

Annual and seasonal climatic variabilities at Ludhiana, Punjab

PRABHJYOT-KAUR, HARPREET SINGH AND S.S. HUNDAL

*Department of Agronomy and Agrometeorology, Punjab Agricultural University,
Ludhiana - 141 004, Punjab*

ABSTRACT

Annual and seasonal variabilities in maximum and minimum temperatures and rainfall were analyzed from historical daily meteorological data for Ludhiana (1970-2004). Two distinct crop growth seasons of *Kharif* (1 May to 31 October) and *rabi* (1 November to 30 April) were characterized for seasonal trends. The analysis of the data revealed that the climate has changed slightly over the past three decades. Both annual as well as seasonal maximum and minimum temperatures exhibited small standard deviation and coefficient of variation indicating minor variations in temperatures. The maximum temperature has remained near normal over the past three decades as the annual and *kharif* season maximum temperature revealed a slight decreasing trend while the *rabi* season maximum temperature revealed a slight increasing trend. On the other hand, the annual *Kharif* and *rabi* minimum temperature have increased significantly at the rate of 0.07 °C/year. The annual as well as seasonal rainfall exhibited high standard deviation and coefficient of variation indicating large variation in rainfall. The five yearly moving average trends in annual rainfall indicated an overall increase of about 6.5 mm/year which was mainly due to an increase in *kharif* season rainfall (9.5 mm/year) while the *rabi* season rainfall has remained nearly stable.

Introduction

Temperature and rainfall are the two important parameters, which affect crop growth and production. The past two decades have witnessed rapid increase in the awareness of global climatic changes and triggered widespread apprehension amongst scientists and governments about their implications (Gadgil, 1996). Recent reports reveal that climate is changing due to an increase in the concentration of green house gases in the atmosphere (Hundal and Abrol, 1991). A simulation study to analyse climate change impact on crop productivity in Punjab revealed that increasing temperature trends pose a serious threat towards decreasing growth and yield of cereal and oilseed crops (Hundal and Prabhjot-Kaur, 1996).

The all-India mean annual surface temperature derived from 73 stations across India showed a significant warming of 0.4 °C over the past 100 years, which is comparable to global mean trend of 0.3 °C increase per 100 years (Hingane *et al*, 1985). Wigley (1989) reported a warming of 0.5 °C by 1995-2005, 1.5 °C by 2015-

2050 and 3.0 °C by 2050-2100. Pant *et al* (1996) analyzed mean rainfall over South Asian region for a period of 1813-1980 and reported a statistically increasing long term trend. However, an analysis of a representative rainfall series over the past 176 years for India as a whole by Sontakke (1990) does not suggest any significant trend. Hundal *et al* (1997) analysed rainfall at Ludhiana over the past 95-years and reported an increasing trend for both annual as well as *Kharif* season rainfall in the past 30 years at Ludhiana.

Keeping in view the importance of climatic variability, the present study was undertaken to assess changes in rainfall and temperature at central Punjab.

Materials and Methods

The variability analysis was carried out by analyzing historical data of temperatures and rainfall for Ludhiana (30°56' N, 75°48" E, 247m above mean sea level). The daily maximum and minimum air temperatures and rainfall data of past 35 years (1970-2004) at Ludhiana was analyzed for annual as well as *kharif* (1 May to

31 October) and *rabi* (1 November-30 April) crop growing seasons, five-year moving averages, standard deviation (s.d.) and coefficient of variation (c.v.)

Results and Discussion

1. Temperature

(a) **Annual trends:** The standard deviation (s.d.) and coefficient of variation for Ludhiana station was small for maximum and minimum temperatures indicating only a minor year-to-year variation. The maximum temperature gave a s.d. 0.57°C and c.v. 1.9 per cent (Table 1). The minimum temperature variability showed s.d. 0.83°C and c.v. of 5.0 percent.

The five-yearly moving averages of annual maximum/minimum temperatures for Ludhiana are shown in Fig 1. In general, the annual maximum temperature decreased over the past three decades at Ludhiana, though no significant trend could be observed. On the other hand, the annual minimum temperature has increased at the rate of $0.07^{\circ}\text{C}/\text{year}$ over the past three decades at Ludhiana.

(b) **Kharif season trends:** Like annual temperatures the s.d. and c.v. were small for maximum and minimum temperatures during *kharif* season (Table 1). The maximum

temperature showed s.d. of 0.60°C and c.v. of 1.7 percent at Ludhiana (Table 1). The minimum temperature data showed a s.d. of 0.89°C and c.v. of 3.9 percent at Ludhiana

From the five-yearly moving averages of *kharif* season maximum/minimum temperatures for the Ludhiana station, it is evident that the maximum temperature decreased at the rate of $0.02^{\circ}\text{C}/\text{year}$ over the past three decades while minimum temperature increased significantly at the rate of $0.08^{\circ}\text{C}/\text{year}$ over the past three decades.

(c) **Rabi season trends:** The c.v. was comparatively larger for minimum temperature (9.1) as compared to maximum temperature (3.2) (Table 1). The maximum temperature showed s.d. 0.780°C and c.v. 3.2 per cent while minimum temperature gave a s.d. 0.88°C and c.v. 9.1 per cent at the Ludhiana station.

The five-year moving averages of *rabi* season maximum / minimum temperatures for Ludhiana are shown in Fig 3. At Ludhiana the *rabi* season maximum temperature showed no significant trend though a slight increase could be observed over the past three decades. On the other hand like annual and *kharif* season, the *rabi* season minimum temperature increased significantly at the rate of $0.07^{\circ}\text{C}/\text{year}$ at Ludhiana.

Table 1. Annual, *kharif* and *rabi* season temperature and rainfall features at Ludhiana

Weather parameters	Annual	<i>kharif</i> season	<i>rabi</i> season
Maximum temperature ($^{\circ}\text{C}$)			
Mean ($^{\circ}\text{C}$)	29.8	34.9	24.5
S.D. ($^{\circ}\text{C}$)	0.57	0.60	0.78
C.V. (%)	1.90	1.70	3.20
Minimum temperature ($^{\circ}\text{C}$)			
Mean ($^{\circ}\text{C}$)	16.5	23.1	9.70
S.D. ($^{\circ}\text{C}$)	0.83	0.89	0.88
C.V. (%)	5.0	3.90	9.10
Rainfall (mm)			
Mean (mm)	750	624	127
S.D. (mm)	236.8	336.8	72.6
C.V. (%)	31.5	37.9	57.2

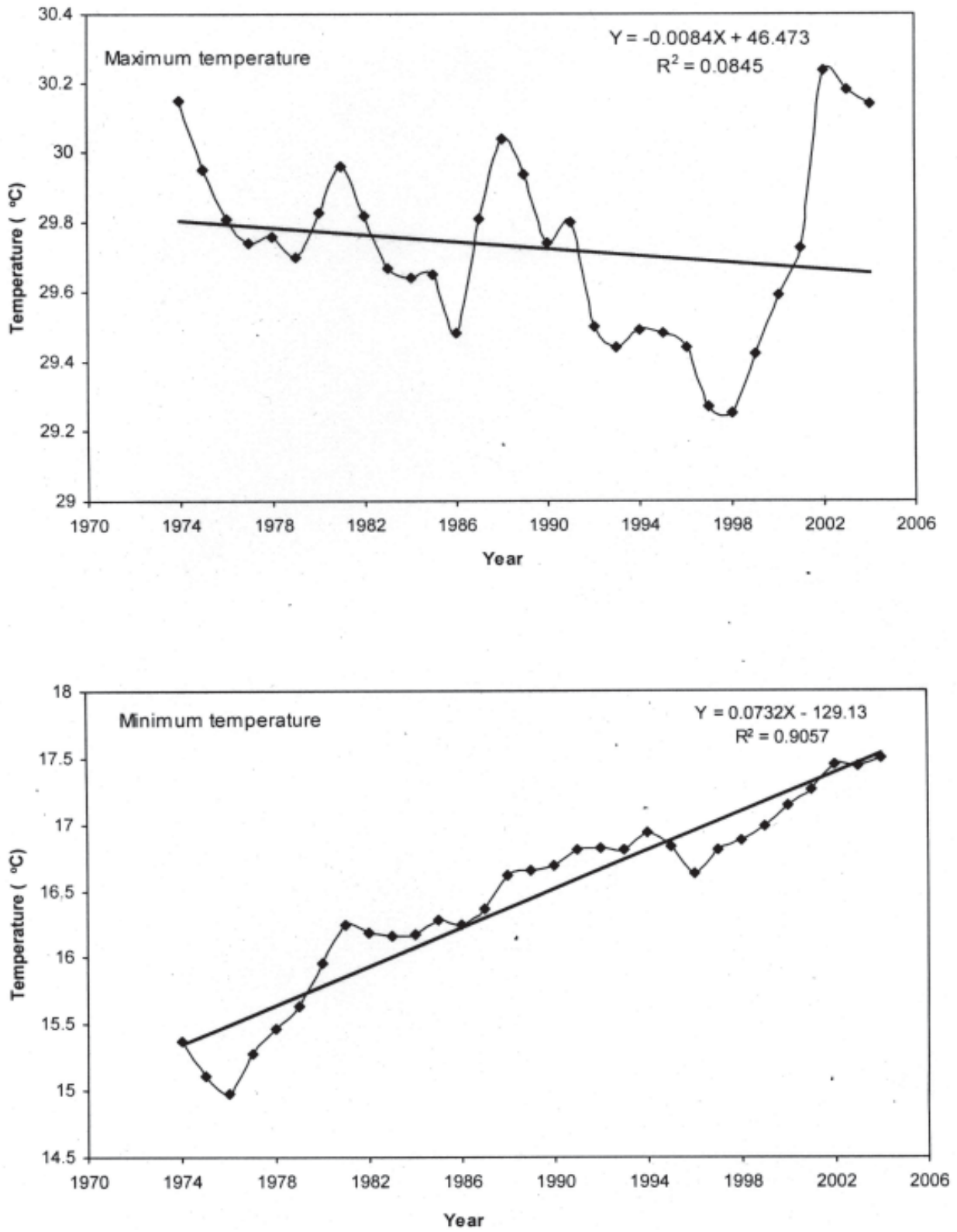


Fig. 1. Annual maximum and minimum temperature (Five yearly moving average) at Ludhiana

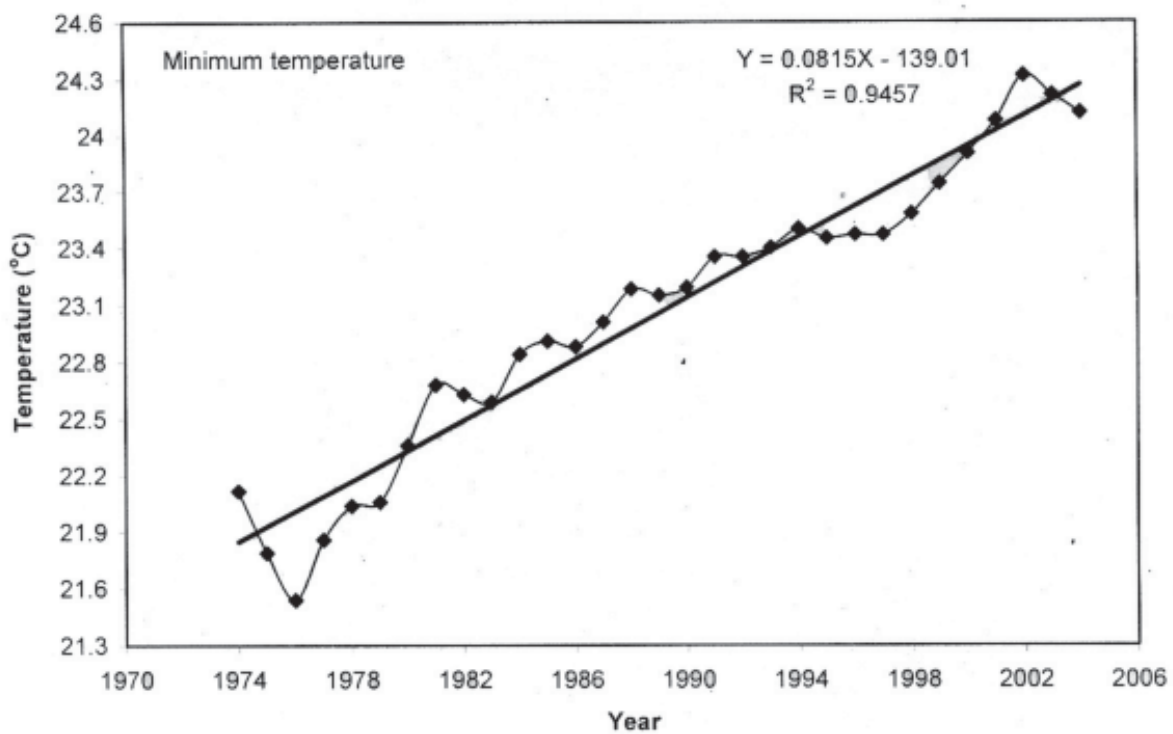
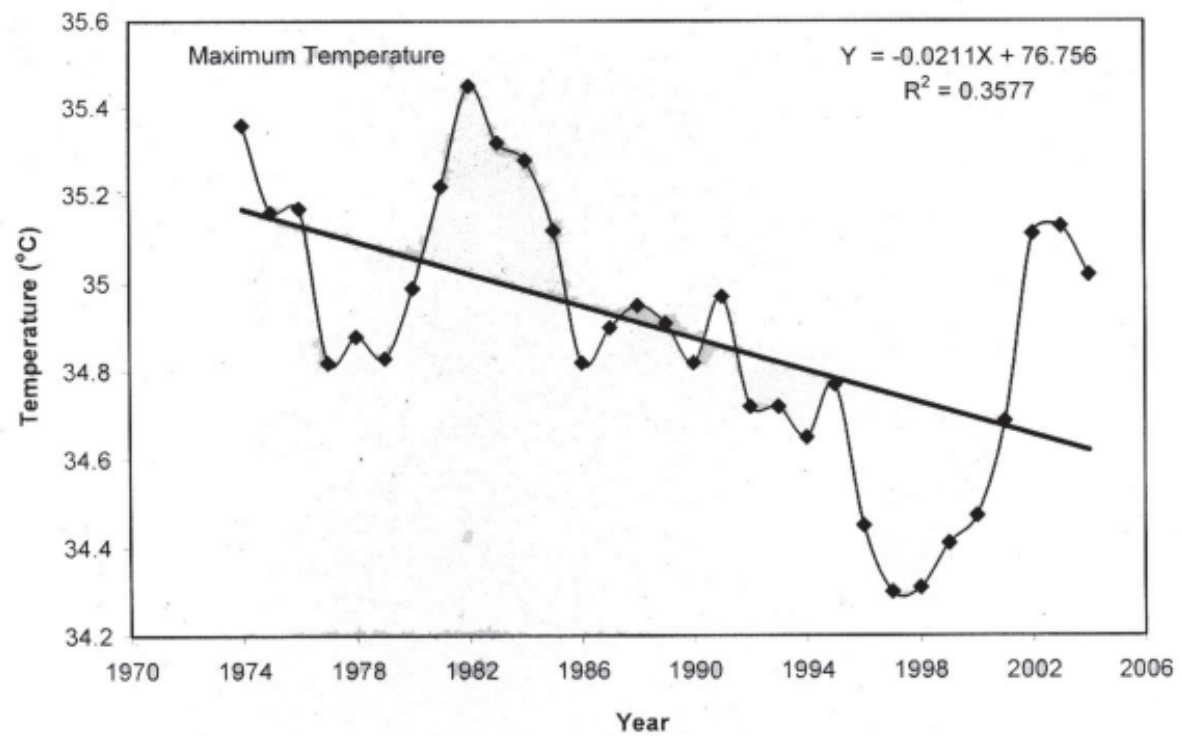


Fig. 2. Kharif season maximum and minimum temperature (Five yearly moving average) at Ludhiana

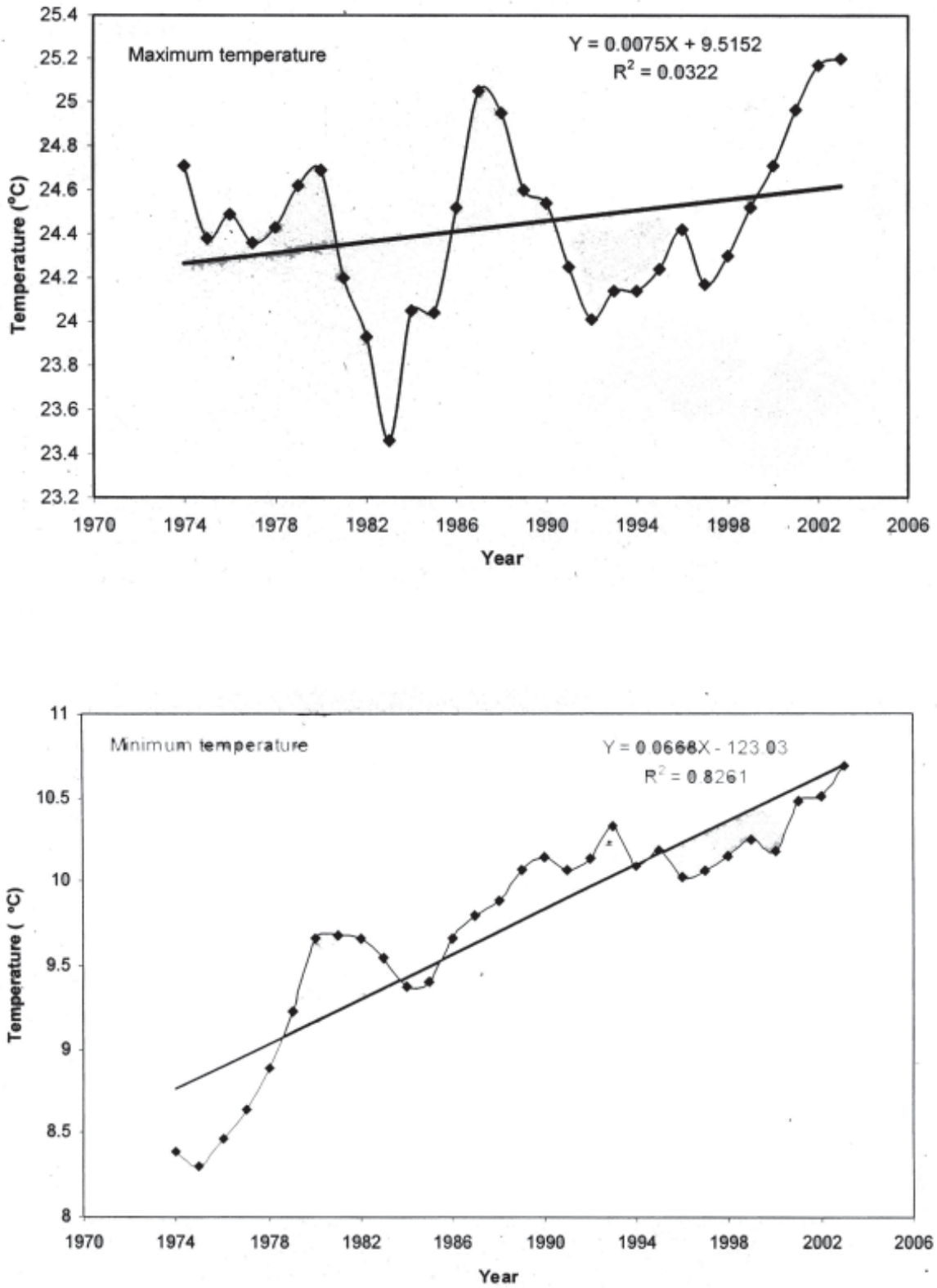


Fig. 3. Rabi season maximum and minimum temperature (Five yearly moving average) at Ludhiana

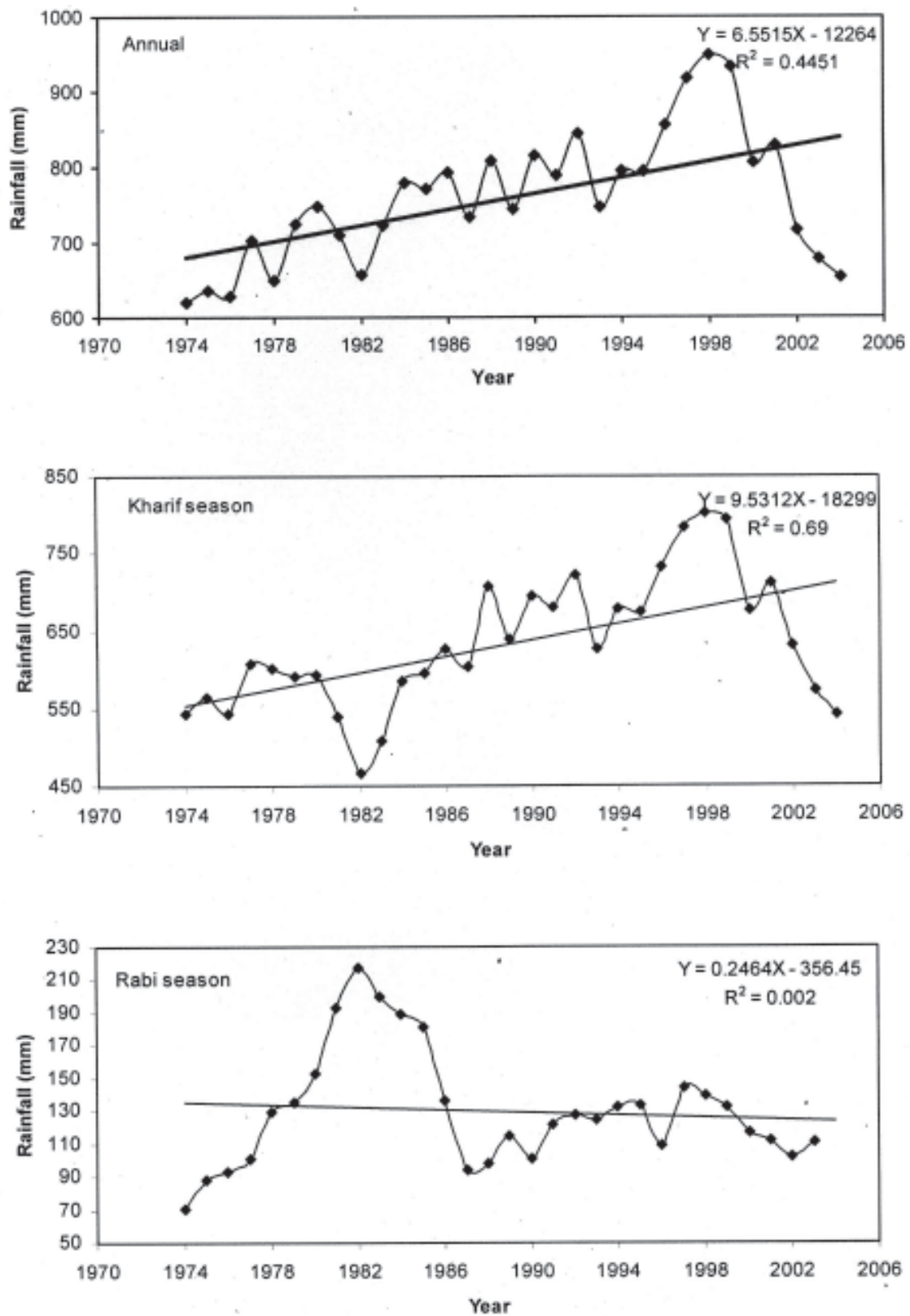


Fig. 4. Annual *kharif* and *rabi* season rainfall (Five yearly moving average) at Ludhiana

2. Rainfall

(a) Annual Trends: The rainfall variability showed a s.d. of 236.8 mm and c.v. of 31.5 per cent at Ludhiana (Table 1). The large s.d. and c.v. values for annual rainfall for the time series indicates high variability in annual rainfall for Ludhiana station. The five-year moving average of annual rainfall revealed that rainfall increased significantly at the rate of 6.6 mm/year over the past three decades at Ludhiana.

(b) Kharif season trends: The rainfall variability gave a s.d. of 336.8 mm and c.v. of 37.9 per cent for Ludhiana. The large s.d. and c.v. for *kharif* season rainfall for the time series indicate high variability in seasonal rainfall at central Punjab. In general, the *Kharif* season rainfall increased at the rate of 9.5 mm/year thereby indicating that increase in annual rainfall was due to increase in *kharif* season rainfall (Fig 4).

(c) Rabi season trends: The *rabi* season rainfall accounts for 17 per cent of the total rainfall. The rainfall variability showed a s.d. of 72.6 mm with c.v. of 57.2 per cent at Ludhiana. The s.d. values are comparably smaller but c.v. values were comparably larger for *rabi* season rainfall as compared to annual and *kharif* season rainfall at Ludhiana. No significant trend was observed in the *rabi* season rainfall over the past three decades (Fig 4).

The analysis in this study indicated that the minimum temperature and rainfall increased significantly over the past three decades at Ludhiana. However, the maximum temperature decreased only slightly over the past three decades.

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