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Weather Elements and Frost Occurrence in Arid Zone of Haryana

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Abstract: The study was conducted at CCS Haryana Agricultural University Hisar. The daily meteorological data of winter seasons (December to February) of past 20 years from 1982 to 2002 were used. Mean frosty days were maximum in January (12.7) followed by December (8.5) and February (5.7). The CV was less in January as compared to December and February. Maximum probability of frost occurrence was 0.70 on 24th January. Grass minimum temperature was correlated with weather parameters of two preceding days. Grass minimum temperature was significantly correlated with minimum temperature; morning and evening actual vapor pressure and morning and evening relative humidity. Minimum temperature and morning actual vapor pressure of previous day (logarithmic relationship) individually explained the variability in grass minimum temperature of next day up to 76%.

Key words: Frost, grass minimum temperature.

Environment has a pronounced effect on growth and development of plants. They can grow only in certain limits of temperature. Most of the crop plants are injured and killed when night temperature is very low. Low temperature interferes with the plant metabolism also. Singh and Jaipal (1983) studied the relationship between minimum temperature and other weather elements and concluded that the maximum temperature had insignificant influence on next day's minimum temperature during January. Attri *et al.* (1995) studied day to day change, departure and persistence of minimum temperature and frequency of cold waves over Gangtok from November to March for the years 1969 to 1992. Khushu *et al.* (2000) also studied the impact of weather on growth and yield of mustard and found that minimum temperature between flower bud initiation and pod formation was negatively associated with seed yield. Therefore, a study was conducted on frost occurrence in arid zone of Haryana.

Materials and Methods

The study was conducted at the Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar, situated at 29°10′N, 75°46′E and 215.2 m amsl. The daily meteorological data of winter seasons (December to February) of past 20 years from 1982 to 2002 of Hisar representing the arid zone of Haryana were taken from the Agromet observatory, CCS Haryana Agricultural University, Hisar, on the parameters: maximum, minimum and grass minimum temperature (°C), actual vapor pressure (mm of Hg), relative humidity (%), wind speed (kmph), sunshine (h) and evaporation (mm). Date of frost occurrence was taken as the date on which grass minimum temperature is less than 0°C.

Frost occurrence probability

Probability of frost occurrence was determined using the formula:

$$\text{Probability} = \frac{\text{Forest events (days)}}{\text{Total number of observations}}$$

Correlation and regression

Correlation and stepwise regression analysis was carried out to quantify the relationship of frost occurrence with previous $(n-1)^{th}$ day and previous to previous $(n-2)^{th}$ day weather parameters and its impact on mustard productivity. Linear, multiple, exponential and logarithmic expressions were used for regression.

Results and Discussion

Frosty days

Mean frosty days were maximum in January (12.7) followed by December (8.5) and February (5.7) as given in Table 1. The mean value of total frosty days during winter season was 26.9. Coefficient of variation was less in January as compared to December and February. In past 20 years, the frosty days were highest (67) in 1996-97

Table 1. Frost occurrence and its continuity in winter season from 1982-2002

	Frost days				Frost continuity		
Year	December	January	February	Total	December	January	February
1982-83	7	18	8	33	4 (24-27)	8 (18-25)	5 (1-5)
1983-84	6	20	13	39	3 (10-12)	8 (24-31)	7 (21-27)
1984-85	5	14	11	30	5 (25-29)	4 (28-31)	6 (10-15)
1985-86	3	21	4	28	2 (9-10)	8 (2-9)	2 (6-7)
1986-87	18	9	0	27	21 (14-3 Jan)	5 (24-28)	0
1987-88	7	8	5	20	6 (4-9)	4 (24-27)	3 (2-4)
1988-89	1	17	9	27	0	6 (10-15)	6 (7-12)
1989-90	8	4	5	17	4 (4-7)	2 (9-10)	5 (1-5)
1990-91	5	9	2	16	4 (20-23)	3 (17-19)	0
1991-92	3	15	8	26	8 (30-6 Jan)	9 (12-20)	3 (9-11)
1992-93	7	1	3	24	4 (14-17)	11 (17-21)	3 (20-22)
1993-94	19	10	1	30	14 (14-27)	3 (30-1 Feb)	0
1994-95	13	5	1	19	11 (11-21)	3 (31 Dec-2 Jan)	2 (31 Jan-1 Feb)
1995-96	9	17	5	31	5 (1-5)	11 (26-5 Feb)	0
1996-97	26	27	14	67	23 (27-18 Jan)	11 (28-7 Feb)	5 (17-21)
1997-98	1	14	3	18	4 (31-3 Jan)	11 (16-26)	3 (5-7)
1998-99	4	0	2	6	3 (11-13)	0	2 (4-5)
1999-00	3	5	0	8	2 (25-26)	5 (15-19)	0
2000-01	19	15	12	46	9 (19-27)	7 (14-20)	12 (1-12)
2001-02	5	13	8	26	5 (21-25)	10 (27-5 Feb)	3 (8-10)
Mean	8.5	12.7	5.7	26.9	6.9	6.5	3.4
C.V. (%)	79.7	50.4	75.4	48.3	86.0	50.8	85.3

Table 2. Regression equations for the prediction of grass minimum temperature with weather parameters of (n-l) and (n-2)th day

	Equation	R^2
(n-l)th day	$Y= 0.2755x_1-2.8925$	0.75
	$Y= 0.6435x_2-5.817$	0.75
	$Y= 0.9804Ln\ (x_1)-3.0701$	0.76
	$Y= 4.1216Ln\ (x_2)-9.3264$	0.76
	$Y= -5.42+8.07\ x_1+0.50\ x_2$	0.73
	$Y= -5.20+9.74\ x_1-0.39\ x_2+5.36x_3$	0.73
(n-2)th day	$Y= 0.2835x_1-2.674$	0.64
	$Y= 0.6784x_2-5.8051\ x_1$	0.70
	$Y= 0.9978Ln\ (x_1)-2.7903$	0.67
	$Y= 4.0676Ln\ (x_2)-9.0039$	0.70
	$Y= -5.26+0.114x_1+0.53x_2$	0.53
	$Y= -5.39+0.0994\ x_1+0.346x_2+0.193x_3$	0.57

Y= Grass minimum temperature (°C)
x_1= Minimum temperature (°C),
x_2= Morning actual vapor pressure (mm of Hg)
x_3= Evening actual vapor pressure (mm of Hg), Ln= Log with base 'e'.

and lowest (6) in 1998-99. In January 1998-99, February 1986-87 and 1999-2000, no frost was observed. Subbaramayya and Rao (1976) reported that frequency of cold waves is maximum in January in the whole country. This is also confirmed by the findings of Vashisth and Pareek (1991). Maximum continuous spell of frosty days (Table 1) was observed in 1996-97 (23) from 27th December to 18th January and no continuous spell was observed in December 1988-89, January 1998-99, February 1986-87, 1990-91, 1993-94, 1995-96 and 1999-2000.

Daily probability of frost occurrence

Probability of frost occurrence in December was less in 1st fortnight as compared to 2nd fortnight. During January, it was higher throughout the month and ranged between 0.20 and 0.70. In February, the probability was higher in 1st fortnight as compared to the 2nd. It was nearly zero in last week of February. Maximum probability of frost occurrence was 0.70 on 24th January and minimum probability was zero on 28th and 29th February.

Relationship of grass minimum temperature with weather parameters

Weather parameters of (n-1)th day were better correlated with grass minimum temperature as compared to those of (n-2)th day. Grass minimum temperature was significantly correlated with minimum temperature (0.87); morning and evening actual vapor pressure (0.85 and 0.60) and morning relative humidity (0.40) of (n-1)th day. The corresponding values for weather parameters of (n-2)th day were 0.82 (minimum temperature); 0.84 and 0.60 (morning and evening actual vapor pressure) and morning relative humidity (0.41). Among the weather parameters, minimum

temperature of two preceding days was best associated with grass minimum temperature. Bootsma (1976) concluded that minimum temperature measured on a clear calm night was highly correlated with estimated frost dates.

Significant logarithmic relationship was observed between grass minimum temperature and minimum temperature and morning actual vapor pressure of preceding two days (Table 2). The variability in grass minimum temperature explained by logarithmic relationship with minimum temperature and morning vapor pressure of $(n-2)^{th}$ day was 67 and 70%, respectively. However, R^2 values of linear relationships were lower as compared to R^2 values of logarithmic relationship. The weather parameters of $(n-1)^{th}$ day collectively explained better variability in grass minimum temperature in comparison with the parameters of $(n-2)^{th}$ day. Attri *et al.* (1995) formulated regression models for forecasting of minimum temperature with knowledge of dew point, cloud amount, maximum and minimum temperature recorded on previous day. Varshali and Allice (1997) also developed regression model using previous day's weather data for prediction of minimum temperature with an accuracy of 74%.

Conclusions

- Maximum probability of frost occurrence was 0.70 on 24^{th} January.
- Minimum temperature and morning actual vapor pressure of previous day individually explained the variability in grass minimum temperature of next day up to 76%.

References

Attri, S.D., Pandya, A.B. and Dubey, D.P. 1995. Forecasting of minimum temperature over Gangtok. *Mausam* 46(1): 63-68.

Bootsma, A. 1976. Estimating minimum temperature and climatological freeze risk in hilly terrain. *Agricultural Meteorology* 16: 425-443.

Khushu, M.K., Raina, A.K. and Sharma, K.D. 2000. Impact of weather on growth and yield of mustard. *Cruciferare Newsletter* 22: 75-76.

Singh, D. and Jaipal 1983. On forecasting night minimum temperatures over New Delhi. *Mausam* 34(2): 185-188.

Subbaramayya, I. and Surya Rao, D.A. 1976. Heat and cold waves in different states of India. *Indian Journal of Meteorology & Hydrological Geophysics* 27(4): 436-440.

Varshali, D. and Alice, P. 1997. Climatological study of severe cold waves and prediction of minimum temperature over Niphad. *Geographical Review of India* 59(2): 101-110.

Vashisth, R.C. and Pareek, R.S. 1991. Forecasting of minimum temperature at Jaipur and South Rajasthan. *Mausam* 42(1): 113-116.