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Influence of rainfall, humidity, sunshine, maximum and minimum temperatures on the yield of cotton at Coimbatore

S. K. SHAHA and J. R. BANERJEE

Meteorological Office, Poona

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ABSTRACT. The statistical technique of Fisher (1924) was used to examine the influence of meteorological parameters on the yield of cotton crop at Coimbatore. It was observed that the rainfall and hours of sunshine should be more than their normal values for a good crop. More humidity during elongation and branching of the crop is useful for more yield. A lower minimum temperature during sowing period and high maximum and minimum temperatures during flowering are attributed to be beneficial for a better cotton crop.

1. Introduction

For examining the influence of rainfall on the yield of wheat at Rothamsted, Fisher (1924) developed a new statistical technique which takes into account not only the total amount of the rainfall during certain period but also the manner in which it is distributed over the period under consideration. He used this technique to find out the response curve which gives the average change in the yield of wheat associated with an additional unit of rainfall at any time of the year. Kalamkar and Satakopan (1940) used the above method to study the effect of rainfall on the yield of cotton at Government Experimental Farms in Akola and Jalgaon. Nair and Bose (1945) used the same technique to estimate the yield of cotton at Sarakand (Sind) taking the combined effect of humidity and temperature. Acharya *et al.* (1960) examined the influence of rainfall on the yield of sugarcane at Pusa. Gangopadhyaya and Sarker (1965) employed the same technique to study the effect of rainfall on the yield of wheat at five important crop-weather stations of India. Same method has neen used in the present study also to examine the effects of rainfall, sunshine, humidity, maximum and minimum temperatures on the yield of cotton at Coimbatore (Lat. 11°00'N, Long. 77°00'E).

2. Technique

If the time period $(0, T)$ over which the influence of the meteorological factor r is required to be examined, be divided into n equal parts then the *linear* regression equation of the yield upon the meteorological factor would be of the form :

$$Y = C + a_1 r_1 + a_2 r_2 + \ldots\ldots + a_n r_n \qquad (1)$$

where $r_1, r_2, \ldots\ldots, r_n$ are the quantities of the meteorological factor in the successive intervals of time and $a_1, a_2, \ldots\ldots, a_n$ are the corresponding partial regression coefficients. In the limiting case when the length of the subdivisions is made infinitely small, the Eqn. (1) assumes the form,

$$Y = C + \int_0^T a\, r\, dt \qquad (2)$$

where rdt is the amount of the meteorological factor in the infinitely small interval of time dt. a in the Eqn. (2) is a continuous function of time and represents the average benefit to the crop corresponding to an additional unit of the meteorological factor at any point of time during the period under consideration. This function is known as the regression function and the graph of it is popularly known as Fisher's Response Curve.

Now if $P_0, P_1, P_2, \ldots\ldots$ etc be a set of polynomial function of time orthonormal in the interval $(0, T)$, *i.e.*,

$$\int_0^T P_l P_m\, dt = 0 \quad (l \neq m)$$

$$\int_0^T P_m^2\, dt = 1$$

where l and m are any two positive integers, the meteorological factor r can always be expressed as :

$$r = A_0 P_0 + A_1 P_1 + \ldots\ldots + A_{n-1} P_{n-1} \quad (3)$$

where the coefficients $A_0, A_1, \ldots\ldots$ etc are called the Meteorological Distribution Constants. Also, as there are relatively slow changes in the function a it can satisfactorily be represented

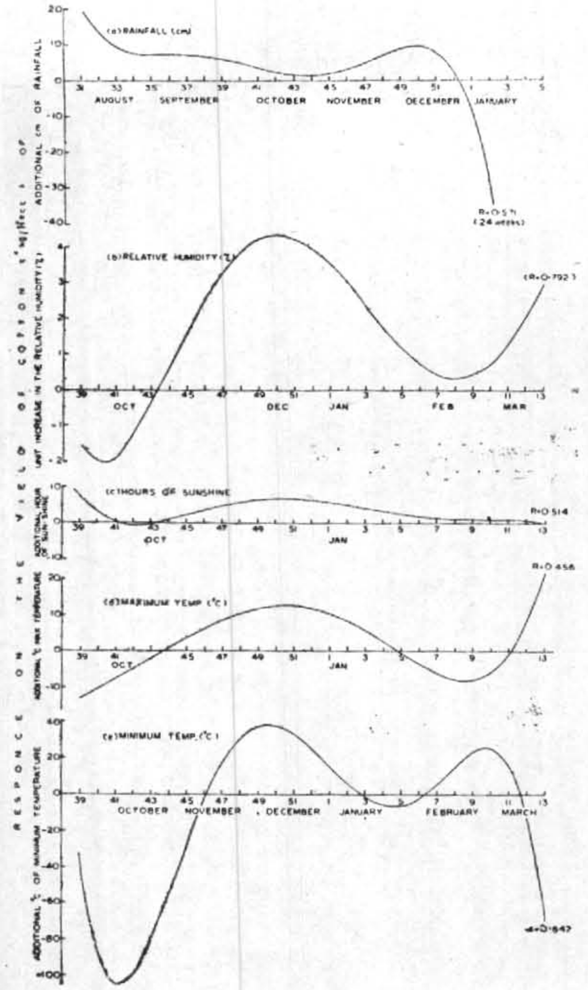

Fig. 1. Curves showing the yield of cotton (kg/hect) with different meteorological parameters

by an orthogonal polynomial of degree five (Fisher 1924). Let,

$$a = B_0P_0 + B_1P_1 + \ldots . + B_5P_5 \qquad (4)$$

Combining the Eqns. (1), (2) and (3) and using the properties of the orthonormal polynomials, we have

$$Y = B_0A_0 + B_1A_1 + \ldots . + B_5A_5 \qquad (5)$$

which holds good in the period (**0**, T).

The Meteorological Distribution Constants can be obtained for each year by fitting an orthogonal polynomial of 5th degree in time to the descrete values of r, *viz.*, r_1, r_2......... r_n and then correlating them with yield figures, the coefficients B_0, B_1,..............., B_5 can be evaluated. The numerical values of these coefficients when substituted back in Eqn. (4) give the required response curve.

As no correlational work is reliable if the variable are having any progressive changes, the yield as well as each of the distribution constants should be subjected to an examination of the slow changes before making any correlational work. For this, the sequence of yields is taken and an orthogonal polynomial of the form:

$$Y = X_1'P_0 + X_2'P_1 + \ldots . + X_6'P_5$$

is fitted. The square of the ratio of each of the coefficients X_2', X_3',..., X_6', to the standard residue (S.R.) where,

$$\text{S. R.} = \sqrt{\frac{\text{Residual sum of squares}}{n-6}}$$

is F-distributed with 1 and $n-6$ degrees of freedom. Testing the significance of these F-values, the slow changes, if any, will easily be revealed. Same procedure is adopted for each of distribution constants. If yield or any of the distribution constants indicates the existence of any slow change then all of them are first corrected for these changes and then only the correlation work is carried out. Eqn. (5) will then take the form:

$$Y' = B_0A_0' + B_1A_1' + \ldots . + B_5A_5' \qquad (6)$$

where Y', A_0', A_1' .....etc stand for the departures of the variables from the corresponding polynomial trend values. Eqn. (5) or Eqn. (6) can be used to calculate the estimated values of yield. The multiple correlation coefficient, which can be calculated at this stage, will give an idea of the extent to which the variation in yield is accounted for by the distribution of the meteorological factor in the period (0, T).

3. Analysis

The technique described above has been used to study the effects of rainfall, humidity, sunshine, maximum and minimum temperatures on the yield of cotton at Coimbatore. Cotton at Coimbatore is sown sometimes between the end of September and the end of October. The elongation starts after about six weeks of sowing and continues for about ten weeks. Branching also starts simultaneously but it contines for about twelve weeks. Flowering starts after about eleven weeks of sowing and continues for three months. Crop is harvested in April or May after about six to seven months of sowing. The length of the period over which the effects of sunshine, humidity, maximum and minimum temperatures are examined is twenty-seven weeks and is taken from the last week of September (week 39) to the last week of March (week 13). The choice of the week 39 as starting point is based upon the assumption that these meteorological factors, much prior to sowing, may not affect the cotton crop. For rainfall, a period of twenty four weeks, from the beginning the August (week No. 31) to the middle of January (week No. 2) is chosen. The arbitrary choice of week 31 as the starting point is made in order to consider the effect of rainfall prior to sowing. The rain beyond the middle of January to the end of March has been left out of consideration as practically there is no rain during this period.

The length of the subdivisions is a week in all the cases. In case of rainfall weekly totals have been used. In case of sunshine, maximum and minimum temperatures weekly means have been used. In case of humidity averages of the weekly means of morning and evening relative humidity percentages have been taken.

The length of the data used is seventeen years and the variety of cotton sown is K_2. The data before the year 1949 and after the year 1965 have been omitted as different varieties of cotton were sown in those years.

As explained earlier an orthogonal polynomial of 5th degree was fitted to the discrete weekly values of these meteorological factors and the constants A_0, A_1, ..., A_5 were obtained for each year. The orthogonal polynomials used for this purpose were those developed by Esscher (1920) and independently by Fisher (1921). The meteorological distribution constants along with the cotton yields are given in the Table 1 (a) to (e).

For examining the presence of the progressive changes, the coefficients X_2', X_3'........,X_6' were evaluated for yield and each of the distribution constants as described earlier. These coefficients with the corresponding standard residues are given in Table 3 (a) to (e).

A glance of the Tables 1 and 3 shows the presence of the progressive changes in the yield values as revealed by X_6', A_1 and A_3 of rainfall, A_6 of the maximum temperature and A_0 and A_1 of humidity show the existence of some secular changes. But all other constants are free from any significant trend.

The regression planes were then fitted taking yield deviations as the dependent variate and similar deviations of distribution constants as independent variates. These equations with the multiple correlations for each of the five meteorological factors are as follows :

Rainfall

$$Y'=20\cdot210\,A_0'-25\cdot828\,A_1'-7\cdot028\,A_2'-25\cdot265\,A_3'-16\cdot341\,A_4'-15\cdot941\,A_5'$$

Multiple correlation $= 0\cdot57112$

Humidity

$$Y'=8\cdot119\,A_0'+2\cdot856A_1'-6\cdot622\,A_2'+4\cdot846\,A_3'+4\cdot232\,A_4'-1\cdot867\,A_5'$$

Multiple correlation $= 0\cdot79190$

Sunshine

$$Y'=16\cdot622\,A_0'-2\cdot488\,A_1'-6\cdot950\,A_2'-2\cdot413\,A_3'+8\cdot168\,A_4'-5\cdot630\,A_5'$$

Multiple correlation $= 0\cdot51395$

Maximum temperature

$$Y'=11\cdot062\,A_0'+9\cdot389\,A_1'-20\cdot184\,A_2'+28\cdot719\,A_3'+23\cdot172\,A_4'+5\cdot089\,A_5'$$

Multiple correlation $= 0\cdot45628$

Minimum temperature

$$Y'=58\cdot035\,A_0'+107\cdot420\,A_1'-136\cdot919\,A_2'-7\cdot899\,A_3'+33\cdot422\,A_4'-135\cdot062\,A_5'$$

Multiple correlation $= 0\cdot84658$

Table 2 gives the estimated values of the yield from these regression equations. Significance of the dependence of the cotton yield on the meteorological distribution constants was tested by partitioning the total sum of squares. It was seen (Table 4) that excepting the case of minimum temperature distribution constants, where the ratio of the mean square due to 'regression' to that due to 'residual' approaches the 5 per cent point for this ratio, variance due to regression and the residual does not differ significantly. The percentage of variation in yield accounted for by rainfall, humidity, sunshine, maximum and minimum temperatures are respectively 32·6, 62·7, 26·4, 20·8 and 71·7.

The response curves for each of the meteorological factors are discussed below.

Rainfall

The equation of the response curve is :

$$a = 20\cdot210\,P_0-25\cdot828\,P_1-7\cdot0283\,P_2-25\cdot265\,P_3-16\cdot341\,P_4-15\cdot941\,P_5$$

and is represented in Fig. 1. From the nature of the curve it appears that upto December end, the rainfall above normal is beneficial to the cotton crop. This satisfies the usual requirement of moisture during germination to reproduction stage (*i.e.*, flowering). After December the rainfall becomes detrimental as rainfall during flowering phase causes flower shedding.

TABLE 1

Yield (kg/hect) and other meteorological parameters distribution constants

Year	Yield	A_0	A_1	A_2	A_3	A_4	A_5
(a) Rainfall distribution constants							
1949	285·0	5·5093	0·7600	44·4018	−1·8021	3·2930	0·9612
1950	377·0	4·7193	−1·4092	−1·8282	−1·4101	2·2934	0·9468
1951	461·0	6·9381	−2·4173	−4·0107	1·3182	1·8189	0·0656
1952	219·0	6·3747	−0·0240	−5·4175	−0·1496	2·7632	0·4933
1953	378.0	4·9622	−0·0219	−3·2556	0·6635	0·8589	−1·3687
1954	165·0	9·0120	0·8989	−1·1944	2·2617	5·0761	−2·9263
1955	212·0	7·1423	−0·1971	−3·1802	0·5487	2·4819	−3·1436
1956	172·0	4·1845	−0·2193	−2·3547	−0·9315	0·6823	0·5180
1957	278·0	8·8344	1·7701	−6·7646	−4·2349	3·6755	5·5782
1958	256·0	14·4029	3·4407	−13·1784	−6·3120	9·8454	8·2904
1959	297·0	6·6034	0·1033	−4·5527	−2·8214	3·8167	2·3698
1960	399·0	8·6834	2·5144	−6.0294	−4·1220	1·5047	2.7658
1961	212·0	9·3407	2·0786	−6·5678	−2·9234	7·4835	4·0687
1962	347·0	22·5597	2·0411	−23·2445	−5·3932	21·4881	7·8556
1963	185·0	9·8755	0·9937	−6·4508	−0·9163	3·1864	−0·8208
1964	283·0	5·7338	2·0513	−1·4889	−3·7875	−1·5147	−0·2128
1965	533·0	10·4838	−3·0520	−0·8248	−3·3153	4·4159	0·3805
(b) Humidity distribution constants							
1949	285·0	317·4462	−29·1557	9·6148	6·9786	−11·6865	2·6942
1950	377·0	328·4159	−47·3905	8·4739	11·2538	12·2096	8·0950
1951	461·0	339·5780	−38·6932	4·1499	2·7409	0·1040	−13·6343
1952	219·0	320·0443	−34·6286	−3·7322	6·6009	5·5045	2·0071
1953	378·0	350·5471	−27·6115	−2·9527	7·6227	4·5207	21·6696
1954	165·0	337·7497	−30·5147	−15·7051	−2·7409	4·4257	20·4754
1955	212·0	333·3234	−41·0034	−14·1242	8·3687	1·1277	−3·0146
1956	172·0	355·6476	−33·9491	−7·6873	8·7981	−7·2131	−0·6190
1957	278·0	351·3175	−32·2196	−10·4061	14·9226	−8·8075	8·4729
1958	256·0	344·1006	−41·5470	−12·9419	10·2164	2·7306	7·9702
1959	297·0	349·5854	−37·4701	−5·8019	17·0492	−5·4682	−6·3533
1960	399·0	359·3041	−25·7584	−13·1397	13·9838	−4·4064	3·2917
1961	212·0	350·2590	−25·5730	−10·5032	7·9612	−7·0937	−0·6263
1962	347·0	368·1569	−36·2347	−2·5547	7·6148	4·4168	8·4710
1963	185·0	354·7816	−37·5813	−6·0382	9.9170	5·7739	−5·6972
1964	283·0	359·1117	−35·6170	−10·4185	15·4366	0·0565	18·7904
1965	533·0	357·0063	−26·2298	−13·3039	7·5891	4·3617	−9·6069
(c) Sunshine distribution constants							
1949	285·0	40·7609	7·1110	2·1580	−3·2637	0·3522	−0·3373
1950	377·0	44·8216	2·8315	−1·8426	−1·0851	1·5578	−0·9371
1951	461·0	42·0503	5·2258	−2·2858	−0·5503	−2·2764	−3·5352
1952	219·0	40·6839	4·5537	0·9893	0·6757	0·2314	2·4238
1953	378·0	44·5906	5·9201	1·1256	−1·4474	0·1860	−0·9751
1954	165·0	39·9526	5·5964	−0·1560	−3·1512	0·4584	−2·8877
1955	212·0	41·7321	6·6712	1·1979	0·8860	−0·2815	−2·8080
1956	172·0	41·5884	5·6903	0·1202	−2·8130	−2·2234	0·7499
1957	278·0	40·3952	7·0492	−1·9093	−1·4584	3·0440	−0·1391
1958	256·0	39·3560	6·1894	3·2688	−3·0945	0·9448	−1·4281
1959	297·0	45·2257	7·5829	1·1061	−0·9888	0·0155	−0·5786
1960	399·0	41·3575	6·1622	−0·0073	−2·5563	2·0088	1·1542
1961	212·0	40·1065	6·7799	3·7262	−1·4988	0·1963	0·6918
1962	347·0	42·8201	3·7087	0·7035	0·0191	−0·4867	1·0745
1963	185·0	40·8186	7·2545	−0·4456	−1·4176	−1·5471	−3·8426
1964	283·0	43·5899	7·1752	1·0008	−4·0646	−0·5612	3·0327
1965	533·0	44·7638	5·2208	−0·1832	−1·1537	1·2194	−3·3556

TABLE 1 *(contd)*

Year	Yield	A_0	A_1	A_2	A_3	A_4	A_5
				(d) Maximum temperature distribution constants			
1949	285·0	161·3693	6·2734	11·4236	0·0535	– 2·0187	– 0·7915
1950	377·0	165·7764	4·9021	6·4524	– 0·4131	– 1·0799	– 0·0172
1951	461·0	163·8326	8·2871	6·7280	0·4240	– 1·7395	– 1·8242
1952	219·0	162·4662	5·8015	8·0384	0·0686	– 1·7744	1·2328
1953	378·0	164·7979	6·7725	9·3258	1·2571	– 1·4376	– 1·4319
1954	165·0	160·4648	5·7866	7·1070	– 1·2007	– 1·9132	– 1·9657
1955	212·0	160·0799	7·0048	7·5336	0·3037	– 0·5663	– 1·4385
1956	172·0	158·8637	7·2914	10·1390	0·7688	– 1·5543	1·6611
1957	278·0	157·7320	6·5625	7·5355	– 1·0804	– 2·0164	0·1888
1958	256·0	160·5418	6·3772	10·0869	– 2·5175	– 0·3804	– 0·3631
1959	297·0	161·9274	8·2550	8·9524	– 0·7422	– 2·2359	0·5413
1960	399·0	157·7320	6·7898	7·2253	– 1·6847	– 1·1512	1·7340
1961	212·0	159·0214	8·1117	9·0017	– 0·7986	– 0·9739	0·6292
1962	347·0	158·8097	5·6977	8·1496	– 0·0219	– 1·2250	1·8750
1963	185·0	157·6550	6·0757	8·0284	– 0·1930	– 1·7173	– 3·1816
1964	283·0	162·1198	6·4315	9·8066	– 2·2275	– 1·9123	0·4626
1965	533·0	156·5773	5·6483	8·7414	1·1180	– 1·9544	– 1·7572
				(e) Minimum temperature distribution constants			
1949	285·0	98·2649	– 5·2060	4·9866	5·4688	– 1·3049	– 0·2796
1950	377·0	98·9963	– 0·7783	10·8289	1·2835	– 4·0075	– 1·3099
1951	461·0	96·1480	– 2·7006	7·9319	2·7265	3·7926	3·3802
1952	219·0	105·3856	– 2·0730	7·5005	2·4939	– 3·7681	– 0·5060
1953	378·0	105·7897	– 2·0310	6·4702	2·2711	– 0·5126	– 0·7443
1954	165·0	101·2094	– 0·7832	7·0792	3·3346	0·7063	2·5252
1955	212·0	102·3834	– 1·2403	4·4316	– 0·0144	0·6043	3·7837
1956	172·0	99·6698	– 4·2844	6·3024	2·8911	– 0·0644	– 0·0481
1957	278·0	102·5373	– 2·5449	5·7539	1·2913	– 2·6913	– 0·7765
1958	256·0	106·3671	– 0·1161	5·4143	3·1396	– 2·1627	0·6846
1959	297·0	104·4426	– 5·0824	1·9351	2·4024	0·3596	1·5364
1960	399·0	103·7305	– 3·0712	6·2563	2·3880	– 1·2767	– 1·7327
1961	212·0	104·7505	– 1·4577	5·0614	2·4447	0·5356	0·8383
1962	347·0	103·8460	– 1·5838	5·3067	0·6635	– 2·7816	– 0·2920
1963	185·0	103·2686	– 2·8809	6·6924	2·5165	0·4373	– 0·9334
1964	283·0	103·3841	– 1·7789	9·0608	4·3830	– 2·1625	– 2·9934
1965	533·0	99·6121	– 3·7916	5·2572	2·6322	0·6763	1·9355

TABLE 2

Year	Actual yield	Yield estimated from regression equation				
		Rainfall	Humidity	Sunshine	Max. temp.	Min. temp.
1949	285·0	269·3	265·6	252·8	262·0	282·3
1950	377·0	406·5	428·1	465·4	439·3	387·4
1951	461·0	432·5	432·0	387·4	404·4	443·7
1952	219·0	320·5	229·5	271·3	287·4	236·2
1953	378 0	249·1	345·1	296·6	281·0	374·1
1954	165·0	161·9	188·5	207·9	167·8	162·5
1955	212·0	240·4	152·6	199·8	255·9	181·6
1956	172·0	196·8	263·0	197·8	210·8	196·1
1957	278·0	254·4	266·7	267·3	241·9	320·1
1958	256·0	309·6	240·5	246·7	247·4	234·4
1959	297·0	301·8	280·7	364·0	336·1	283·7
1960	399·0	352·0	400·2	326·3	311·0	335·4
1961	212·0	201·3	242·9	245·3	300·0	299·2
1962	347·0	313·3	291·8	276·3	283·0	322·5
1963	185·0	254·3	220·1	244·1	227·6	198·4
1964	283·0	269·6	286·6	289·8	271·0	259·0
1965	533·0	525·6	526·1	520·1	532·1	542·2

TABLE 3

Secular changes in yield and other meteorological parameter distribution constants

	Mean	X_2'	X_3'	X_4'	X_5'	X_6'	S.R.
			(a) Rainfall distribution constants				
Yield	297·58	29·80	200·60	58·06	21·33	263·35	75·46
A_0	8·55	8·47	−1·84	−4·09	−2·75	0·41	4·41
A_1	0·54	2·08	−3·10	−3·72	−0·37	−2·23	1·18
A_2	−5·57	−5·64	4·71	9·99	5·38	0·16	5·12
A_3	−1·96	−5·64	0·27	4·65	−2·73	−2·38	1·60
A_4	4·30	5·53	−2·38	−6·83	−3·12	0·48	5·47
A_5	1·51	3·77	−3·05	−7·21	1·23	4·50	2·66
			(b) Humidity distribution constants				
A_0	345·66	46·91	−12·03	0·04	−5·76	1·37	9·04
A_1	−34·18	6·25	0·81	1·12	4·23	−1·44	7·11
A_2	−6·29	−18·90	16·33	−11·23	−6·10	2·31	3·84
A_3	9·07	7·55	−2·05	−6·94	3·96	3·58	4·56
A_4	0·03	−0·21	5·85	11·50	−12·53	3·28	5·48
A_5	3·66	−4·08	−6·08	4·09	−4·37	−16·94	10·83
			(c) Sunshine distribution constants				
A_0	42·03	0·87	2·74	1·71	−0·19	2·24	1·95
A_1	5·92	1·51	−1·18	−1·03	1·74	−1·84	1·22
A_2	0·50	1·21	−0·99	−1·99	0·87	−1·29	1·78
A_3	−1·58	−0·73	−0·52	1·44	−2·02	1·49	1·45
A_4	0·16	−0·06	−0·41	−0·60	2·13	1·77	1·44
A_5	−0·68	0·79	−0·74	−2·35	−1·07	−0·37	2·36
			(d) Maximum temperature distribution constants				
A_0	160·58	−7·19	1·77	0·86	−3·59	1·36	1·96
A_1	6·59	0·09	−1·59	−0·65	−0·08	0·69	1·02
A_2	8·47	0·60	0·83	−1·23	2·46	−1·90	1·28
A_3	−0·40	−1·15	1·11	1·68	−0·14	−0·13	1·11
A_4	−1·56	0·02	−0.46	−0.43	−0 46	0·35	0·66
A_5	−0·26	0·59	−1·75	−2·17	−0·03	1·31	1·53
			(e) Minimum temperature distribution constants				
A_5	102·34	4·49	−5·88	−0·90	−2·71	−0·68	2.56
A_1	−2·43	−0·12	−1·36	1·21	−2·42	−0·12	1.53
A_2	6·25	−2·10	3·04	1·84	−3·34	0·05	1·74
A_3	2·48	−0·41	2·16	−0·78	1·26	−1·03	1·28
A_4	−0·80	0·45	−0·34	1·76	−0·08	0·26	2·33
A_5	0·29	−1·43	−1·45	2·33	1·19	1·16	1·94

Humidity

The equation of the response curve for humidity is :

$$a = 8 \cdot 119\, P_0 + 2 \cdot 856\, P_1 - 6 \cdot 622\, P_2 + 4 \cdot 846\, P_3 + 4 \cdot 232\, P_4 - 1 \cdot 867\, P_5$$

It is represented in Fig. 1. It shows that from the beginning of November which is the period of commencement of elongation and branching, more than normal relative humidity is beneficial to the yield. During the germination period the relative humidity above normal is detrimental to the cotton yield.

Sunshine

The equation of the response curve is :

$$a = 16 \cdot 622\, P_0 - 2 \cdot 488\, P_1 - 6 \cdot 950\, P_2 - 2 \cdot 413\, P_3 + 8 \cdot 168\, P_4 - 5 \cdot 630\, P_5$$

It is also represented in Fig. 1. The curve shows that the sunshine has practically no effect on the cotton crop. However, it will be better if the sunshine is always above the normal.

Maximum temperature

The equation of the response curve is :

$$a = 11 \cdot 062\, P_0 + 9 \cdot 389\, P_1 - 20 \cdot 184\, P_2 + 28 \cdot 719\, P_3 + 23 \cdot 172\, P_4 + 5 \cdot 089\, P_5$$

It is also represented in Fig. 1. The response curve clearly shows that during October which is the sowing period also, a fall in the maximum temperature is beneficial, because at high maximum temperature, germination of seeds are affected adversely. During the elongation and early flowering periods a rise in the maximum temperature is good for the cotton yield. Maximum temperature below the normal during February and March is again beneficial to the yield. This being the peak flowering period, moderate to low temperature facilitates good flowering.

Minimum temperature

The equation of the response curve is :

$$a = -58.035\ P_0 + 107{\cdot}420\ P_1 - 136{\cdot}919\ P_2 - 7{\cdot}899\ P_3 + 33{\cdot}422\ P_4 - 135{\cdot}062\ P_5$$

It is also represented in Fig. 1. From the curve it is evident that upto the middle of November which is the commencement period of elongation and branching in the cotton plants, it is highly beneficial to the crop if the minimum temperature goes down, as average to moderately lower minimum temperatures are required for good growth during the early stages of crop. From the middle of November to the middle of January minimum temperature is beneficial. From middle of January to the middle of February any increase or fall in the minimum temperature does not affect the yield much. After the middle of February again an increase in the minimum temperature is desirable for a good cotton yield.

TABLE 4

Analysis of variance

Variation due to factors	S.S.	D.F.	M.S.	F(cal)	F (table)*
		Rainfall			
Regression	20433·95	6	3405·63	0·4034	4·39
Polynomial	114313·80	5	22862·76		8·75
Residual	42212·33	5	8442·46		
Total	176960·08	16			
		Humidity			
Regression	39285·80	6	6547·63	1·4014	4·39
Polynomial	114313·80	5	22862·76		8·75
Residual	23360·49	5	4672·09		
Total	176960·09	16			
		Sunshine			
Regression	16547·44	6	2757·90	0·2991	4·39
Polynomial	114313·80	5	22862·76		8·75
Residual	46098·85	5	9219·77		
Total	176960·09	16			
		Maximum temperature			
Regression	13042·65	6	2173·77	0·2191	4·39
Polynomial	114313·80	5	22862·76		8·75
Residual	49603·63	5	9920·72		
Total	176960·09	16			
		Minimum temperature			
Regression	44898·90	6	7483·15	2·1082	4·39
Polynomial	114313·80	5	22862·76		8·75
Residual	17747·38	5	3549·47		
Total	176960·09	16			

* F(table) of 5 per cent and 1 per cent

4. Conclusion

The significance of the effects of rainfall, sunshine and maximum temperature could not be established clearly, because of the respective low multiple correlation coefficient. However, it was observed that more sunshine during the crop period and more rainfall upto the middle of January were beneficial to the crop. More relative humidity during the elongation and branching period is useful for the crop. During the elongation, branching and flowering period higher maximum temperature benefits the yield. Minimum temperature plays the most important role in explaining about 72 per cent of the total variation in cotton yield. Minimum temperature during the month of sowing and the early stages of elongation and branching of cotton plants should be below normal for a good yield. During the flowering period it should be above normal.

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