633.15 : 551.515

CROP WEATHER MODELLING ON MAIZE (FODDER)

1. About 68% of total cultivated area of 143.8 million ha in India is occupied by dry lands but the production and productivity is very low and unstable in dry lands due to aberrant weather, erratic and uneven distribution of rainfall and prolonged drought situation; risk of crop failure is a common feature. Weather has been recognized as a major control over the growth and yield of crops. But the precise manner in which they influence on crop is not very well understood. Weather affects crop growth differently at different phenological phases. Therefore, large variation in yield from year - to - year and place to place is due to weather parameters. The main worker on this aspect are, Fisher (1924), Thompson (1969), Baier (1973), Jain *et al.* (1980) and Ranjna *et al.* (1986). The present study relates to individual effects of weather parameters on maize (fodder) yield at Jhansi.

2. Weekly weather data (28 to 38 standard week) on average daily maximum (*Tx*), minimum (*Tn*) and mean temperature (*Tm*), average relative humidity (*Rh*) at 0700 hr and 1400 hr IST, total rainfall (*Rf*) and number of rainy days (*Rd*) from 1979 to 1992 were collected from Indian Grassland and Fodder Research Institute, meteorological station, Jhansi, for the crop growth period. Data on relative humidity have been transferred into arc-sign root proportion as they were in percentage. Square root transformation $(X + 1/2)^{1/2}$ was used for data on number of rainy days, where X stands for number of rainy days. Weekly correlation coefficient of each weather variable with yield was worked out. The effect of yield per unit change in weather variable in w^{th} week was worked out by differentiating of the respective equation.

2.1. The crop was taken from 28 week (in July) to 38 week (in September) and the whole season was divided into 5 stages, *viz.*, germination, knee high, tasseling and silking, milk and maturity stage.

2.2. The weekly weather data covering full crop season from mid July to mid September were utilized for studying the effect of weather variables on yield.

TABLE 1

Coefficient of determination (R^2) under different models

Weather variables	Models							
	I	II	III	IV	V	VI	VII	VIII
Maximum temperature	0.84	0.84	0.80	0.77	0.90	0.90	0.86	0.81
Minimum temperature	0.81	0.81	0.64	0.58	0.95	0.86	0.89	0.61
Mean temperature	0.83	0.83	0.66	0.65	0.88	0.88	0.68	0.65
Mean Relative Humidity	0.74	0.68	0.77	0.54	0.89	0.88	0.86	0.81
Rainfall	0.60	0.58	0.28	0.26	0.81	0.60	0.48	0.35
Rainy days	0.60	0.54	0.31	0.34	0.75	0.64	0.62	0.61

TABLE 2

Percent change in yield per unit increase in weather variable over its average value

Stage	Week No.	Week S.No.	Max. temp.	Min. temp.	Mean temp.	Humidity (%)	Rainfall	Rainy days
Germination	28	1	-1.57	4.31	-4.72	-0.18	0.17	-18.72
	29	2	0.51	-4.21	-1.00	0.05	-0.10	-27.95
Knee-high	30	3	0.14	1.30	-1.75	1.25	0.94	8.41
	31	4	1.15	4.62	0.03	1.23	-0.31	-45.36
	32	5	3.67	3.50	4.21	2.68	0.01	-14.56
Tasselling and Silking	33	6	2.82	4.32	2.96	-1.15	-0.22	-10.93
	34	7	1.98	4.50	1.81	0.30	-0.50	-13.00
	35	8	-3.21	-2.62	-4.35	1.75	0.04	-6.08
Milk stage	36	9	-4.35	-8.55	-5.59	0.59	0.24	24.94
	37	10	-5.32	-6.97	-5.05	0.64	025	38.87
Maturity	38	11	-1.12	1.41	-7.15	1.49	-0.01	-22.24

2.3. In these models effect of changes in weather variable on yield in w week as a linear function of respective correlation coefficient between yield and weather variables were studied. As trend effect on yield was significant, when the correlation between years and yield was found significant. Its effect was removed from yield while calculating correlation coefficient of yield with weather variables to be used as weights.

3. In all eight models have been studied which are as under :

(*i*) *Models I & II* — In these models effect of weather variables on yield in different weeks was expressed as a linear function of respective correlation coefficient of weather variables and yield.

(a) *Model I* :

$$Y = a + b_o Z_o + b_1 Z_1 + b_2 Z_2 + cT \qquad (1)$$

(b) *Model II* :

$$Y = a + b_o Z_o + b_1 Z_1 + cT \qquad (2)$$

where a_o, b_o, b_1, b_2 and c are constants and have their usual meanings. T is a trend variable,

$$Z_0 = \sum_{w=1}^{n} X_w, \quad Z_1 = \sum_{w=1}^{n} r_{xy}(w)\, X_w \text{ and}$$

$$Z_2 = \sum_{w=1}^{n} r^2 xy\,(w)\, X_w$$

where $r_{xy}(w)$ is the correlation between weather variable X_w with the yield corresponding to w week. X_w is the value of the weather variable under study in w week.

(*ii*) *Models III & IV* — These models are same as models I & II respectively except that $r_{xy(w)}$ is obtained using yield adjusted for trend effect.

(*iii*) *Model V* — This is obtained by including quadratic terms of weather variables in model I, as such the model becomes

$$Y = a + b_o Z_o + b_1 Z_1 + b_2 Z_2 + b_{oo} Z_{oo} + b11\, Z_{11} + b_{22} Z_{22} + cT \qquad (3)$$

where, again a, b_o, b_1, b_2, b_{oo}, b_{11}, b_{22} and c are constant and have their usual meanings and Z_{00}, Z_{11} and Z_{22} are the quadratic terms related to Z_o, Z_1 and Z_2 respectively and represented as

$$Z_{oo} = \sum_{w=1}^{n} X_w^2 \quad , Z_{11} = \sum_{w=1}^{n} r_{xy(w)}\, X_w^2 \text{ and } Z_{22} = \sum_{w=1}^{n} r_{xy}^2\,(w)\, X_w^2$$

(*iv*) *Model VI* — This is obtained by including quadratic terms of weather variable in model II, as such model becomes:

$$Y = a+b_0 Z_0+b_1 Z_1+b_{00} Z_{00}+b_{11}Z_{11}+cT \quad (4)$$

(*v*) *Models VII & VIII* — Same as models V and VI respectively except that correlation coefficient are obtained using adjusted yield.

3.1. Weekly correlation coefficient between weather variable and yield has indicated that during the first three weeks of August, maximum, minimum and mean temperatures alongwith average humidity has shown high positive correlation coefficient which ranges between (0.47 to 0.76), (0.56 to 0.70), (0.53 to 0.75) and (0.53 to 0.70), respectively implies a positive effect on fodder yield of maize crop. On the basis of coefficient of determination (R^2) which are presented in Table 1, it was observed that model No.V is best as its R^2 value is maximum as compaired to other models, which is an extension of model I, by including the quadratic terms in the model. It indicated that this model can be used to study the effect of weather on yield of maize fodder.

3.2. The effect of one unit increase above average on weather parameters at different growth stages of crop has been worked out by differentiating the above equations with respect to X_w and are presented in Table 2. Effect of one unit decrease below the average can be obtained by reversing the vertical scale. It has been seen from the Table 2 that temperature has its beneficial effect from 4 to 7 week of crop growth, humidity has shown its beneficial effects through out the crop period except 1 and 6 week. Rainfall and rainy days has good effect during 8,9 and 10 week.

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