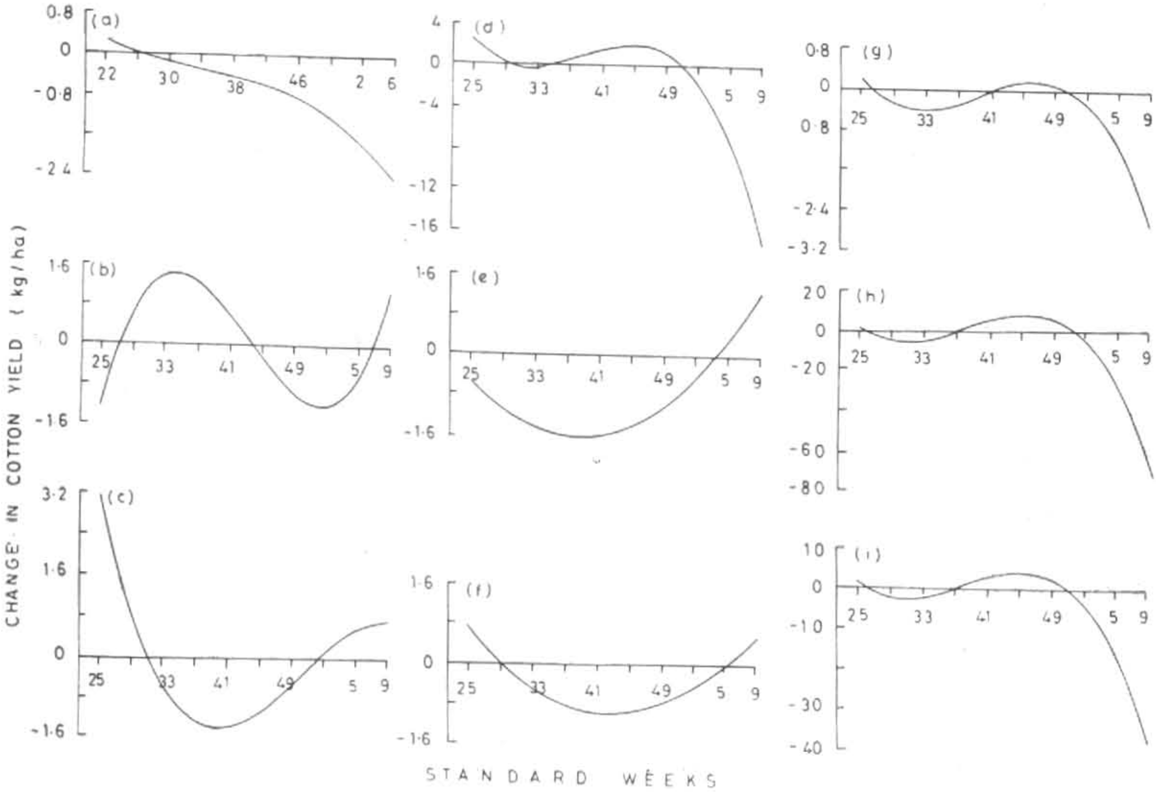
551.586 : 632.1 : 633.51

INFLUENCE OF WEATHER PARAMETERS AND AGROCLIMATIC ELEMENTS ON THE COTTON YIELD AT SURAT

1. Fisher (1924) developed a polynomial summation technique to study the effect of distribution of rainfall during growing season on crop yield. This technique and its modified form have been applied by many workers (Gangopadhyaya and Sarker 1965, Runge 1968, Huda *et al*. 1975, Rupakumar 1984, Pandey and Gupta 1989) to study the effect of weather parameters on crop yields. Cotton, a major fibre crop, is extensively grown in Gujarat. In this paper an attempt has been made to study the influence of distribution of agroclimatic variables such as rainfall, temperature, humidity, sunshine, soil moisture, evapotranspiration and moisture adequacy index on cotton yield at Surat.

2. The district yield data of cotton for Surat were collected from Directorate of Agriculture, Ahmedabad from 1950-51 to 1981-82. The weather data of corresponding periods were collected from Division of Agri-



Figs. 1 (a-i). Yield response curves for cotton effect of above average of : (a) 10 mm of rainfall, (b) 1°C of maximum temperature, (c) 1°C of minimum temperature, (d) 1 hr/day of sunshine duration, (e) 5% of morning relative humidity, (f) 5% of afternoon relative humidity, (g) 10 mm of soil moisture, (h) 5 mm of actual evapotranspiration and (i) 0.1 of moisture adequacy index

TABLE 1

Phase-wise correlation coefficients between weather variables and cotton yield at Surat

Weather variables	Phenophases				
	1	2	3	4	5
Rainfall	—0.19	—0.19	—0.26	—0.15	—0.04
Maximum temp.	—0.16	0.20	0.11	—0.66**	—0.38**
Minimum temp.	0.41**	—0.03	—0.24	0.10	0.35**
Sunshine	0.16	—0.19	0.29	0.30*	—0.39**
Morning R. H.	0.22	—0.20	—0.28	0.08	0.48**
Afternoon R.H.	0.33*	—0.05	—0.49***	0.09	0.39**
Soil moisture storage	0.25	—0.13	—0.13	—0.14	—0.16
Actual evapotranspiration	0.09	—0.03	0.23	—0.19	—0.20
Moisture adequacy index	0.10	—0.19	0.12	0.19	—0.16

The correlation coefficient with pre-sowing rainfall is 0.26, 1, 2, 3, 4 and 5 are phenological periods mentioned in text.

*—Significant at $P=0.10$, **—Significant at $P=0.05$, ***—Significant at $P=0.01$.

TABLE 2

Partial regression coefficients of different terms and regression constant alongwith coefficients of determination (R^2) for different variables

Weather variables	Regression terms					Regression constant (A_0)	R^2
	a_1	a_2	a_3	a_4	D		
Rainfall	0.0311	—0.0080	0.0004	—0.00001	12.567	114.78	69.4**
Maximum temperature	—1.9448	0.7485	—0.0050	0.0009	12.120	8.02	69.3**
Minimum temperature	3.8596	—0.7850	0.0356	—0.0005	16.061	200.87	70.5**
Sunshine duration	3.4536	—0.9675	0.0845	—0.0020	11.573	598.08	69.4**
Morning relative humidity	—0.0689	—0.0317	0.0011	0.000001	16.061	556.99	75.0**
Afternoon relative humidity	0.1842	—0.0433	0.0014	—0.00001	17.679	222.80	75.3**
Soil moisture storage	0.0437	—0.0219	0.0018	—0.00004	13.192	196.12	70.0**
Actual evapotranspiration	1.0383	—0.6768	0.6622	—0.0016	12.888	261.12	72.4**
Moisture adequacy index	32.0718	—19.2820	1.8874	—0.0451	12.874	262.35	72.2**

**— Significant at $P = 0.01$ a_1, a_2, a_3, a_4 and D are regression coefficients

cultural Meteorology IMD, Pune. The periods over which the effects of weather parameters were examined are 37 weeks (25th to 9th standard week). The total growing period was divided into following phenological periods :

Phenological periods	*Durations (standard week)*
(1) Sowing to germination	25-28
(2) Germination to bud formation	29-36
(3) Bud formation to flowering	37-45
(4) Flowering to opening of first boll	46-50
(5) Opening of first boll to maturity	51-9

3. The soil moisture storage, actual evapotranspiration and moisture adequacy index were computed using Thornthwaite and Mather (1955) water balance technique. The correlation coefficients were worked out between cotton yield and each of the agroclimatic variable during different phases. The following form of third degree polynomial regression was developed for each variable to obtain yield response curve :

$$Y = A_0 + \sum_{i=0}^{3} a_i \left(\sum_{t=1}^{37} t^i X_t\right) + D.\,T$$

where, Y is cotton yield in kg/ha, A_0, a_i and D are partial regression coefficients obtained by least square technique, X_t is any agroclimatic variable over a seven days crop period t. T is used to correct the time trend yield.

4. It is found that rainfall is negatively correlated with cotton yield throughout the growing season (Table 1). The correlation with maximum temperature during flowering to maturity period is negative and significant whereas the minimum temperature has positive and significant correlation with cotton yield during first and last phase of crop life. The sunshine duration has negative and significant correlation with yield during maturity period. The correlations between cotton yield are non-significant with soil moisture storage, actual evapotranspiration and moisture adequacy index during different phenological periods.

5. Multiple regression equations are developed to each variable. The variation in cotton yield accounted for (R^2) by the variables ranged between 69.3 and 75.3 per cent. These are significant at 1% level. The yield variation explained is maximum (R^2=75.3) with afternoon relative humidity followed by morning relative humidity (R^2=75%), actual evapotranspiration (R^2=72.4) and moisture adequacy index (R^2 = 72.2). It is minimum with maximum temperature. The partial regression coefficients of each equation are given in Table 2.

The response curves are obtained from regression equations developed for 10 mm above-average of rainfall; 1°C above-average of maximum and minimum temperatures; 1 hour/day above-average of sunshine duration; 5% above average of morning and afternoon relative humidity; 10 mm above-average soil moisture storage; 5 mm above average actual evapotranspiration and 0.1 above-average moisture adequacy index. These curves are shown in Figs. 1 (a-i). It may be seen from the figures that rainfall adversely affects the cotton yield during most of the growing season. Only the above-average pre-sowing rains are favourable to crop [Fig. 1(a)]. During germination, flowering and opening of bolls periods the higher daily maximum temperature adversely affects the yield whereas it is beneficial to cotton during bud formation period [Fig. 1(b)]. The higher daily minimum temperature during germination and maturity periods increase the cotton yield while the decrease in yield is observed during bud formation and flowering periods [Fig. 1(c)]. The higher sunshine duration during germination and flowering periods increase the yield while during maturity period higher sunshine duration decrease the yield [Fig. 1(d)]. The above-average morning relative humidity adversely affects the cotton yield during most of the crop life period except during maturity [Fig. 1(e)]. The beneficial effect of afternoon relative humidity is observed only during germination and maturity periods [Fig. 1(f)]. The soil moisture storage, actual evapotranspiration and moisture adequacy index influence the cotton yield in more or similar way with varying magnitude during crop life periods [Figs. 1(g-i)].

6. From the above results it is clear that different variables influence the cotton yield differently during its growth period. The response results obtained are in general agreement with the correlation study. Although at times the correlations are not significant. Amongst the variables used in the study, the afternoon relative humidity gives the best estimates of cotton yield (R^2=75.3%).

The variation in yield accounted for by the derived variables, *viz.*, actual evapotranspiration (R^2=72.4) and moisture adequacy index (R^2=72.2) are more than that of simple weather variables, *viz.*, rainfall (R^2= 69.4%) and maximum temperature (R^2=69.3%).

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