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Research Article

Effect of Climatic Factors on Chill Units Accumulation and Productivity of Apple Crop in Mountainous Region of Himachal Pradesh

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ABSTRACT

The present investigation was carried out for during 2016-2017 for Kullu and Shimla district of Himachal Pradesh. The results revealed that cumulative chill units of Kullu showed a decreasing trend of the order of 6.61 CU/year. Month-wise chill units accumulation (Nov-Feb) revealed maximum decrease of 2.54 CU for the month of February. Similarly, the cumulative chill units of Shimla also showed decreasing trend of the order of 10.9 CU/year and overall decrease of 337.9 CU over the last thirty-one years. The maximum monthly decrease of 5.19 CU for the month November at Shimla district. The average number of chill units available for the apple crop followed a decreasing trend as 1182 CU at Shimla followed by 558.29 CU at Kullu. The productivity of last five years (20012-2017) showed a decreasing trend of the order of 0.11 ton/ha/year for Kullu and 0.186 ton/ha/year for Shimla.

Keywords: *Utah model, Chill units, Productivity.*

INTRODUCTION

Apple is the predominant temperate fruit crop of the state. But now the temperate region of the state is facing climate variability which is indicated by erratic rainfall, increase in temperature and lack of chilling hours (Bhagat et al., 2009) there by productivity of the crops especially apple is adversely affected. The reduced snowfall in sub-temperate regions resulted in shifting of apple growing areas to higher altitudes. In addition to this the orchard management practices being performed in the region may also influence soil health and ultimately the apple crop productivity. The temperate fruit trees fall dormant in autumn and winter and develop their fruiting buds in summer. The dormancy is composed of an endodormancy phase, followed by an ecodormancy period (Lang et al., 1987). Apple buds remain dormant until they have accumulated the effective chill units. The chilling and forcing temperatures during the bud development periods are perceived by the floral primordial (Legave et al., 2008), and the corresponding chilling and heat requirements are generally considered to be the main driving factors in the breaking of both dormancy stages (Luedeling, 2012).

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Variation in the rates of chilling and heat accumulation caused by climate changes could influence the fulfilment of chilling and heat requirements, leading to advanced or delayed spring phenological events. Climatic factors have affected the chilling rate for apple. Insufficient chilling can lead to uneven leafing and bloom, and can cause varying fruit sizes and maturity times, both of which can reduce the quantity and quality of fruits. The climatic factors mainly temperature and precipitation change in a region beyond the tolerance of species. According to IPCC (2007) on an average the air temperature could be increase 6.4°C by the end of 21st century. The impacts on climate change on the apple orchards of Himachal Pradesh is already visible. Due to increasing temperature, apple has frequently failed to meet chilling requirements in the lower areas of Himachal Pradesh, due to which its cultivation is shifting towards higher reaches of the mountains (Sharma, 2013). In lower regions, climate change has adversely affected flowering, fruit set, fruit quality and yield of apple (Randev, 2009). Kullu valley of the state at one time was known for best quality apple in the country but now apple have become uneconomical, non-viable, less profitable and even unproductive in such a short period. Therefore, it is a matter of great concern that apple orchards which at one time were very promising and productive have deteriorated both in productivity and quality of the produce. While, the cold desert of Lahaul and Spiti district once considered unsuitable for apple cultivation due to extreme cold conditions is currently witnessing increase plantation of apple sapling each year due to warming of climate in the region. Therefore, the present investigation was undertaken in Kullu and Shimla district of Himachal Pradesh to study effect of climate change on chilling units and associated changes in apple productivity.

MATERIALS AND METHODS

The present investigation was conducted during the year 2016-2017 in the two major apple growing districts of Himachal Pradesh i.e. Kullu and Shimla.

DATA COLLECTION

The data on daily maximum and minimum temperature were collected from the Indian Meteorological Department, Shimla for the period of 1986 to 2017. The temperature data for four winter months (November to February) was used to evaluate chill units. The data on apple area and productivity (2002-2017) was procured from the directorate of Horticulture, Shimla, Himachal Pradesh.

EFFECTIVE CHILL UNITS FOR APPLE

The effective chill units for apple crop were worked out using UTAH model (Byrne and Bacon, 1992). It quantifies winter chill as the number of hours during the winter season temperature between 0 and 7.2 °C (Bennett, 1950). The dataset on daily maximum and minimum temperature for four winter months i.e. November to February was used for effective chill unit hours calculation.

UTAH model range

1 hour below 32 ° F	=	0.0 chill unit
1 hour 32-36 ° F	=	0.5 chill units
1 hour 37-48 ° F	=	1.0 chill units
1 hour 49-54 ° F	=	0.5 chill units
1 hour 55-60 ° F	=	0.0 chill units
1 hour 61-65 ° F	=	-0.5 chill units
1 hour >68 ° F	=	-1.0 chill units

RESULTS AND DISCUSSION

The winter temperature and precipitation (snow) are the sensitive factors for dormancy break, accumulation of effective chill units and bud break in temperate fruit crop like apple. The data on accumulations of chill units at

Kullu and Shimla region of Himachal Pradesh presented in fig 1 & 2.

The Perusal of data showed a decreasing trend in order of 6.61 chill units (CU) per year as per the regression equation (y = -6.6154x + 558.29) in Kullu during 1986-2017. Further, the Month wise cumulative chill unit was also calculated during the study period for four winter months, i.e. November to February were showed decreasing trends (Fig.3-6). The decrease of 2.5.4 CU to 0.65 CU per year was observed during the months of November to February. The maximum reduction was observed in the month of February 2.54 CU per year followed by December (1.66 CU per year) and November (1.16 CU per year). The minimum reduction of the order of 0.65 CU per year recorded in the month of January. This decrease in chill unit may be attributed to contrary increased in average air temperature (0.07°C per year) in last thirty years (Fig 17) The similar trend of decrease in chill units were recorded by rana et al. (2009). The last ten years also showed the reduction in chill unit accumulations (fig 7) during the study period. The magnitude of decrease as per the regression equation was 7.81 CU per year for apple crop in Kullu. The model showed an overall decrease of 205.06 CU for the last thirty-one years. On an average 558.28 CU were available for apple crop at Kullu during last thirty-one years (1986-2017).

The similar study was carried out for Shimla district (Fig 2). The Data on accumulation of cumulative chill units was calculated for the period of 1986 to 2017 from daily maximum and minimum temperature by using UTAH model showed the same decreasing trend of the order of 10.9 chill units per year as per the regression equation (y = -10.906x + 1182). The data present in the fig 8-11 exhibited the same decreasing trend in chill units from December to February. Whereas January showed the increasing trend of 3.49 CU per year as per the regression equation (y = 3.49 + 199.35). The maximum decreasing trend of 5.191 chill units per year as per regression equation (y = -5.191x+173.52) was observed for the month of November followed by December (3.139 CU per year) and February (2.080 CU per year). The average chill units hours (CU hrs.) accumulated for apple crop at Shimla were 1182 CU in last thirty-one years (1986-2017). The data on trend analysis of last ten years (2008-2017) followed decreasing trend in the chill unit accumulation as per regression equation y = 815.66 - 2.88x (Fig 12). The finding of present investigation corresponded to the studies conducted on chill units for apple crop in Kullu and Shimla district by Bhagat et al. (2009). They reported a decrease at the rate of 11.9 and 17.9 chill units per year at Kullu and Shimla due to rise in temperature.

The productivity of apple in Kullu and Shimla was presented in Fig (13 & 15). The highest productivity (7.97 tons/ha) & (17.41 tons/ha) were recorded in the year 2011 in Kullu and Shimla districts. The maximum temperature during the year in Kullu (26.0 °C) and (19.9 °C) in Shimla. Whereas, the minimum temperature was (10.7°C) in Kullu and (11.0°C) in Shimla. This showed that the temperature range of the year is suitable for high productivity of apple. Further, the productivity trend showed the decreasing trend of 0.0831 tons/ha per year as per regression equation (y = -0.0831x + 6.3746) in Kullu during the period 2002-2017. While productivity showed the increasing trend of the order of (0.024 tons/ha/per) as per the regression equation (y = 0.0244x + 9.3956).

The productivity trends of last five years (2012-2017) showed the decreasing trends (0.114 tons/ha) per year as per the regression equation (y = -0.114x + 5.932) in Kullu. The similar decreasing trends of the order of 0.186 (y = -0.1863x + 10.47) (fig 14 &16). The decrease in apple productivity trend was highest in Kullu as compare to Shimla. This could be attributed to increase in maximum and minimum temperature in Kullu district. Sen *et al.* (2015) also observed the decreasing trend in the apple productivity (tons/ha/year) in Kullu valley during the period of 1985-2009.

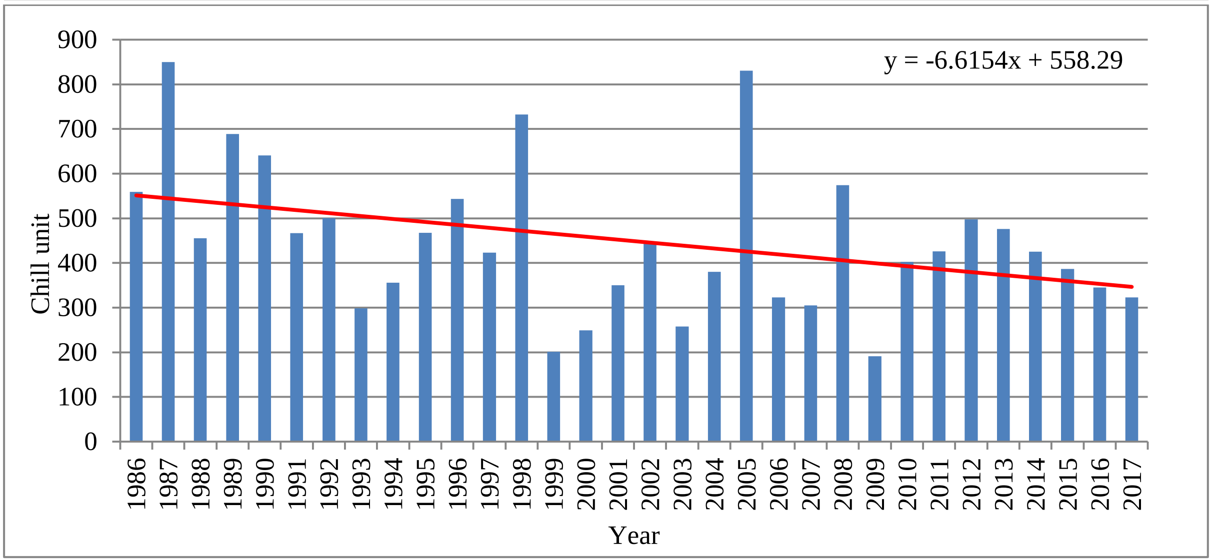

Fig. 1: Cumulative chill units trend at Kullu for the period of 1986-2017

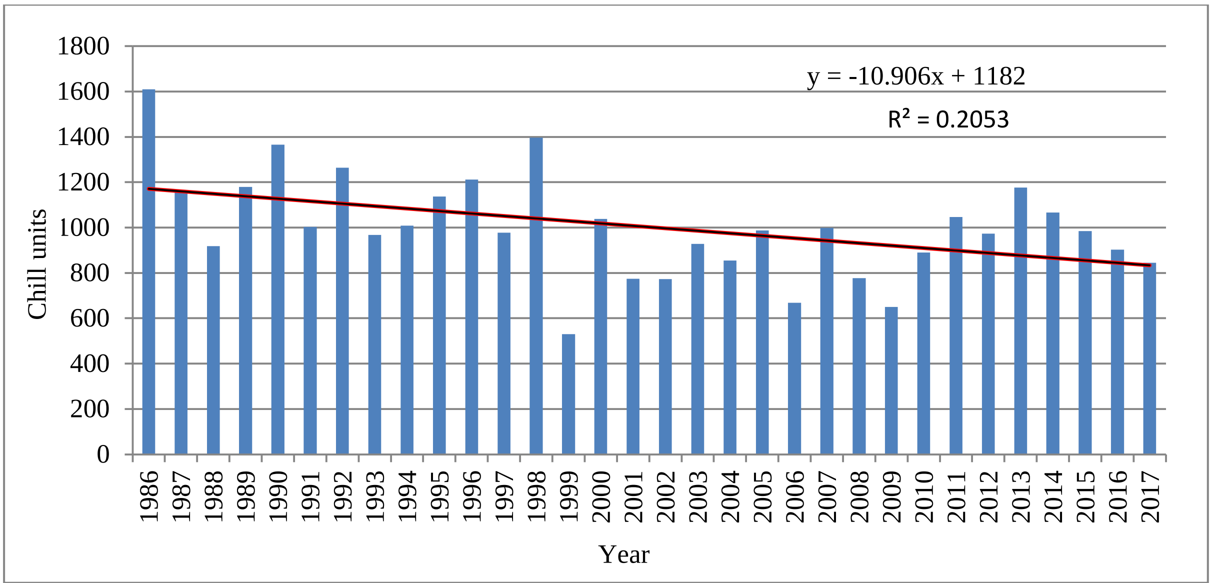

Fig. 2: Cumulative chill units trend at Shimla for the period of 1986-2017

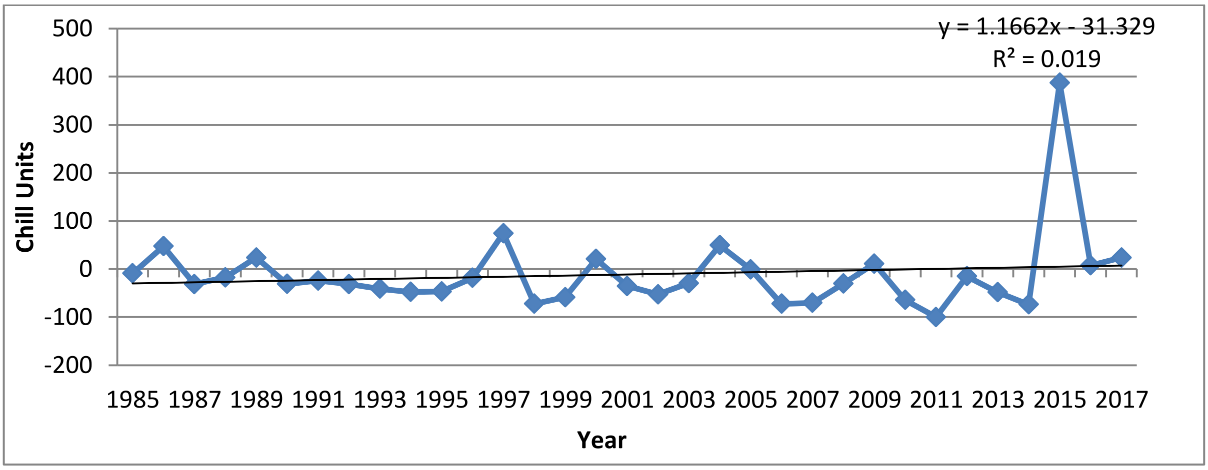

Fig. 3: Chill units trends for November at Kullu (1985-2017)

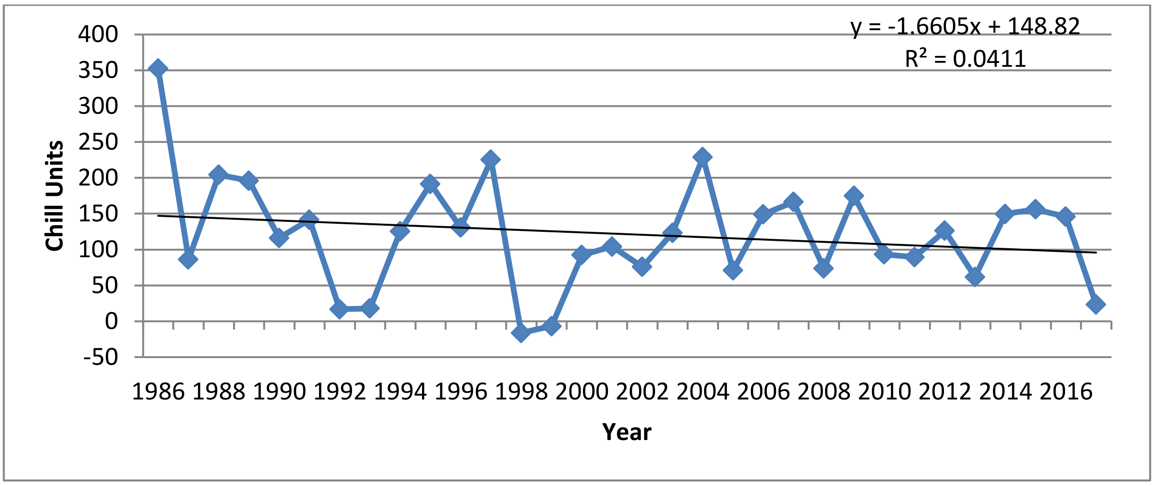

Fig. 4: Chill units trends for December at Kullu (1986-2016)

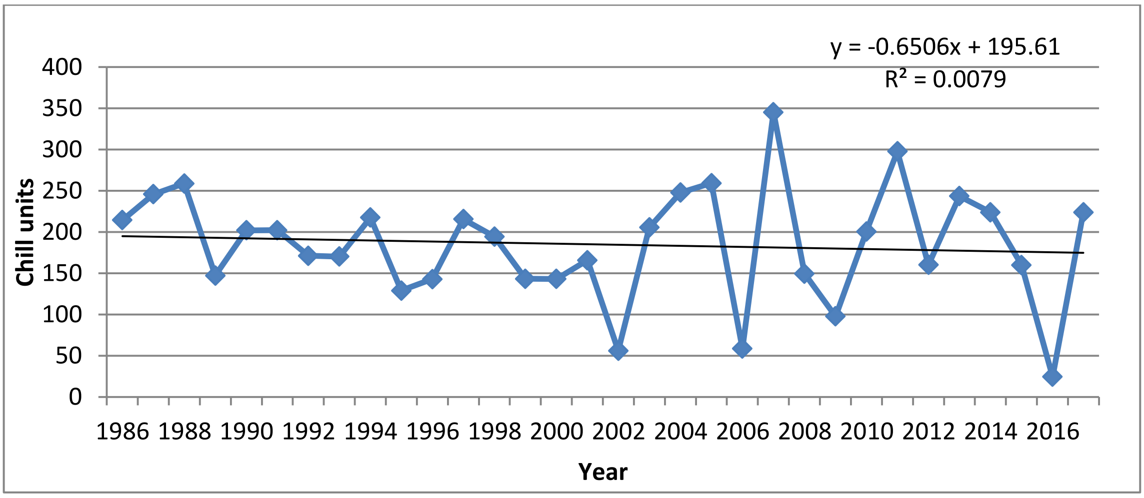

Fig. 5: Chill units trends for January at Kullu (1986-2016)

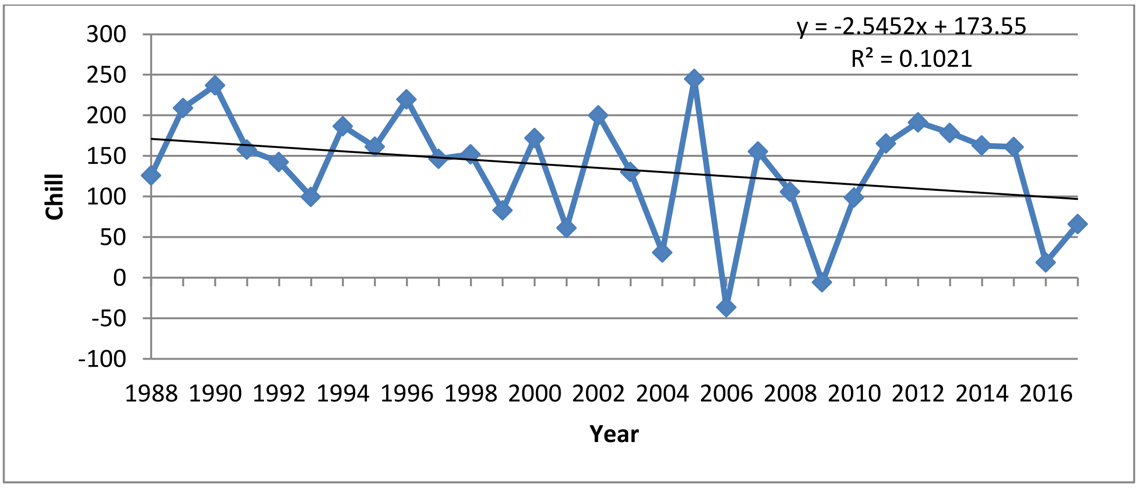

Fig. 6: Chill units trends for February at Kullu (1988-2016)

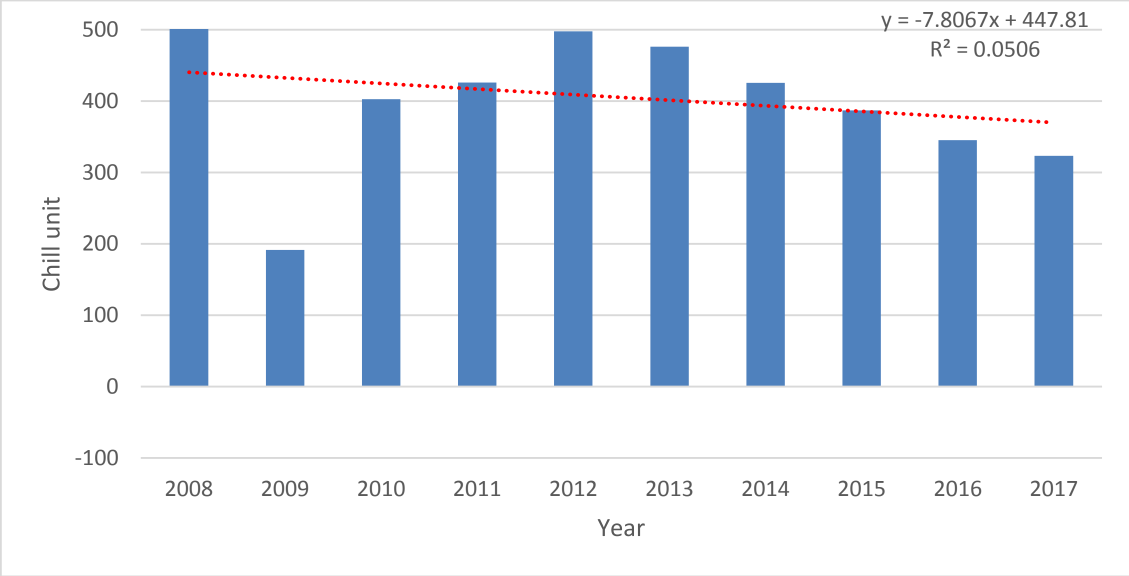

Fig. 7: Trend of cumulative chill units at Kullu for last ten years

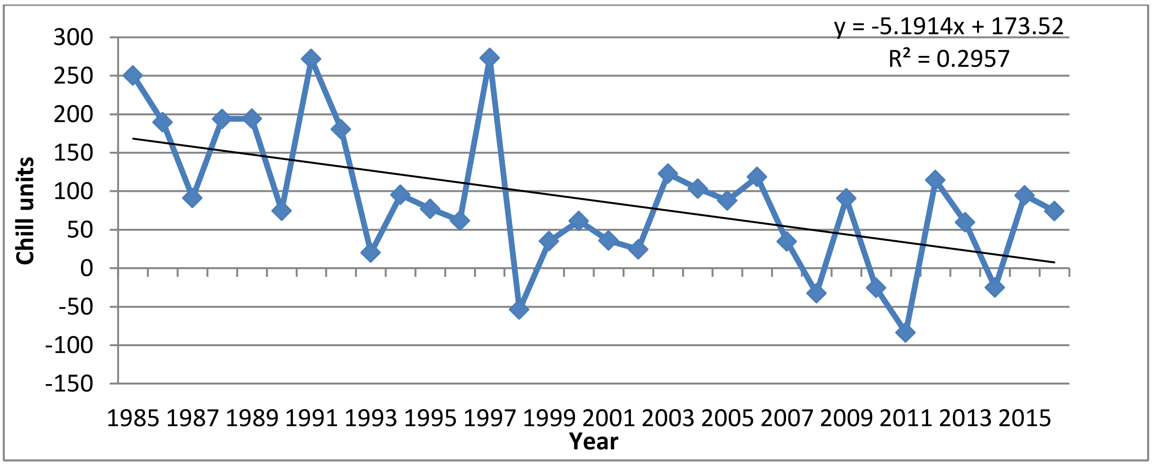

Fig. 8: Chill units trends for November at Shimla (1985-2016)

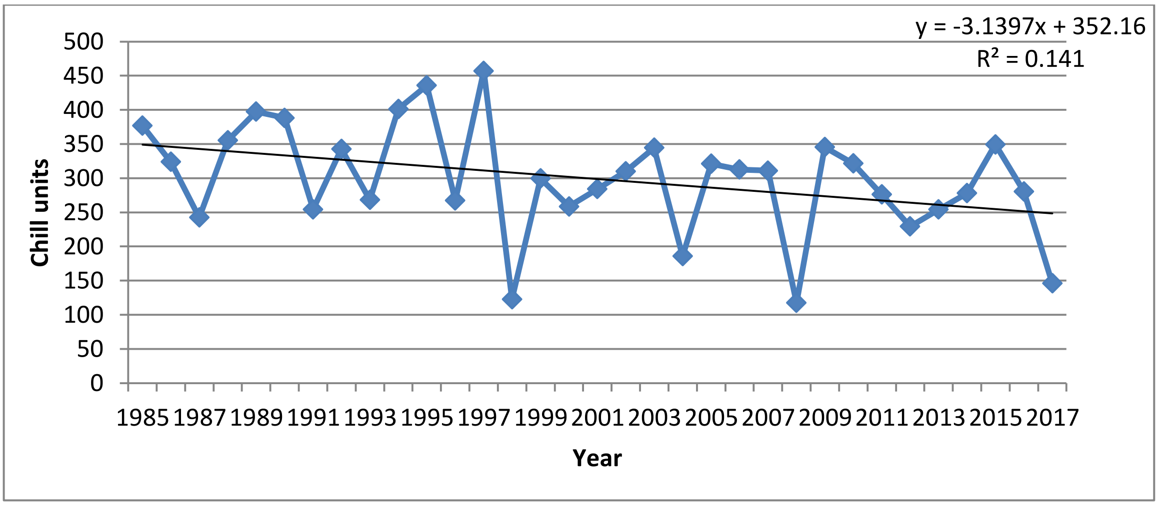

Fig. 9: Chill units trends for December at Shimla (1985-2017)

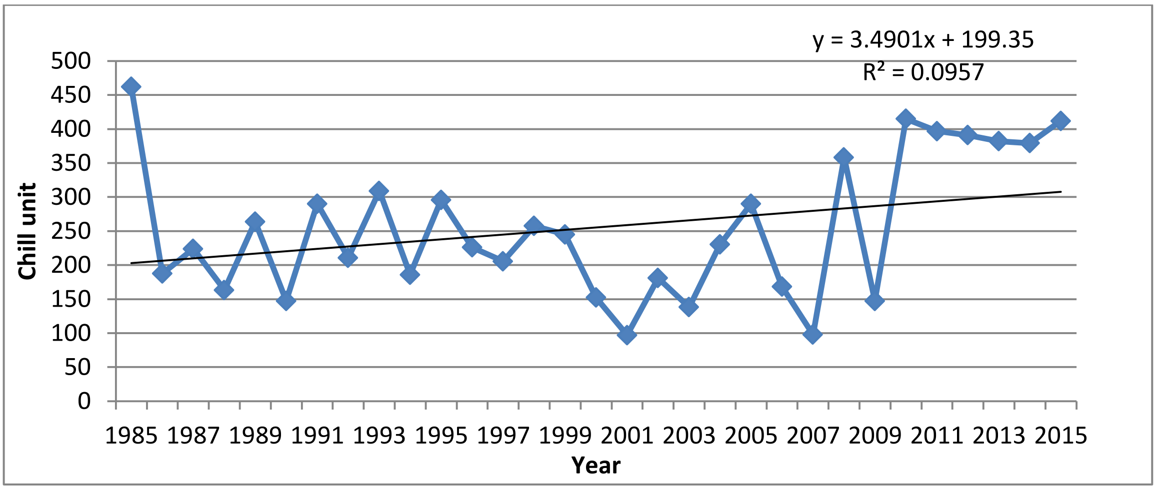

Fig. 10: Chill units trends for January at Shimla (1985-2015)

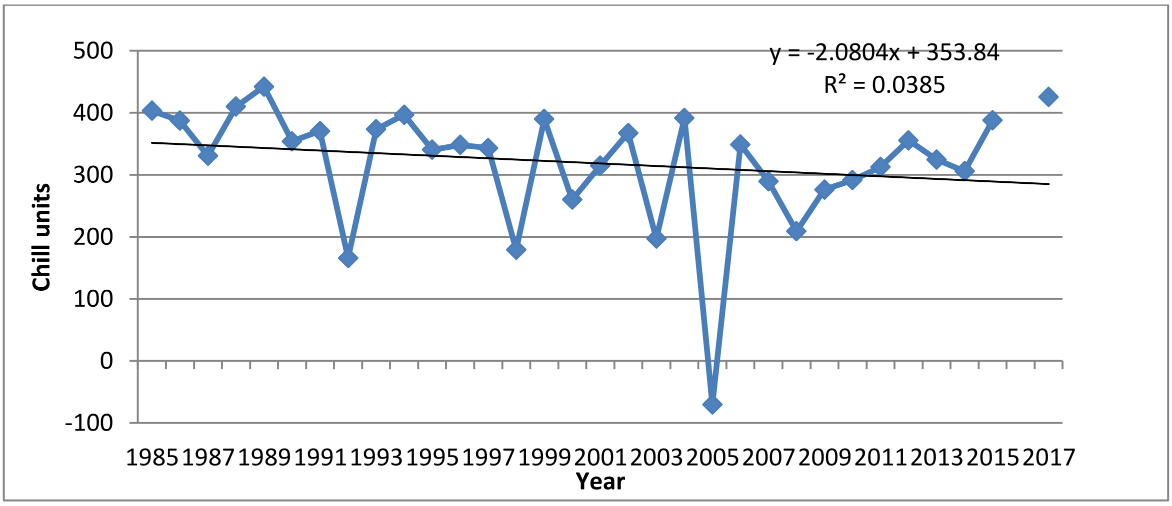

Fig. 11: Chill units trends for February at Shimla (1985-2017)

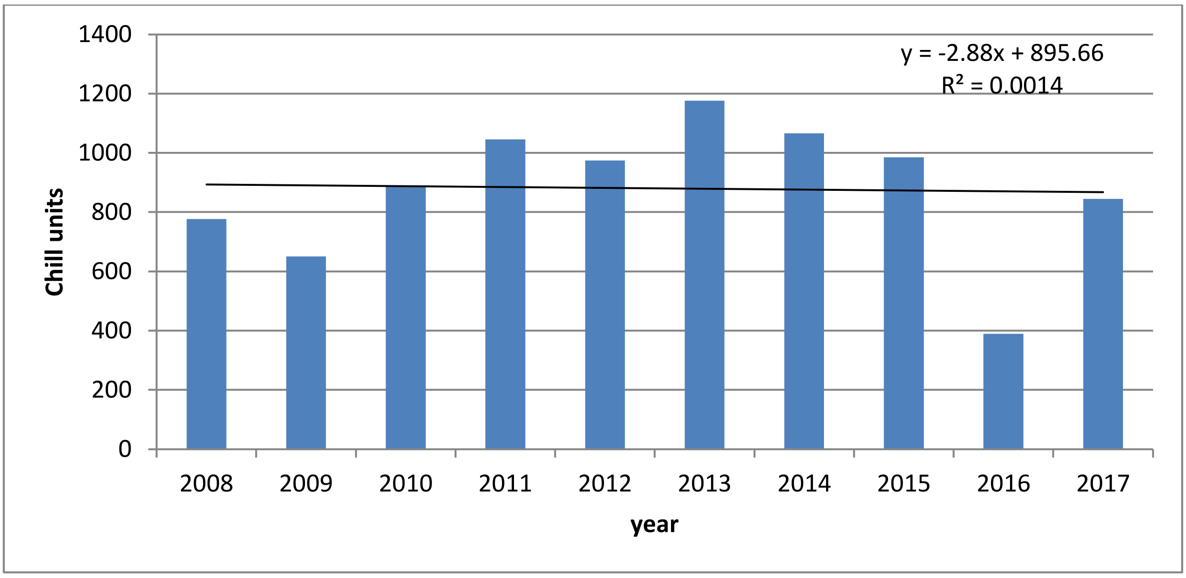

Fig. 12: Trend of cumulative chill unit at Shimla for last ten years

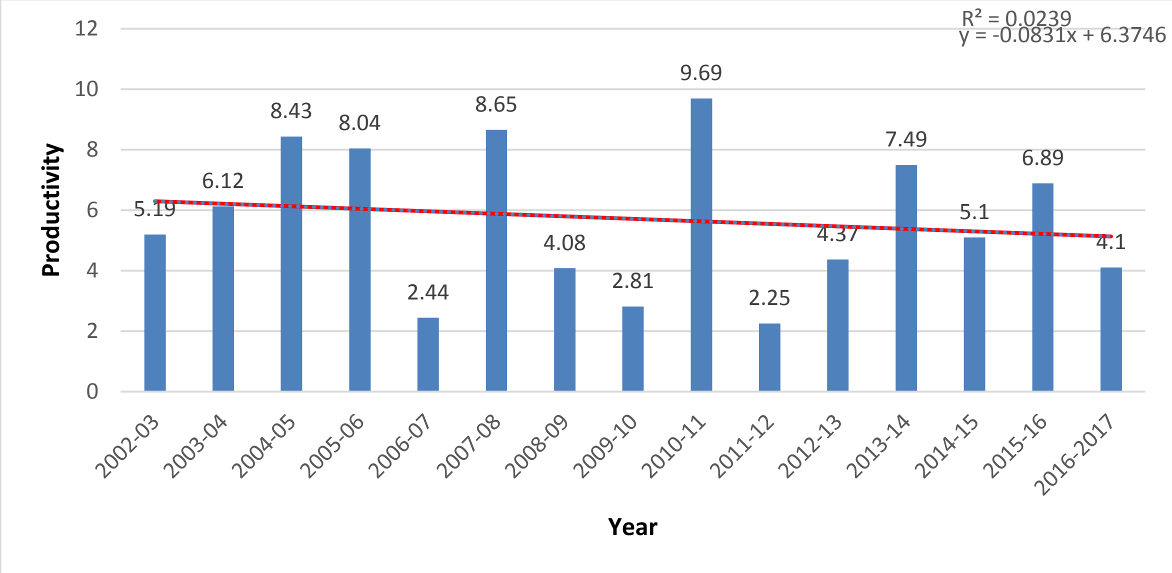

Fig. 13: Trends of apple productivity at Kullu district of HP

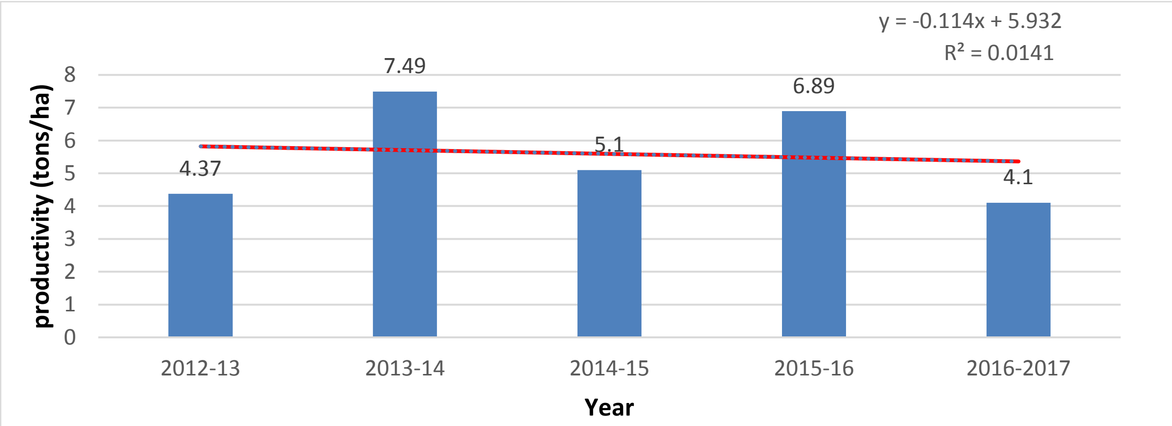

Fig. 14: Trends of apple productivity for Kullu district of HP for the last five years

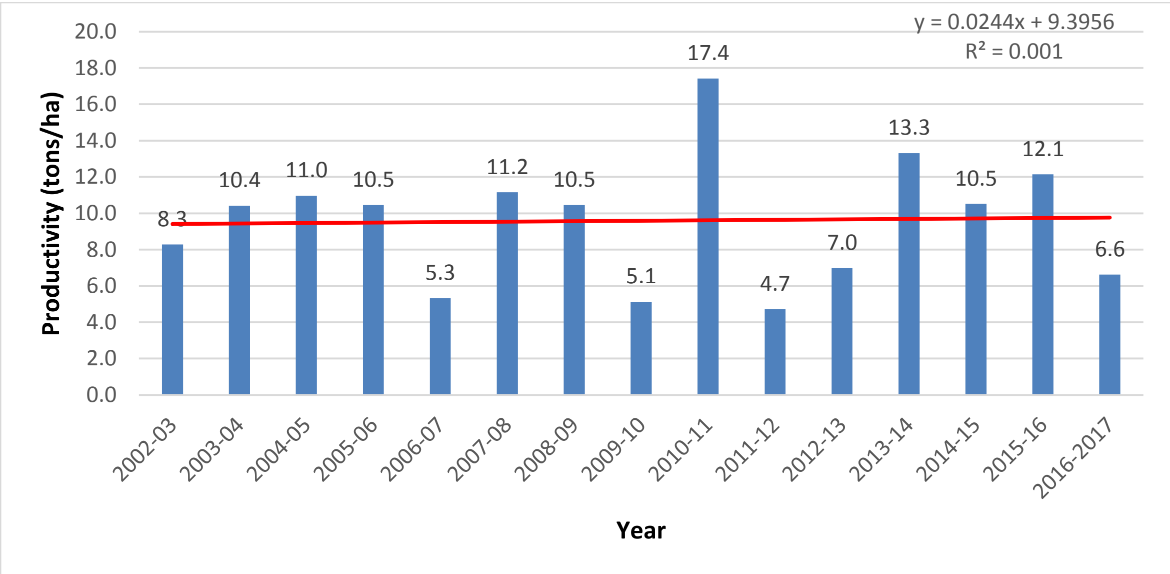

Fig. 15: Trends of apple productivity at Shimla district of HP

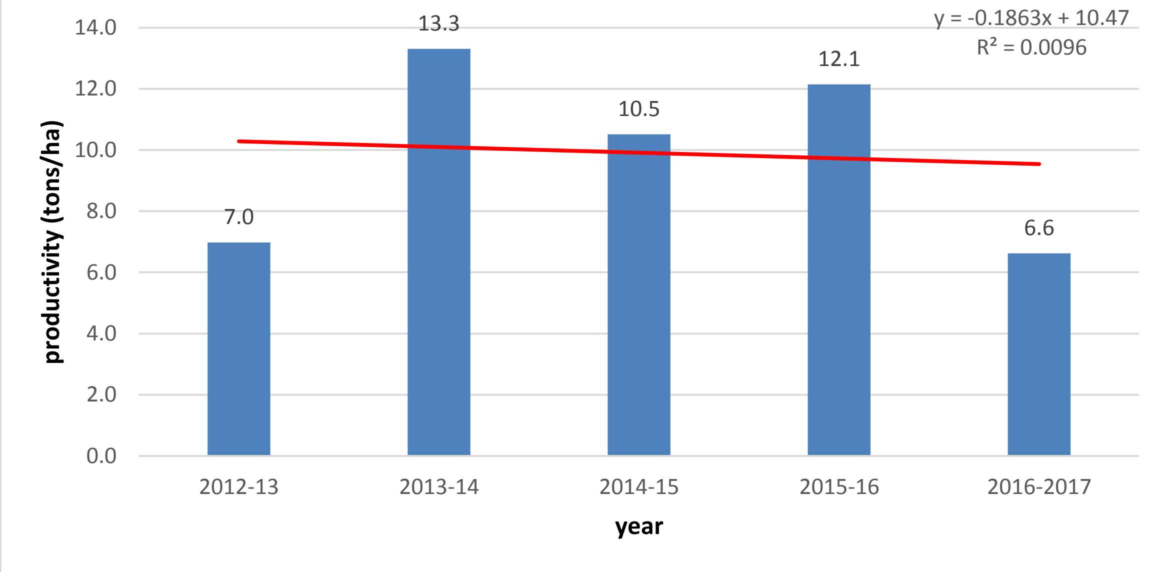

Fig. 16: Trends of apple productivity for Shimla district of HP for the last five years

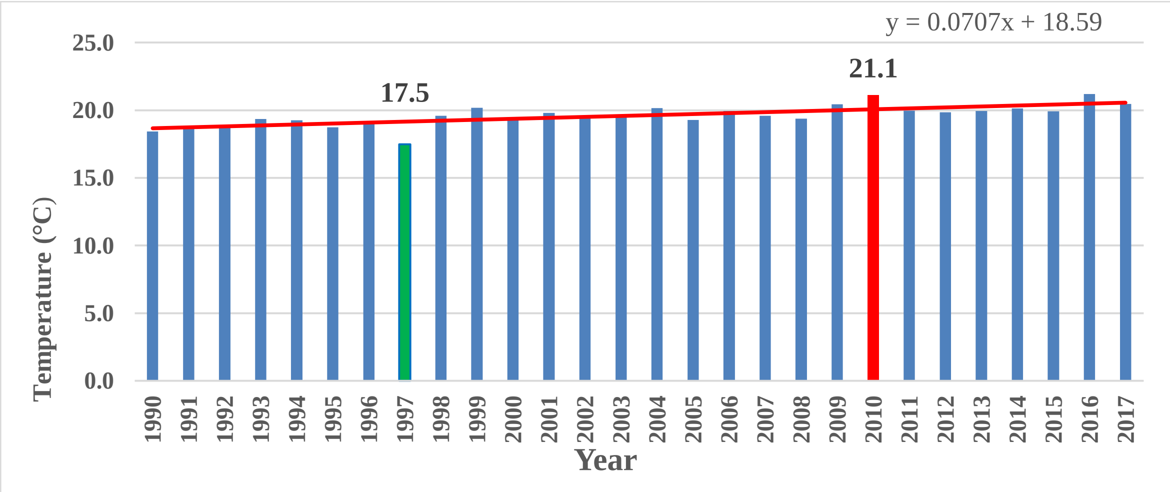

Fig. 17: Trend of annual average mean temperature at Kullu

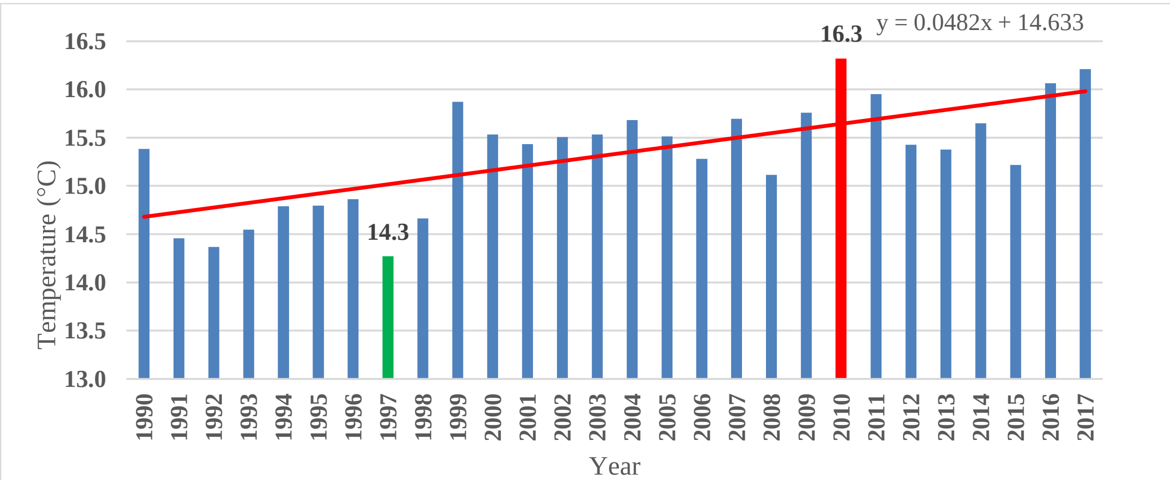

Fig. 18: Trend of annual average mean temperature at Shimla

CONCLUSION

The study revealed that air temperature for apple cultivation at mountainous region of Himachal Pradesh was higher during the accumulation of chill units. Thus, decrease in chill units which further will decrease the productivity. They may result in shift of apple belt to higher altitude.

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