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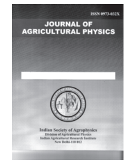

Research Article

Farmers' Perception in relation to Climate Variability in Apple Growing Regions of Kullu District of Himachal Pradesh

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ABSTRACT

The study assessed the farmers' awareness and perception of climate variability. The climate change is described by farmers as temporal displacement of weather cycle reflecting change in crop enterprises and livelihood options. Most of the apple growers revealed that reduction in snowfall, change in temperature, abrupt rainfall patterns and extreme weather phenomena i.e. hailstorms, droughts, torrential rains, floods, cloudbursts etc. can be ascribed to the decreased apple production. Meteorological data was used to obtain the temperature and rainfall trends. These trends showed an increase in temperature and decrease in rainfall and the similar pattern was also perceived by the farmers. Chill units showed a decreasing trend in the area when these were worked out using the UTAH model. The decrease in chill units due to an increase in temperature adversely affected the apple productivity. Shift towards new varieties, change of choice of crops, shift of orchards to higher altitudes, bee keeping and setting up of polyhouses were some of the strategic measures adopted by the farmers to compensate the loss due to climate change.

Key words: Apple, climate change, perception, temperature, rainfall, chill units

Introduction

Apple is one of the most important temperate fruit crops of Himachal Pradesh occupying the place of pride in its economy. The decreased productivity of apple orchards in the recent years due to the change in climatic conditions has become a serious concern of the growers in Himachal Pradesh. If climatic factors such as temperature and precipitation change in a region beyond the limits of the species phenotypic plasticity, then distribution or replacement, changes of species may become inevitable (Lynch and Lande, 1993). There is already evidence that plant species are shifting their ranges in altitude and latitude as a response to changing regional climates. The timing of phenological events such as flowering is often related to environmental variables such as temperature. In fact, synchronous profuse flowering with minimum flower shedding is a measure of the adaptability of a plant type to a particular location. Changing environments are therefore, expected to lead to changes in life cycle events (Parmesan and Yohe, 2003). The climate change impacts have been clearly deciphered by changes like dry and warm climate, change in snowfall and precipitation pattern (Bhagat *et al.,* 2004). As one of the critical variables beyond our control, weather catches the interest of home gardeners, but to commercial

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farmers, abrupt weather fluctuations can imperil their very livelihoods. In the present study, Kullu district in Himachal Pradesh has been chosen as a typical high mountain environment exhibiting most of the climatic features of mountainous areas. It is characterized by vertical zonation of eco-climatic zones controlled by decreasing temperatures with increasing elevation above sea level. Mountainous areas of a Himalayan catchment like Kullu district in Himachal Pradesh assume importance because the impact of climatic variability on the extreme weather events and economic activities like agriculture tends to be quite pronounced in such environments. Hence, study of climatic variability and its effect in such areas helps in maximizing our knowledge on general subject of climate change itself.

Material and Methods

Study area

The present study was undertaken in the Kullu District of Himachal Pradesh. The geographical extent of the district is between 30º51’00" North latitude and 77º06’04" East longitudes and altitude ranges from 500-5000 meters above the mean sea level, but the habitation is only up to 3500 meters. The District is characterized by cold dry weather. The maximum temperature varies from 15.8°C in January to 32.8°C in June, whereas the minimum temperature ranges from 21.1°C in July to as low as 0.7°C. (Anon., 2009). Four blocks Kullu, Banjar, Naggar, and Ani of the district representing different elevations and dominant by the apple cultivation were selected to examine the indigenous perceptions of farmers for climate change and to relate the chill units with apple cultivations in the face of climate change.

Data collection

The data on farmers’ perception was collected in a pre-tested survey schedule through personal interview method. Thirty farmers from each region comprising small, marginal and large farmers were selected and asked about apple production during the last several years. Subsequently, they were asked about the variability in yields and their views on the ways in which they perceive climate change. The focus was laid on various aspects to extract the detailed information on climate change, its impacts on apple productivity, apple quality, shifting trends, extreme weather phenomena and strategic measures to combat the change. Temperature trends, precipitation patterns, extreme weather phenomenon were main parameters studied. Changes in the planting; flowering and fruiting time of apple fruit, source of water, pest infestation, introduction of new varieties, changes in appearance and taste and quality of apples, effect on pollinators, decrease in apple production, change in choice of crops were used to draw useful inferences. The daily maximum and minimum temperature and rainfall data was analyzed using statistical tools for the period of twenty five years i.e. 1985-2009. The temperature data was also used to calculate chill units. Apple area and production data from the district was used to be correlated with the chill units.

Chill Unit Calculation Model Used

The effective apple chill units were worked out and correlated with productivity using UTAH model (Byrne and Bacon, 1992).

1 hour below 32 degrees F =0.0 chill units

1 hour 35-36 degrees F =0.5 chill units

1 hour 37-48 degrees F =1.0 chill units

1 hour 49-54 degrees F =0.5 chill units

1 hour 55-60 degrees F =0.0 chill units

1 hour 61-65 degrees F =-0.5 chill units

1 hour >68 degrees F =-1.0 chill units

Data Analysis

Descriptive statistics for simplistic presentation based on summary counts of the questionnaire structure were used to provide insights into farmers’ perceptions of climate change and variability. Climatic data recorded at meteorological station (trends and variability) was used as a tool to assess local people’s perceptions of climate change and variability. Perceptions as observed and experienced ideas were assessed by comparing with objective data on local precipitation and temperature trend with the responses given by the farmers.

Results and Discussion

Farmers' perception on climate change

1. Temperature

The results revealed that 95 percent of local people interviewed perceived long-term changes in temperature. While, 100 percent perceived temperature has increased. Farmers in all the four blocks i.e. Kullu, Naggar, Banjar, Ani perceived that summer season was more prolonged and temperatures have also gone up in this season in recent years. All respondents in Kullu block, 83 percent in Banjar, 97 percent in Naggar and 80 percent in Ani block perceived that the duration and the intensity of cold in the winters has decreased. Orchard owners were of the opinion that apple orchards are neither left to be productive nor economically viable, particularly in lower Kullu Valley area due to rise in temperature. Earlier situations like low favorable temperature for effective chill accumulation, good flowering and hence, good production is now restricted only to locations at higher altitudes. The respondents reported that the lack of chilling, late snowfall and quick rise in temperature in February have become frequently common leading to reduction in the period for pollination and unconducive weather during fruit setting and maturation. Change in the flowering and fruiting time of apples was also reported by almost 60 percent respondents. Apple flowering was previously reported to take place in the month of March-April, but now this has been observed to have shifted a month earlier i.e. February-March. Farmers also believed the periodicity of temperature to be influenced by the timing of snowfall. The short winter period with reducing snowfall during winter and increasing temperature during the summer season have been among the most visible signs of changing climate as opined by 90 percent of the farmers in the Kullu District (Table 1).

The maximum temperature showed an increasing trend whereas, minimum temperature revealed a decreasing trend which clearly indicated a warming trend in the study area. During the last 25 years, an increase of about 1.18^{0}C in maximum temperature (Figure 1) and 0.53^{0}C decrease in minimum temperature (Figure 2) was recorded. People perceived increase in temperature with higher increase during the winter months. To asses this perception the temperature data for 25 years was analyzed for winter (November to February) and summer (May and June) months. An increasing trend was observed in both the cases with winter months showing more increase (Figure 3). The analysis showed that local people's perceptions appear to be in accordance and agreement with the objective statistical record in the region. Earlier Bhusal (2009) took local perception of climate change into consideration and related it with the meteorological data and had found similar results.

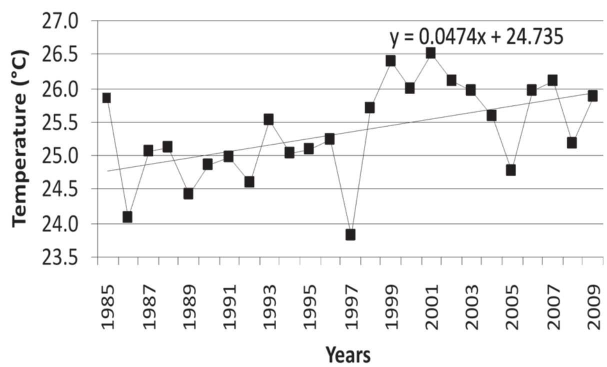

Fig. 1. Trends of maximum temperature

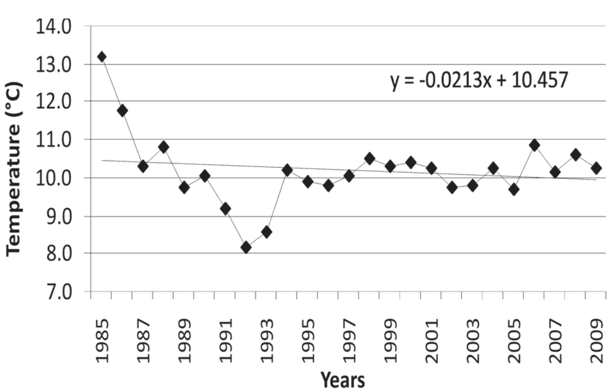

Fig. 2. Trends of minimum temperature data

Table 1 Farmers' perception regarding climate change

Particulars	KULLU	BANJAR	NAGAR	ANI
Increasing temperature during summer	100	100	100	100
Prolonged summer season	100	100	100	100
Change in snowfall pattern	100	100	100	30
Reducing snowfall in winter	100	100	100	100
Non-occurrence of snow	90	0	0	40
Delay in the onset of rainy season	100	100	90	100
Uneven distribution of rainfall	100	100	100	100
Unpredictable rainfall	100	100	100	100
Insufficient rainfall during rainy season	100	43	90	83
Delay in the onset of winter season	100	100	100	100
Low temperature in winter season	0	33	40	7
Short winter period	100	83	97	80
Temperature above normal during winter	90	67	70	90
High humid weather	10	37	13	13
Increasing foggy and cloudy days in winter	0	53	3	30
Threat of floods and mud slides	10	0	17	20
High velocity winds	3	47	47	23
Hails	7	27	97	7
High intensity of rainfall and soil erosion	17	80	17	33
Drought	90	0	10	37
Change in planting time of apple crop	27	33	3	17
Advancement in flowering time	90	67	83	67
Advancement in fruit setting	93	77	87	67
Change in appearance of apple fruit	90	67	73	83
Change in taste and quality of apple fruit	87	30	27	67
Decrease in pollinators	93	100	100	100
Pest infestation increased	100	100	100	100
Introduction of new varieties	70	23	20	33
Change in choice of crops	77	30	10	37
Decrease in apple production	100	100	100	100
Increase in glacial melting	100	100	100	100
Strategic measures adopted	97	20	20	23

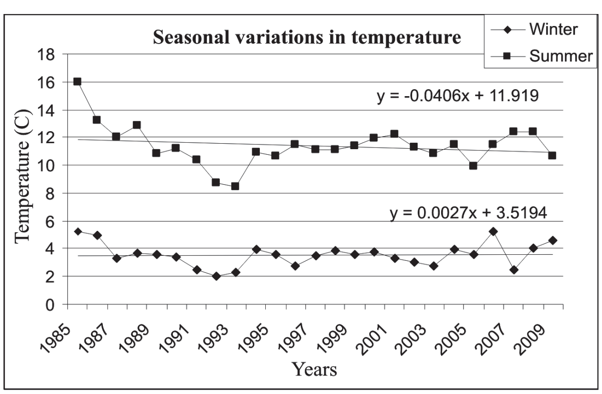

Fig 3. Seasonal variations in temperature

2. Precipitation

In all the four blocks of the district, respondents reported an increase in the unpredictable pattern of rainfall with incidences of occurrence of rain at any time of the year. They also experienced that the rainfall was unevenly distributed. Dry summers with extended drought spells because of decreased rainfall impaired the fruit quality especially the fruit size and colour. Respondents in the Kullu block of the district reported huge reduction in the amount of the rainfall. They were no more dependent on the rainfall as the source of water to the orchard. Unpredictive and lower rainfall has forced the people to go for the adoption of various irrigation methods like lift irrigation, tank irrigation, usage of own wells. Yet, at higher altitudes, it was found that 97 percent people are still dependent on rainfall only. In addition, a decrease in natural spring water has been attributed by the respondents to the low snowfall in the catchment area (Table 1).

The data on rainfall from 1973 to 2009 showed an overall decreasing trend over the years. The annual rainfall was decreasing at the rate of 0.8 mm per year with an overall decrease of 27.1 mm in the last 37 years (Figure 4). Local perceptions indicated that the incidence of rainfall in December and January has conspicuously decreased (Figure 5 and Figure 6). Both the months have showed a decrease in rainfall amount. However, decrease was more in the month of January which is a crucial month for good chill accumulation. (Jindal *et al.,* 2001).

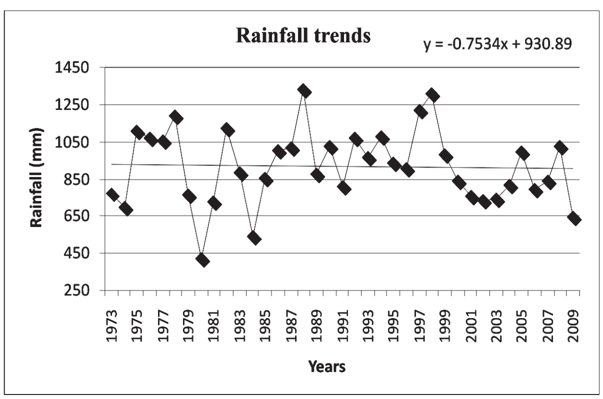

Fig. 4. Rainfall trends

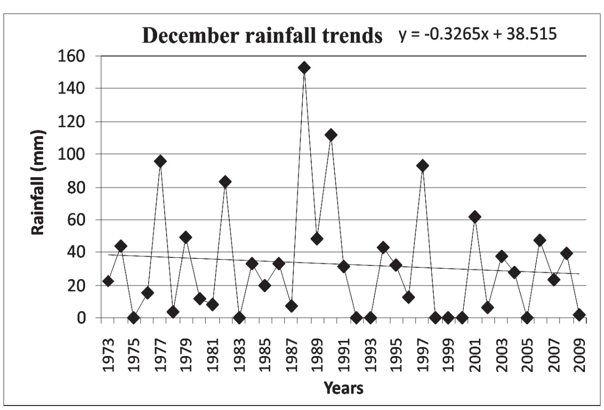

Fig. 5. December rainfall trends

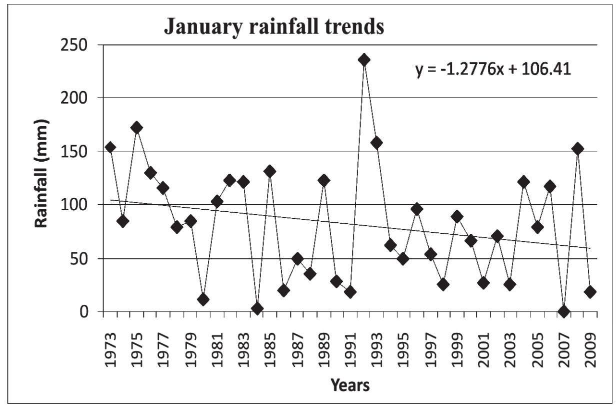

Fig. 6. January rainfall trends

The results of the study revealed that people perceived a definite reduction of snowfall over the time. Lower Kullu valley, which used to be the initial point of the apple belt, now has received no snowfall at all. Almost 90 percent people in the Kullu block and 40 percent in Ani block reported no snowfall in their region since past few years. In other blocks of the district which received although optimum snowfall but not without some aberrations in the snowfall events. Farmers reported that the onset of early snow in December and January has occurred more infrequently over time and the period of snowfall now extended through the months of February and March (Table 1).

3. Extreme weather phenomena

People perceived that the development of infrastructure such as roads, trails and buildings, intensification of agricultural/ horticultural activities, timber extraction (for fuel and building material), and grazing activity have increased the risks associated with landslides, floods, and other erosion processes. About 17 percent, 20 percent and 10 percent farmers in Naggar, Ani and Kullu block, respectively, also felt that the threat of floods has increased. Farmers to the tune of 17 percent felt that the chances of cloudbursts in the Naggar block were now high. Abnormal occurrence of hailstorms and the warmer wind patterns were also perceived. 27 percent in Banjar and 97 percent farmers in Naggar block held increase in hailstorms incidences to be responsible for harming the apple crop. Majority of the people

(90%) in Kullu block felt increased spells of dry period leading to the drought conditions (Table 1).

A decrease in number of the pollinators (honey bees) and vanishing of some species of butterflies was also reported. Farmers to the tune of 23 percent preferred shifting their orchards to the higher elevations which they thought were becoming suitable for apple cultivation because of the decreasing cold at higher altitudes favouring the apple crop. The construction of roads, execution of hydroelectric projects, denudation of forests, illegal and non-scientific mining, increased tourist load and increased population pressure etc. have also led to more pollution leading to changes in the climate. 10 percent people considered the construction of Pandoh and Larji dam to have adversely affected the local climate of the nearby areas. They felt that after the construction of the dams there was more of the pollution, less rainfall (Sainjh area), increased intensity of fog affecting the colour of apple (appearance of black patches) (Table 1).

Adaptation measures

The apple productivity over the years has showed a fluctuating pattern with an overall decreasing trend of 0.4 tons/ha in the last 25 years (Figure 8). There were some local coping measures and strategies adopted by the farmers in response to observed risks and hazards related to climate and non-climatic factors.

- **Shift towards new varieties (low chill and high yield varieties):** 80% of the orchardists in the lower regions shifted their choice to low chill varieties (Gala, Vance, Vance delicious, Spur red, Oregon spur, etc.).
- **Change of choice of cash crops (vegetables and fruits):** to compensate the loss from the low productivity of apples, 73% farmers in the Kullu block have also introduced alternate crops (pears, kiwis, pomegranates, persimmon, cabbage and other vegetables) along with apples.
- **Shift of orchards to higher altitudes:** 23% orchardists at Kullu block and 10% at Ani block felt higher altitudes were getting more suitable for apple cultivation and hence shifted their orchards towards upper valley.
- **Polyhouses and floriculture:** as people were facing threats of low productivity, 23% of farmers switched over to the setting up of poly houses and floriculture (carnations).
- **Bee keeping:** many farmers felt decrease in the number of pollinators. To combat this change, many farmers had their own source of pollinators or hired bee colonies for successful pollination.

Chill units trends

Cumulative chill units were calculated every year for the period of November to February. The model showed decrease of 8.20 chill units every year and 205.25 chill units for the 25 years due to increase in temperature at Kullu (Figure 7). Similar decreasing trend in chill units was observed in studies conducted at Kullu and Shimla by Bhagat *et al.* (2007) and Verma *et al.* (2007) at Mashobra, Kinnaur and Kullu.

Correlation studies

Correlations were worked out between various weather parameters (maximum temperature, minimum temperature, and rainfall), cumulative chill units and productivity (Table 2). Maximum temperature amongst these showed a negative correlation with the productivity signifying an inverse relationship between the two. Whereas, minimum temperature and rainfall showed a positive correlation, thereby, implying that with an increase in these parameters, the

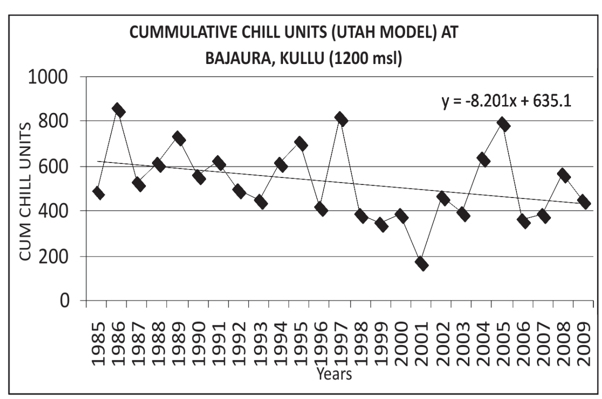

Fig. 7. Cumulative Chill units trends at Kullu

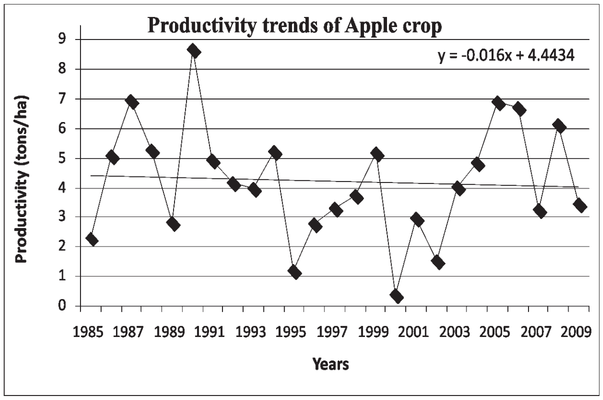

Fig. 8. Productivity trends of apple crop

Table 2. Correlation coefficients between weather parameters and productivity

Weather Parameters	Chill units	Productivity
Maximum Temperature (°C)	-0.87	-0.23
Minimum Temperature (°C)	0.05	-0.02
Rainfall (mm)	0.34	0.23

productivity will also increase. When chill units were correlated with the productivity, a positive correlation was obtained which clearly signifies a direct relation between them.

Conclusions

The study clearly revealed the impact of changing climatic conditions in the study area to be adversely affecting the apple productivity and hence, livelihoods of the people. It was remarked by many people that the suitable ecological niche of apple cultivation has shifted to higher elevations from Bajaura which earlier used to be the starting point for apple cultivation. The orchardists were facing the problems of degraded appearance, flavour, texture and storage ability and overall depletion in the productivity. In order to sustain the productivity of apple crop, people have increased the proportion of low chill cultivars (Gala, Spur, Vance, etc.) in orchards which are less sensitive to climatic changes. A majority of orchardists have also shifted their choice of crops to other fruits like pears, pomegranate, kiwis etc. which fetched higher prices as well as to the vegetables in the lower belts. As the necessary chilling requirement was not met at locations in lower heights, the apple crop, the mainstay of the economy of the district has suffered a loss. Many farmers adopted strategic measures to compensate for this loss which included beekeeping, floriculture, polyhouses, irrigation methods etc.

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