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Climatological study of severe cold waves and probabilities of minimum temperature over Sabour (Bihar)

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ABSTRACTS

Minimum temperature data for the winter months at Sabour (Bihar, India) during December 1979- February 2003 have been analysed to work out frequency of cold waves. The number of events with zero or negative minimum temperature during the study period were 400, with maximum in the month of January. Mild categories were found to be maximum in all the months varying from 40 percent in January to 50 percent in February, with severe categories account for 0.4 to 5 % of events in all months. In January, cold wave had always been severe. Yield reduction of the *rabi* maize (70 %), wheat (55 %) and mustard (60 %) crops were reported due to higher minimum temperature in December 2002 and February 2003 and only how minimum temperature during January 2003, due to cold wave occurrence.

Key words: Minimum temperature, Departure and cold waves.

Most of the severe cold waves are the manifestations of intense western disturbances, which are more common in winter over the northern region of India. The western disturbance synoptic system affects Indo-gangetic plains as it moves eastwards. Occasionally, the North - eastern states are also affected. Raghavan (1967) and Bedekar *et al.*, (1974) studied occurrence of cold waves that prevailed over Indian sub continent during 1911 to 1967. Recently more such studies have been reported by Jain and Dubey (1991) for Bhopal region, Samui and Gupta (1992) and Attri *et al.* (1995) for stations in Sikkim. Ram Singh (2003) reported a climatological study on minimum temperature at Hisar in Haryana state. The temperatures fall rapidly during October and drop down to sub-zero temperatures during winter. In mid Himalayan region during grain filling stage of amaranthus, even 1°C drop in minimum temperature in October, results in drastic yield reduction was observed (Murty *et al.* 2000, Pant *et. al.* 1988 and Murty, *et. al.* 2004). Early sown rabi maize in more than 36,000 hectares was adversely affected by cold wave of December 2002- February 2003 with 70-80 % loss in seed setting in Bihar (Samara *et. al.* 2004). The present study is an attempt in this direction for Sabour region in Bihar state. The main crops in the region during winter season are wheat, gram and mustard.

MATERIAL AND METHODS

The data on daily minimum temperature at Sabour, Bhagalpur district,

Table 1: Extreme values of minimum temperature (°C) at Sabour, Bihar (December 1979-February 2003)

Months	Extremes						Minimum temperature (°C)		
	Highest temperature (°C)			Lowest temperature (°C)					
	Date	Year	Value	Date	Year	Value	Mean	CV (%)	SD
December	7	1994	18.5	23	1997	4.2	9.8	23.8	2.3
January	21	2002	19.2	22	2003	1.2	8.2	33.3	2.7
February	26	2001	18.5	4	2001	3.8	10.6	25.7	2.7

for the period from December 1979-February 2003 were collected from the Department of Agronomy, Bihar Agriculture college, Sabour (Bihar). The daily minimum temperatures were converted to monthly, seasonly and yearly average for statistical analysis (Deka *et.al.* 2002 and Murty *et.al* 2004) and were also analyzed with respect to the normal minimum temperature, the number of events with minimum temperature below zero and the daily departure of minimum temperature from the normal.

The number of cold wave events was computed as per criteria given by India Meteorological Department (IMD) as below:

Severe cold wave conditions are said to prevail when the minimum temperature departure from its normal deviates by –7°C over a region where the normal minimum temperature is more than or equal to 10°C and departure of –5°C for a region where the normal minimum temperature is less than 10°C. Similarly, cold wave is said to period when the minimum temperature departures from normal lies between –5°C to –6°C over the region where normal minimum temperature is more than or equal to 10°C and where departure is by –3°C to –4°C for a region where normal minimum temperature is less than 10°C.

RESULTS AND DISCUSSION

The highest and the lowest minimum temperature recorded at Sabour in winter season viz., December January and February during December1979-February 2003 are given in Table-1. During winter months, the highest minimum temperature of 19.2°C was recorded on 21st January 2002 and the lowest of 1.2°C was recorded on 22nd January 2003 during the study period. The highest minimum temperature for month of February is 18.5°C reported on 26th during the year 2001.The mean minimum temperature varied between 8.2°C to 10.6°C.The coefficient of variation was the highest in January and was the lowest in the month of December. The standard deviation was the highest in January and February, and was the lowest in December (Table 1).

Table 2: Number of days with below normal minimum temperature (°C) at Sabour; Bihar (December1979-February 2003)

Years	Dec.	Jan.	Feb	Total
1979	12	-	-	12
1980	15	17	14	46
1981	13	14	14	41
1982	18	12	17	47
1983	18	17	16	51
1984	18	17	16	51
1985	11	12	22	45
1986	10	16	14	40
1987	16	15	12	43
1988	18	18	18	54
1989	19	22	20	61
1990	19	12	7	38
1991	22	21	10	53
1992	25	19	28	72
1993	17	18	14	49
1994	19	10	18	47
1995	13	21	15	49
1996	30	12	13	55
1997	8	26	19	53
1998	14	12	12	38
1999	8	18	8	34
2000	23	12	17	52
2001	13	23	15	51
2002	11	15	10	36
2003	-	21	5	26
Total	390	400	354	1144

Total number of events (days) when minimum temperature (Table 2) was recorded either as zero or negative were counted as 1144 out of total number of 2166 observation during the last 25 years and

Table 3: Number of cases (%) in different ranges of departure of minimum temperature (°C) from normal at Sabour (December 1979-February 2003).

Months	Nearly normal (-1.4°C to +1.4°C)	Above normal (+1.5 °C to +3.4°C)	Appreciably Above normal (+3.5°C to +5.4°C)	Markedly above normal (≥ +5.5°C)	Below normal (-1.5°C to -3.4°C)	Appreciably Below normal (-3.5°C to -5.4°C)	Markedly Below normal (≤ - 5.5°C)
December	49	14	6	2	23	5	1
January	45	13	8	4	21	8	1
February	39	18	7	3	23	9	1

maximum number (400) occurred in the month of January.

Departure of minimum temperature:

Number of cases (%) in different ranges of the percentage departure of minimum temperature from the normal values in different categories is given in Table 3. The cases of near normal were found maximum in all the months varying from 39 percent in February to 49 in December. The second place (21-23 %) was occupied by below normal categories in all the months.

The different categories of cold wave condition (mild, Moderate and severe) are more than 50 percent from normal for all three months of winter. Mild categories were found maximum in all the months varying from 40 percent in January to 50 percent in February. Normal conditions account for 46-48 percent of events. In Sabour region, December and February month recorded moderate cold wave while in January, cold waves had always been severe (Table 4) when they occurred.

Daily minimum temperature variations during December 2002 to February 2003 in relation to normal minimum temperature for the corresponding dates are depicted in Fig.1. As far as minimum temperature is concerned, there were three significant events during the crop growth period. Two period above - normal minimum temperature (i) from 11 to 26th December 2002 and 1 to 14th February 2003 (ii) below - normal minimum temperature with cold wave conditions between 6 to 26th January 2003 .The effect of this pattern of low minimum temperature on yield is presented in Table 5. All the three crops nearly *rabi* maize, wheat and mustard recorded much below normal yields. Comparatively mustard crop yield is seen to be less affected .In this period phenophase of different crops maize, wheat and mustard are given in Table 5. It was observed that maize had shortened internodal length, thick stalk and stunted growth. The influence of low minimum temperature occurring at the different growth stages of these crops on final yield is evident. Field observation showed that at that time wheat was at seedling stage and mustard at flowering stage. But during 6th to 26th January 2003, lower temperature resulted in poor tassel development, restricted growth of anther lobe and filament, pollen availability and viability was badly affected, silk emergence was delayed and perhaps became non - synchronous with pollen availability. Due to excessive cold, seed setting was as low as 20-30 percent in early sown winter maize; flowering in early planted maize escaped cold and gave 70 to 100 % seed setting. Sheltered sowing near villages and orchards suffered less damage.

Rabi maize being a thermophilic species requires temperatures above the threshold limits (average day and night temperatures above 10 and 4.4 °C, respectively). It is known that exposure of maize to short photoperiods and cool nights (<5°C) for more than 3 days during flowering causes severe male sterility.

Table 4: Frequency of number of events under different categories at Sabour (December 1979-February 2003).

Months	Number of events under			Total	Normal
	Mild	Moderate	Severe		
December	336 (45%)	31 (4%)	22 (3%)	389 (52%)	355 (48%)
January	301 (40%)	62 (8%)	36 (5 %)	399 (54%)	345 (46%)
February	341 (50.3 %)	9 (1.3 %)	3 (0.4 %)	353 (52%)	325 (48 %)

Table 5: Yield as affected by minimum temperature prevailing at different stages of crops at Sabour (December02- February 03).

Period	Crops		
	Phenophase		
	Rabi Maize	Wheat	Mustard
11-26 December 2002	Knee height	Seedling	Flowering
6-26 January 2003	Grand growth	Crown root initiation	Pod formation
1-14 February 2003	Tasseling & milking	Tillering	Maturity
Yield (q / ha)	15-18	15-20	3-4
Average yield (q / ha)	60-65	30-35	8-10

Further, the concentration and activity of floral hormones such as gibberellins and cytokinins, and other essential enzymes are known to decline sharply under low temperature conditions.

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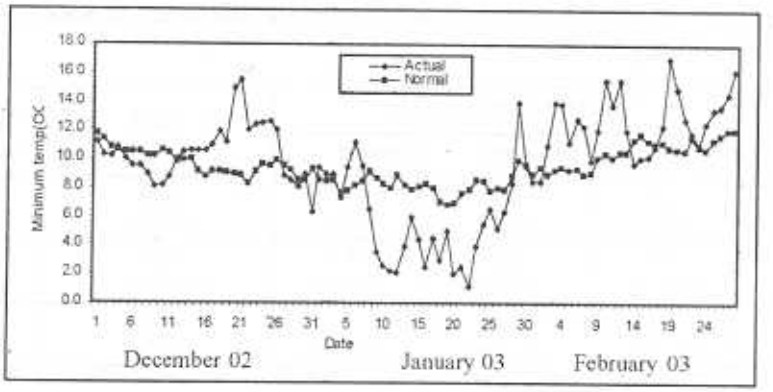

Fig. 1: Daily minimum temperature of December 2002- February 2003 and average (December1979- February 2002) minimum temperature at Sabour, Bihar.

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