

Review Article

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A Review on Impact of Climate Change on Apple Production and Scope of Diversification in Himachal Pradesh

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ABSTRACT

Climate change is the most profound challenge over the international community in 21st century. It already affects livelihood and health of people worldwide and mostly people under poverty line. A few years ago snowfall was a regular phenomenon but from the past 20 years only 2-3 instances of snowfall are recorded particularly in Himachal Pradesh. There is an average increase in temperature of about 1.5°C till October, whereas, 2-10% reduction in rainfall and 50-100 ppm increase in CO₂ concentration has been observed, that reduce the apple yield. Apple cultivation is an important profession in Himachal Pradesh and temperature variation changes weather parameters hampering the availability of weather factors at critical stages of growth causing decrease in productivity of apple. In apple, there is decrease in yield due to water shortage (80%) and evaporation rate (20%) leads to reduction in chilling hours. This cause shifting of apple belts towards higher hills of Himachal Pradesh as most cultivars require 1000-1600 chilling hours at or below 7°C. Climate change has resulted in a decreasing productivity at some extent of apple crop in recent years.

Keywords

Apple, climate change, diversification, varieties, rootstock

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Introduction

Natural systems, human health and agricultural production have been badly affected by devastating environmental changes (Arunanondchai *et al.*, 2018). A significant change in the weather patterns based on statistical distribution and the change persisting for an extended period of time (typically decades to many years) is referred to as climate change. Climate change

and increasing climatic variability are recently considered a matter of concern worldwide. Due to emission of greenhouse gases to the atmosphere and its affect is more visible on fruit crops because of their perennial nature. This climatic change adversely affect crop physiology, biochemistry, biotic stress like disease pest incidence, which ultimately results in reduction of yield and quality of fruit crops (Rajatiya *et al.*, 2018). Climate change can be caused due to some factors like

biotic or natural process, external forcing, solar radiations received by earth that cause warming up of its surface. Some weather events like floods, droughts, landslides, cold waves, hailstorms and natural calamities adversely affect atmosphere. Climate change may be progressing faster than expected, bringing new environmental conditions for growing horticultural crops (Bisbis *et al.*, 2019). Deforestation is another factor that is responsible for climate change as deforestation increase the incidence of soil erosion by removing forest cover. With the adopt changes in environmental conditions, the harsh impact on plant productivity are progressing in great intensities owing to direct and indirect effect of abiotic stresses (Raza *et al.*, 2019). Emission of dangerous gases especially carbon dioxide are the main factors for greenhouse effect and warmer average global temperatures (Vaughan *et al.*, 2018). The productivity of quality besides aggravate the environmental stress such as increasing temperature, reduced irrigation, water availability, flooding and salinity are affects on crop by climate change. Due to melting of ice in peaks of Himalayas, the production of apple and other horticulture crops which are grown in open are severely affected (Hirpo and Gebeyehu, 2019).

Himachal Pradesh is located between 33°22' and 33°12'N latitude and 75°47' and 79°4' East longitude. In Himachal Pradesh, climate is the most important factor that affects the fruit crop distribution and on the basis of temperature, Himachal Pradesh has 3 main regions *viz.*, temperate, sub temperate and sub tropical. Apple is most commercial crop grown in temperate region of Himachal Pradesh having share of about 48 per cent in area and 76 per cent in production among fruit crops. It contributes 2.8 per cent of total fruit production of country (Department of Horticulture, 2016-17).

Apple mostly require a chilling period of about 1000-1600 hours at or below 7°C along with short days and cool nights that is possible only at higher altitudes (Awasthi *et al.*, 2001). Kullu valley of Himachal Pradesh is known for good quality apples and has regular instances of snowfall but from past few years, there is not regular snowfall resulting in lesser chilling hours. This resulted in replacement of apple orchards with other crops and apple belts are shifted to higher altitudes (Sharma *et al.*, 2013). Apple growth is divided into 4 stages *viz.*, Dormant stage from December-March, Flowering and fruit set stage from April-May, Growth and development stage from June-September and Pre-dormant stage from October-November. Each stage has specific requirements of weather parameters like temperature, rainfall, snowfall, humidity, evaporation etc (Randev, 2009). Climate change will result in increase in water stress, desertification and adverse health effects by spread of infectious diseases due to more heat and many others.

Climate element trends in apple growing regions

Climate change had adversely affected the apple production in these two areas of Himachal Pradesh:

Theog region

Theog is located in district Shimla and is 2200-3250 m above mean sea level and have area from mid hills to high hills and is the southern part of state. This represents 8.8% of total geographical area of Himachal Pradesh. Average mean temperature varies from 7.7°C (in winter) to 20.7°C (in summer) with annual temperature of 15.4°C. Rainfall of the area is about 1100-1533 mm. There is increase in mean temperature of about 1.8°C annually having 2.4°C during rabi season and 1.2°C in kharif season and rainfall trend decrease

during rabi season and increase by 5.1 mm during kharif season due to climate change (Randev, 2009).

Kullu Valley

Kullu valley located in Kullu district representing 1200-2500 m above mean sea level and represent 16.04% of total area of state and contains regions from mid hills to higher hills. Higher hills have snowfall and hence become source of water in Beas. Annual temperature is between 7.9-25.6°C having 12.7°C during rabi season and 23.0°C in kharif season with mean temperature of 17.0°C. Annual rainfall is 1095 mm. Apple is grown in Himachal Pradesh at commercial level. There is increase in temperature by 4.1°C having 5.5°C during rabi season and decrease by 1.7°C during kharif season. The temperature fluctuation coincides with decrease in rainfall trend by 270mm in northern part of Himachal Pradesh having mean temperature below 14°C due to climate change (Randev, 2009).

Diversification in fruit cultivation

Effect of climate change in apple is such that its cultivation is becoming difficult in various regions hence farmers are generally shifting towards other crops options like kiwi, pomegranate and other vegetable crops (Rana *et al.*, 2009).

Apple belt is shifted to higher altitudes of Himachal Pradesh like high hills of Kullu, Kinnaur, Lahaul and Spiti etc. from Kullu valley, Rajgarh area of district Sirmour, Theog and Kotkhai area of district Shimla and some areas of district Solan (Kuniyal, 2012). Climate change has become a universal phenomenon and various strategies should be adopted with regard to diversification for appropriate fruit production (Belsare, 2015).

Climatic factors affecting apple cultivation

Global warming

Global warming has caused greater effect on apple production areas in Himachal Pradesh. The main gasses present in atmosphere have resulted in the change of climate they have increased from earlier concentration such as nitrous oxide (6%), carbon dioxide (76%), and methane (16%). The changing climatic conditions have affected the apple production which has become serious problem for apple producers (IPCC, 2014). Recent reports of 3 years have shown that apple crop is affected by climate change in hilly regions. Change of this climate is clearly visible as the apple cultivation has shifted from lower altitudes to higher altitudes. This has happened due to decrease in chilling units (-3.5 to -17.9) per year in Shimla and lower hills (Kuniyal *et al.*, 2012). Global warming put direct or indirect impact on crop, soil, livestock, and overall yield of plant (Aggarwal, 2008). Studies have shown that yield gradually increased earlier but now has decreased from 10.8 to 5.8 tons per hectare in apple (Askew *et al.*, 2001). The monoculture of delicious varieties is giving poor yield due to effect of climatic changes (Jindal *et al.*, 2001). “Every extra bit of warming matters, especially since warming of 1.5°C or higher increases the risk associated with long lasting or irreversible changes, such as the loss of some ecosystems”, said Hans Otto Portner Co Chair of IPCC working group II.

Supreme weather conditions

Rainfall: Reduction in rainfall by 0.8 mm per year and December-January have shown reduction in amount than past years (Jindal *et al.*, 2001). This reduced amount of rainfall have fluctuated chilling environment required for proper development of apple fruit.

Temperature: The population of pollinators such as honeybees and butterflies had declined due to high temperature at higher hills which has greater impact on apple production. Due to lack of lower temperature, trees fail to enter into bud development and flowering causing potentially death of tree (Aditya *et al.*, 2012). According to recent reports, temperature has increased by 1.5°C which is above the pre industrial level, for detail see Fig.1 (IPCC, 2018).

Snowfall: Depletion of snow cover in lower hills of Himachal has greater impact on fruit bearing conditions. The reduced instances and the change in timing of snowfall had decreased the chilling hours, ultimately resulting in poor quality yield of apple cultivars (Rana, 2010). The temperature in North West Himalayas has increased by 1.6°C in the last century. A gradual decrease in snowfall has been found in Shimla since 1996. It has been observed that seasonal snowfall has decreased by 280 cm over the Pir Panjal and by 440 cm over the Greater Himalayas year by year (IPCC, 2018).

Other climatic factors: Other climatic conditions such as floods increased by 17, 20 and 10 per cent, recorded by Naggar, Anil and Kullu, respectively. Cloud burst have been reported by 17 per cent and irregular hailstorms, warm winds have interrupted with apple development (Singh *et al.*, 2013). The past years have shown run of record-breaking storms, forest fires, droughts, heat waves, and floods around the world with just 1.8°F (1.0°C) of global warming (IPCC, 2018).

Increase in carbon dioxide level

The greater increase in CO₂ level will cause damage to the cultivation of apple as this will ultimately interfere with the growth and development stages of fruits (Aditya *et al.*,

2012). Global CO₂ emission rose again to 2°C above pre-industrial levels (IPCC, 2018). Heat-trapping CO₂ gas in the atmosphere is largely responsible for rising global temperatures and the global emissions have reached to higher levels (UNEP'S Global Emission Report, 2018).

Ice melting

Antarctica's ice is melting more rapidly than previously expected. Environmentalists have revealed adding to the sense of urgency to act on climate change. This study, conducted by NASA and the European Space Agency (ESA), concludes that reduction of continent snow have tripled since 2012, and 180 billion tons of ice pouring into the ocean every year. The rapid melting of ice has resulted in increase in river water and floods because the Himalayan glacier is diminishing with rapid speed every year. This overall activity will have direct decline in apple crop yield and the crop will not get optimum conditions to get maximum yield of good quality (Aditya *et al.*, 2012).

Problems associated with climate change

Insufficient chilling hours and soil moisture: Apples generally require chilling period of about 1000-1600 hours at or below 7°C but at present this requirement is not fulfilled due to increase in earth's surface temperature resulted by climate change (IPCC, 2007). This will ultimately result in the low fruit set and cause yield loss. This condition is occurring in the mid hills as a result of which apple belt is shifted to higher hill region to meet the requirement of chilling hours. In mid hills, the instances of snowfall have decreased along with rainfall causing drought like conditions and this will hamper tree growth. This affect the flowering and fruit set period by affecting pollination and

directly causing yield loss (Verma *et al.*, 2015).

Incidence of hailstorms: Hailstorms cause damage to flowers and developing fruits. Hailstorms result due to fluctuation in temperature in the atmosphere. This causes damage to the young plants. In apple orchards hail cause huge damage to young trees, cause flower drop and also damage to the developing fruits at various stages of development (Randev *et al.*, 2009).

Incidence of spring frost: Spring frost is resulted due to low temperature during growing time and this will cause frost injury to plant, flowers and fruit. In apple spring frost hampers pollination, damages young fruits hence resulting in poor fruit setting and yield loss (Verma *et al.*, 2001).

Incidence of cold waves and hot waves: Cold waves directly affect the fruit size and fruit quality in apple. However, hot waves cause early flowering and large scale fruit drop in apple (Singh, 2016).

Incidence of diseases and insect-pest: Increased temperature is favoring the incidence of various diseases due to development of bacteria, viruses and fungus. In apple, already identified pathogens and pests cause damage to crop more frequently. This leads to increase in disease and pest incidence and climate change comprises shifting of disease ecology affecting apple production (Gautam *et al.*, 2004). For this, control over pests and diseases require more frequent control measures. In this regard, number of pesticide sprays are increased from 4- 12 per year depending upon infestation (Bhardwaj, 2013).

Elevated carbon dioxide level: Apple being a C₃ plant shows positive results towards increased CO₂ concentration as it helps to

accumulate more biomass. Increase in temperature, resulting from climate change, hampers effective biomass accumulation. Water shortage in addition completely nullifies positive impact of elevated CO₂ causing reduction in apple productivity (Singh, 2010).

Reduction in yield and quality of apples: In Himachal Pradesh, there is loss in yield by 40-50 per cent up to elevation of 1500m above mean sea level. This is due to increase in temperature and reduction in chilling hours. As a result, at lower elevations apple cultivation is affected and larger area has been reduced and become unfit for cultivation of apple (Petri and Leite, 2004). However, climate change has also affect the quality of apple fruits as too much heat mess up with the apple color. If the nights are not cold enough after a hot day, than the anthocyanin content get accumulated in a specific place and cause musky pinkish brown appearance. Besides this, high temperature also results in sun burn and cracking of fruits causing production of low quality apples (Joshi *et al.*, 2015).

Remedial measures against effect of climate change

Climate change has lead to a difficulty in apple cultivation in lower hills of Himachal Pradesh causing reduction in large cultivated area by increase in temperature, abnormal rainfall causing water shortage, irregular snowfall causing reduced soil moisture content etc. To overcome these problems resulted by climate change, some remedial measures should be adopted and some of them can be discussed as under:

Efforts should be done to make water available to growers in order to reduce water stress so as to maintain soil moisture level. For this purpose water harvesting structures should be constructed so that it can be utilized

during critical stages of growth in apple. Adopting effective genetic and biotechnological approaches in order to generate tolerance in crop against adverse conditions.

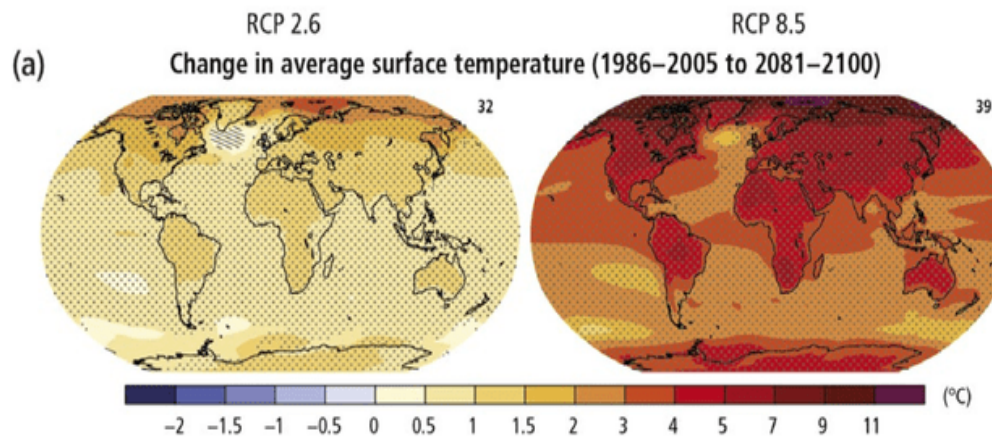
Growing low chill varieties in lower hills viz., Anna, Tamma, Vered etc.

Using rootstocks that are resistant to drought, (M7, M111), have high water use efficiency and are tolerant to high temperature.

Using such cultivars that can withstand adverse climatic conditions and show resistance against large scale insect pest and disease attack e.g. White Angle, David against powdery mildew of apple and Northern Spy against Collar Rot of apple.

Diversification of horticulture by replacing apple growing regions in mid hills with some other crop options like kiwi, pomegranate, persimmon and some vegetable crops.

Fig.1 The IPCC reported revealed that it is 'extremely likely' that human activity is the dominant cause for global warming. It claims a rise in temperature in the Northern Hemisphere (right) will cause snow cover to decrease by 25 per cent by the end of the 21st century. But the report failed to conclusively explain why the rise in global average surface temperatures had largely 'paused' over the past two decades (left)



(IPCC, 2018)

In conclusion, apple is the most commercial crop grown in Himachal Pradesh and is considered as main cash crop at present. Apple develops fruiting and vegetative buds in summer and these buds undergo dormancy in winters. These buds require a specific amount of chilling hours to break that dormancy (1000-1600 hours at or below 7°C). The lack of chilling units resulted in to some physiological changes appear in apple tree like reduction in fruit set, poor fruit quality etc. It was also reported that production is increased but the productivity is decreased gradually from 10.8 t/ha to 5.8 t/ha (Awasthi

et al., 2001). Further, reduction in productivity is caused by climate change including rise in temperature, lesser chilling period, reduced instances of snowfall etc. Other limiting factors affecting apple production in Himachal Pradesh are occurrence of hailstorms, cold waves, poor pollination and increased incidences of insect pest and diseases. To overcome problems caused due to climate change it is important to reduce water stress, growing low chill and highly resistant cultivars of apple against adverse climatic conditions. Some resistant rootstocks like M7, M111 can also be used

against drought conditions and also Northern Spy, Maling Merton series against various insect pest and disease infestation. Another best option can be the diversification of horticulture by replacing apple growing regions with some other crop options like kiwi, persimmon, pomegranate etc.

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