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PREDICTION OF MINIMUM TEMPERATURE AT HISAR

1. Temperature exerts major control in agricultural production through the thresholds of its critical values. Frost hazards occur when the minimum temperature falls below freezing point and crops are adversely affected (Mather, 1974). Therefore, farmers are very interested in having an accurate forecast of minimum temperature during winter season. The minimum temperatures are generally controlled by advection of air and amount of local cooling at the ground surface and adjoining layers of the atmosphere due to radiation and convection. Cooling is further influenced by composition of soil, moisture content in soil and atmosphere, clouds, surface winds and topographical features of an area. Minimum temperature depends on several complicated physical processes involving net flux of terrestrial radiation, transport of heat by turbulence in air, latent heat transfer, heat conducted within the soil to or from earth's surface, total insolation etc. (Haltiner and Martin, 1957). Quite a lot of work has already been done for forecasting daily minimum temperature by developing regression models and techniques such as Vashishtha and Pareek (1991), Attri *et. al*. (1995) and Deosthali and Payyappalli (1997). Present study is also an attempt in this direction to predict minimum temperature during three months of winter season at Hisar station.

2. The daily data on minimum, maximum and grass minimum temperatures; morning and evening time actual vapour pressure; sunshine hours and wind speed during the months of December, January and February for Hisar station (Lat. 29° 10' N, Long. 75° 46' E and Alt. 215.2m msl) from December 1969 to February 2001, were used in the present study. The minimum temperature has been taken as dependent variable, whereas all the weather elements of $(n\text{-}1)^{th}$ and $(n\text{-}2)^{th}$ days mentioned above have been taken as independent variables in the regression equations. The minimum temperature of n^{th} day has been correlated with the weather parameters of $(n\text{-}1)^{th}$ and $(n\text{-}2)^{th}$ days. Simple and multiple linear regression equations have been developed for prediction of minimum temperature using the significant weather parameters of $(n\text{-}1)^{th}$ and $(n\text{-}2)^{th}$ days by stepwise multiple regression technique as given below :

$$Y = \mathrm{a} + \mathrm{b}X$$

$$Y = \mathrm{a} + \mathrm{b}X_1+\mathrm{c}X_2+\mathrm{d}X_3+\mathrm{e}X_4+\mathrm{f}X_5+\mathrm{g}X_6+\mathrm{h}X_7$$

Where, $(n\text{-}1)^{th}$ = previous day, $(n\text{-}2)^{th}$ = previous to previous day

Y = Predicted minimum temperature

X = Weather parameters

X_1 = Maximum temperature

X_2 = Minimum temperature

X_3 = Grass minimum temperature

X_4 = Morning actual vapour pressure

TABLE 1

Correlation coefficients (*r*) between minimum temperature of n^{th} day and weather parameters of (*n*-1)th and (*n*-2)th days

Minimum temp. of n^{th} day		Weather parameters						
	Observation days	X_1	X_2	X_3	X_4	X_5	X_6	X_7
	$(n\text{-}1)^{th}$ day	0.48	0.82	0.47	0.60	0.62	-0.12*	0.57
	$(n\text{-}2)^{th}$ day	0.48	0.70	0.37	0.50	0.52	-0.10*	0.52

*Non-significant at 1% level of confidence

TABLE 2

Simple linear regression equations for prediction of minimum temperature using values of individual significant weather variables of (*n*-1)th and (*n*-2)th days

Weather parameters	Regression equation	*R^2
$(n\text{-}1)^{th}$ day	$Y = -3.696 + 0.423\,X_1$	0.23
	$Y = 1.013 + 0.821\,X_2$	0.67
	$Y = 4.978 + 0.634\,X_3$	0.22
	$Y = 1.790 + 1.252\,X_4$	0.36
	$Y = -2.109 + 1.174\,X_5$	0.38
	$Y = 2.610 + 0.569\,X_7$	0.33
$(n\text{-}2)^{th}$ day	$Y = -3.817 + 0.429\,X_1$	0.24
	$Y = 1.691 + 0.700\,X_2$	0.49
	$Y = 5.126 + 0.494\,X_3$	0.14
	$Y = -0.515 + 1.038\,X_4$	0.25
	$Y = -0.811 + 0.978\,X_5$	0.27
	$Y = 2.902 + 0.516\,X_7$	0.23

*R^2 – Coefficient of determination

TABLE 3

Multiple regression models for prediction of minimum temperature using values of weather variables of (*n*-1)th and (*n*-2)th days

Weather parameters	*Regression models*	R^2
$(n\text{-}1)^{th}$ day	$Y = 1.081+0.83X_2-0.19X_4+0.15X_5$	0.68
	$Y = -0.256+0.07X_1+0.82X_2-0.05X_3-0.19X_4+0.14X_5$	0.68
	$Y = -0.255+0.069X_1+0.82X_2-0.047X_3-0.19X_4+0.135X_5+0.003X_6$	0.68
	$Y = 0.023 - 0.063\,X_1 + 0.802\,X_2 - 0.054\,X_3 - 0.223\,X_4 + 0.118\,X_5 + 0.055\,X_7$	0.69
$(n\text{-}2)^{th}$ day	$Y = 1.589 + 0.691\,X_2 + 0.023\,X_5$	0.49
	$Y = 1.721 + 0.647\,X_2 - 0.514\,X_5 + 0.116\,X_7$	0.50
	$Y = 2.281 + 0.70\,X_2 - 0.232\,X_4 + 0.025\,X_5 + 0.118\,X_7$	0.50
	$Y = -0.658 + 0.146\,X_1 + 0.688\,X_2 - 0.127\,X_3 - 0.209\,X_4 + 0.019\,X_5 + 0.084\,X_7$	0.53

X_5 = Evening actual vapour pressure

X_6 = Sunshine hours

X_7 = Wind speed

3. The minimum temperature was correlated with weather parameters of $(n\text{-}1)^{th}$ and $(n\text{-}2)^{th}$ days and the correlation coefficients have been presented in Table 1. The correlation coefficients (*r*) values for all the parameters are highly significant except for X_6. The (*r*) values ranged between –0.10 and 0.82 in case of various weather parameters of $(n\text{-}1)^{th}$ and $(n\text{-}2)^{th}$ days. The correlation coefficients (*r*) values were lower in case of weather parameters of $(n\text{-}2)^{th}$ day in comparison with weather parameters of $(n\text{-}1)^{th}$ day.

3.1. Significant weather parameters of $(n\text{-}1)^{th}$ and $(n\text{-}2)^{th}$ days were selected based on *r* values and simple models were developed for prediction of minimum temperature using these parameters as input. The regression equations so obtained are presented in Table 2 alongwith R^2 values. The model based on minimum temperature of $(n\text{-}1)^{th}$ day showed highest accuracy (67 per cent) in prediction of minimum temperature. The accuracy decreased to 49 percent if the minimum temperature of $(n\text{-}2)^{th}$ day was used in the model. Around 14 to 38 per cent variation in predicted value of minimum temperature could be explained by other weather parameters of (n-1)th and (n-2)th days individually.

3.2. Multiple regression models were developed for forecasting minimum temperature by clubbing weather parameters of (n-1)th and (n-2)th days. The regression models are presented in Table 3 alongwith R^2 values. The minimum temperature, morning and evening actual vapour pressure of (n-1)th day collectively predicted value of minimum temperature upto 68 per cent. The predictability of this model was further improved (~1 per cent) with addition of three more parameters *viz*., maximum, grass minimum temperatures and wind speed. The addition of sunshine hours failed to influence the accuracy of above model. The prediction accuracy of all these models decreased if we used the parameters of (n-2)th day. The prediction accuracy of 69 per cent with the best fit model based on (n-1)th day parameters was decreased to 53 per cent if we used the parameters of (n-2)th day. Similar regression models were also developed by Attri *et al.* (1995) using the weather variables like dew point, cloud amount, maximum and minimum temperature recorded on previous day. Deosthali and Payyappalli (1997) developed similar models for prediction of minimum temperature using weather data of previous day with accuracy of 74 per cent over Niphad region.

Based on the results of present study, it may be concluded that simple models based on minimum temperature of (n-1)th and (n-2)th days are best as these require minimum data and the predictability of the models was 67 and 49 per cent respectively. The multiple models based on all weather parameters of (n-1)th and (n-2)th days were also found suitable for prediction and the accuracy was upto 69 and 53 per cent respectively. However, the prediction accuracy decreased with the consideration of weather parameters of (n-2)th day, but the model would serve better purpose if the forecast is made available two days in advance instead of one day.

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