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Climate Change and Apple Cultivation in India

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Abstract

Apple crop is highly sensitive to weather stress. Temperature plays an important role on successful production of apple in temperate regions. This crop requires very specific temperature at its different stages. The average summer temperature should be around 21-24oC during active growth period. Apple succeeds best in regions where the trees experience uninterrupted rest in winter and abundant sunshine for good colour development. It can be grown at an altitude of 1500- 2700 m above the sea level. Bud dormancy, break and development are affected by variation in temperature. The amount of cold needed by a plant to resume normal spring growth following the winter period is referred to as its "chilling requirement." Buds remain dormant until they have accumulated sufficient chilling units of cold weather. Apple also requires accumulated heat units for onset of flowering. Mean maximum temperature in February, March and April is found to be most important variable in apple yield prediction in Indian conditions. Besides, above ground temperature, variations in soil thermal regimes also impact on tree physiology. Fruiting is also a temperature driven process. Frost can damage the full bloom stage up to 60-70% crop when temperature is around -2.2OC. Spring frost is not damaging as much as winter frost. In the changing climatic scenarios, apple production in Uttrakhand is unquestionably going to be affected in forthcoming days.

Keywords: Apple; Climate Change; Global Warming; Future Prospect.

Introduction

Apple cultivation and weather

A prospective apple farmer shall make an extensive research regarding the variety that most closely matches the climate conditions of his/her region. Apple is temperate deciduous thermal sensitive long day plant. It is one of the important fruit in the temperate regions. It is mainly cultivated with in the range of elevation of 1350-2700 meter above the mean sea level. Well distributed rainfall of 1000-1250 mm throughout the growing season is most favourable for optimum growth and fruitfulness of apple trees. Ignoring the quality of the harvested product substantially biases the impact of weather extremes on agricultural income and the potential effects of climate change. (Dalhaus, *et. al.*, 2020).

Soil: Apples grow best on a well drained, loam soils having a depth of 45 cm and a pH range of pH 5.5-6.5. The soil should be free from hard substrata and water logged conditions. Soils with heavy clay or compact subsoil are to be avoided.

Apple cultivation is confined to northwest (Jammu and Kashmir & Hinanchal Pradesh), north (Kumaun Hills) and north east (Arunanchal Pradesh) in India. The crop is highly sensitive to weather stress and accounts for limiting factors in its survival and production.

The average summer temperature should be

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around 21-24^{O}C during active growth period. Apple succeeds best in regions where the trees experience uninterrupted rest in winter and abundant sunshine for good colour development.

Nevertheless its growth and development are influenced by many weather parameters; the temperature is identified as one of the most important factors which affect its various phonological developmental phases. The rate of growth and development of a crop is a function of the energy receipt and thermal regime. The consequences of global warming in the form of erratic precipitation, increase in temperature, lesser days serving as the chilling period have started affecting the mountain agricultural production systems and ultimately the food security of the people.

Therefore agrometeorological conditions in growing apple is one of the most important aspects for its proper cultivation. Besides this apple fruit set being, heavily dependent upon insect pollination, is indirectly affected by vagaries of weather.

Climate change effect on Apple cultivation

Global warming put direct or indirect impact on crop, soil, livestock, and overall yield of plant. Apple production is directly affected by temperature, water availability, solar radiation, air pollution, and carbon dioxide (CO_2). Walthall *et al*. (2012) document current and projected shifts in climate patterns and weather and their impacts on United States (U.S.) agricultural production. It was four climate risk is an additional risk joining production, finance and marketing risks already managed by growers. Climate risk will add complexity and increase uncertainty in decision environments throughout many dimensions of U.S. apple production systems. 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^{o}C which is above the pre industrial level (IPCC, 2018).

As climate and weather become more variable, apple growers face increased uncertainty in making decisions about their crop. One interpretation of this uncertainty is that growers may not have quite enough information to adequately evaluate their management options in the context of climate risk. Uncertainty can stem from social, economic, relational and/ or biophysical factors that constrain or limit knowledge needed to make timely, good decisions.

Requirement of chilling units

It requires temperature below 7^{0}C for 600-900 hrs. which is called chilling period. This chilling period is required for growth, bud initiation, blossom and fruiting.

The chilling hour's requirement for standard apple variety is 800-1100. The amount of cold needed by a plant to resume normal spring growth following the winter period is commonly referred to as its "chilling requirement." One chilling unit is equal to one hour's exposure to the chilling temperature; these units are summed up for a whole season. It is still true that the most popular varieties need certain hours of cold in order to produce fruits for the next 30-40 years. Advanced models assign different weights to different temperature bands. The daily temperatures of 70°F and higher for 4 or more hours received by the plant during the previous 24 to 36 hours can actually negate chilling.

Apple trees develop their vegetative and fruiting buds in the summer and as winter approaches; the already developed buds go dormant due to both shorter day lengths and cooler temperatures. These buds remain dormant until they have accumulated sufficient chilling units (CU) of cold weather. The buds are ready to grow in response to warm temperatures only when enough chilling units accumulate. As long as there have been enough CUs the flower and leaf buds develop normally. However, in case the buds are unable to receive sufficient chilling temperatures during winter to completely release dormancy, trees will develop one or more following symptoms chilling consequently affect the yield and quality of the fruit:

- delayed foliation
- reduced fruit set and increased buttoning
- reduced fruit quality.

Temperature in relation to apple cultivation

Temperature requirement

Temperature is one of the most important factors for growth of any crop, especially to temperate region crops, though it can not be altered much in field conditions. However, modified orchard management can be used to capitalize to minimize

the unfavorable effects. Certain amount of temperature units are necessary to attain and complete each of the different phenophase which is termed as "thermal unit" or "heat units". The crop remains in dormancy from October to March and bud beak takes place from last week of March to first week of April after completing the chilling requirements. Mean maximum temperature in February, March and April is found to be most important variable in apple yield prediction in Indian conditions. Chilling units, chilling hours, number of hours with temperature more than 18^0C during dormancy temperature during bloom and relative humidity during bloom has been more emphasized in the various studies. The yield is found not to be affected by chilling units but by number of cumulative hours with temperature between 14-20^0C and Relative Humidity 40-60% in case of Royal Delecious Apple.

Bud dormancy and temperature

Bud dormancy, break and development are affected by variation in temperature. Early bud break occurs when mean February temperature remains around 6.5^0C and delays when temperature falls below freezing point. High temperature ranging 18-21^0C during bud formation delays bud break. Insufficient chilling period during winter is responsible for delay in foliation. Besides, above ground temperature, variations in soil thermal regimes also impact on tree physiology. Root temperature around 20^0C is found to increase bud break over those at 10^0C. If the day time temperature is around 10^0C during pre bloom period, it may delay flowering in comparison to that of 15^0C.

Higher number of bud formation is favoured by long warm autumns with temperature more than 10^0C. Apple also require accumulated heat units for onset of flowering. It is found better to use daily temperature rather than using only cardinal temperature. Fruiting is also a temperature driven process. Temperature less than 4^0C and also more than 27^0C adversely affect bee activities besides the pollen germination. Temperature around 15^0C during full bloom increase fruit set. A sudden drop in temperature can kill the fruit lets. Night temperature above 16^0C around one month after full bloom can accelerate premature drops.

Cool nights favour the proper colour development due to increased anthocyanin synthesis, while, on the other hand, high temperature affect the same adversely. Flavour is also enhanced by low temperature at the time of harvest.

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.

Frost and freezing injury

There are two types of frosts that may affect the crop: wind frost and radiation frost. wind frost is not very much common in spring. Radiation frost occurs during clear sky nights. It can damage the full bloom stage up to 60-70% crop when temperature is around -2.2^0C. spring frost is not damaging as much as winter frost. A temperature of -3.5^0C at full bloom stage and -1.9^0C at bud closing can be critical for frost damage. Frost damage is less in late flowering cultivars.

A sudden drop in temperature to the tune of -10 to -15OC or a prolonged spells of -20OC can cause bud damage, besides damaging young and matured fruits subjected to the variation within cultivars. Freezing also badly hampers roots and bark woods. Roots are also adversely affected if temperature goes below -4^0C. Vertical cracks if the bark of stems also developed due to extreme fall in temperature.

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.

Being a temperate crop, each phenophase of apple is directly affected by temperature to which it is exposed. It can be concluded that, in the changing climatic perspective, which mainly affect the air temperature, apple production in Uttrakhand will certainly going to be affected as in future.

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