climate Change on fruit crops

- The extreme weather events of hot and cold wave conditions have been reported to cause considerable damage to many fruit crops. In perennial crops like mango and guava, temperature is reported to have influence on flowering. Mango has vegetative bias, and this becomes stronger with increase in temperature, thus influencing the flowering phenology. The percentage of hermaphrodite flowers was greater in late emerging panicles, which coincided with higher temperatures (Balogounet al. 2016). During peak bloom period, high temperature (35°C) accompanied by low relative humidity (49%) and long sunshine hours resulted in excessive transpiration and dehydration injury to panicles. Leaf scorching and twig dying are common symptoms of heat stroke in bearing and non-bearing mango plants. Major observed effects of climate change on mango include early or delayed flowering, multiple reproductive flushes, variations in fruit maturity, abnormal fruit set and transformation of reproductive buds into vegetative ones (Rajanet al, 2011).

- In guava, there is severe increase in pests and diseases due to hot and humid conditions. Fruit fly in guava is becoming alarming due to hot and humid conditions.
- The crops like peach, plum, which requires low chilling temperature also showing sign of decline in productivity (Hazarika, 2013). High temperature and moisture stress also increase sunburn and cracking in apples, apricot and cherries. Increase in temperature at fruit maturity lead to fruit cracking and burning in litchi (Kumar and Kumar, 2007) and premature ripening of mango. Untimely winter rains promote vegetative flushes in citrus instead of flowering flushes. Dry spell during flower emergence and fruit set affects flower initiation and aggravates incidence of pest (Psylla).
- Recent studies have indicated that in Shimla district at relatively higher altitude orchards have been replaced from high chilling requiring apple cultivars of apple (Royal Delicious) to low-chilling requiring cultivars and other fruit crops like kiwi, pear, peach and plum and vegetables. In mid hills of Shimla district, trend is to shift from apple and potato cultivation totally. It is corroborated by declining trend in snowfall and apple productivity in Himachal Pradesh. The production of apple has fallen from 10.8 to 5.8 tonnes/ ha (Awasthiet al 2001).
- Under climate change conditions there would be changes in availability of growing degree-days (GDD)/temperature leading to hastening of the phenological processes (Wolfe et al. 2005).

- Under conditions of higher temperatures (42oC) vines are not capable of utilizing radiant energy possibly because of degradation of enzymes and chlorophyll exceeds rate of photosynthesis (Kliewer 1968).
- In citrus severe water stress causes reduction in leaf initiation, leaf size gets reduced and leaves become leathery and thick. Root growth is adversely affected by water stress. It may lead to increased rooting depth and higher proportion of feeder roots in citrus. In grape vine, developing water stress reduced inflorescence initiation in conjunction with reduced shoot growth.
- The studies conducted in apple show that, the productivity will continue to decline up to 1500 m msl to the tune of 40-50% due to warmer climate and lack of chilling requirement during winter and warmer summers in lower elevations resulting into shifting of apple production to higher elevation (2700 m msl). Winter snowfall affects flowering. In spring, low fluctuating temperatures during bloom results in poor fruit set while warm temperatures result in desiccation of floral parts. Mild winter temperatures followed by warmer springs advanced bud burst and exposing buds to frost damage in almond and apricot. High temperature and moisture stress increased sunburn and cracking in apples, apricot and cherries (Singh 2010).

## Adaptation

Potential impacts of climate change depend not only on climate per se, but also on the system's ability to adapt to change Adaptation is defined as the adjustment in natural or human systems in response to actual or expected climatic stimuli and their effects, which moderates harm or exploits beneficial opportunity.

## Strategies for adaptation

1. Crop based adaptation through adapting climate-ready crops or rootstock
2. Based on cropping pattern including cropping systems, intercropping, alternative crops, crop diversification and relocation of crops in alternative areas
3. Adaptation based on cultivars/varieties

- Development of tolerant or resistant cultivars/varieties/rootstock against climate change.
- Planting different varieties or crop species

4. Modifying crop management practices
    - Modifying date of planting or date of sowing, adjusting cropping season and off seasonal production & marketing of horticultural crops
    - Using sustainable, customized or liquid fertilizer
    - Tillage practices to improve soil drainage, zero tillage, etc and implementing new or improving existing irrigation systems like drip irrigation.
    - Improvement in crop residue and weed management and changes in land use management practices
    - Efficient use of resources
    - Adopting new farm techniques, resource conserving technologies (e.g. bagging of fruits, fertigation, etc.). The bagging of mango fruits at marble stage with brown paper and scurting bag gave maximum fruit retention (%), while bagging with newspaper bag gave highest fruit weight and fruit of newspaper and brown paper bags are free from spongy tissue. Bagging of pomegranate fruits with pargmen bags was reducing fruit cracking and sunburn physiological disorders.
    - Improved pest and disease management
5. Mulching which conserve the soil moisture, improve soil microclimate, microbial activity and soil health.
6. Use of anti-traspirants like chitosane, kaolin, etc. which reflect the heat radiation from plant parts so they reduce the water losses through transpiration and reduce the temperature of fruit and leaf surface and other chemicals.
7. Wind breaks or shelter belts which modified the microclimate of orchard as well as soil and windbreak also provide shelter for pollinating insects, protect orchard from wind erosion and other natural disaster, etc.
8. Weather forecasting and crop insurance schemes for farmers and Use of GIS

9. Recycling of waste water and solid wastes in agriculture and use water harvesting technologies

## Mitigation

"Climate mitigation means a human intervention to reduce the sources or enhance the sinks of greenhouse gases, which permanently eliminate or reduce the long term risk and hazard of climate change to human life and their properties". The various ways to mitigate climate change through orchard crops are as under.

**Crops and farming system management**

- Improve residue management e.g. avoid biomass burning
- Include nitrogen fixing plants into crop rotations
- Fertilizer, manure and biomass management
- Reduce use and production of synthetic fertilizers
- Avoid leaching and volatilization of N from organic fertilizers during storage and application.
- Improve storage management of manures
- Biogas production (methane capture)
- Improve efficiency of energy-use by increasing fuel efficiency in agricultural machinery, use wind and solar power, minimal or no tillage, etc.
- Fertilizer, manure and biomass management through reduce use and production of synthetic fertilizers, avoid leaching and volatilization of N from fertilizers during storage and application, use slow-releasing fertilizers, Nitrification inhibitors, etc. Dicyandiamide (DCD) anitrification inhibitors Efficiently Mitigating Nitrous Oxide Emission (1342%) Followed By Nimin, coated Cacarbide, neem cake, neem oil and thiosulphate. Whereas, when dicyandiamide applied with organic manures and urea decrease cumulative N2O emission.
- Soil management for increasing soil carbon (%) by using organic fertilizers, reduced tillage, avoid soil compaction, use biochar, cover crops, intercropping and other cropping system.

- ❖ Crop modelling is also an important strategy to combat with climate change

## Conclusion

Global climate changes are likely to exert pressure on fruit production system and may constrain in attainment of future fruit production targets. These changes are natural but its control in our hand through several mitigation measures which reduce the concentration gases in atmosphere which are responsible for climate change and fruit crops have a great in mitigation of these gases through carbon sequestration by photosynthesis. At present, available adaptation strategies can help to reduce negative impact in short term but to a limited extent. We therefore need to urgently take steps to increase our adaptation capacity by increasing research on adaptation, capacity building and changes in polices and implementation of adaptation assessment frameworks that are relevant, robust, and easily operated by all stakeholders, practitioners, policymakers, and scientists.

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