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The impact of weather on the two varieties of winter jowar at Sholapur

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ABSTRACT. The paper analyses the relationship between different weather factors like rainfall, minimum and maximum temperatures as independent variables and winter jowar yield as the dependent variable by two methods, namely, (*a*) the Fisher's technique of regression integral and (*b*) the selected periods of regression function. For a discontinuous phenomenon such as rainfall at Sholapur, the Fisherian technique seems to be not quite appropriate. The 22-year data analysed was collected at the crop weather station located in Sholapur (Maharashtra).

The estimated values of yield by the Fisherian technique applied to the maximum temperature and by the selected periods method as applied to rainfall are found to be quite good in agreement.

1. Introduction

In the sticky black soil of the Deccan trap with a high clay content, jowar is grown in the winter season of October to middle of February. This practice is in vogue mainly because the land is not easily amenable for cultivation during the rainy season. Very often, the field is left fallow during the rainy season and with the cessation of rains in the month of September, the crop is sown in October with the help of seed-drill.

Since practically all the rain in the Deccan trap is received during the monsoon season of June to September, the winter crop is mainly dependent on the moisture stored in the various layers of the soil.

Sholapur (Lat. 17°40'N, Long. 75°54'E, altitude 476 m) is situated in the State of Maharashtra. Jowar under the crop-weather study at Sholapur is grown in the medium black soil.

2. Basic data

The basic data discussed in this paper have been recorded on the winter jowar grown in the crop weather fields of Sholapur from 1946 to 1968 (exclude 1963) for a period of 22 years. The two varieties under observations were M 35-1 and ND-15. The crop was grown in six randomised blocks for recording periodical growth observations and yields. The general layout is given in the monograph on *Crops and Weather in India* by Ramdas (1960).

The simultaneous meteorological observations were recorded two times a day namely, 0700 and 1400 hours local mean time, in the open meteorological yard located in the plot adjacent to the crop-weather field. The weekly data discussed in this paper refer to the 52 standard weeks indicated in the monograph referred above. The weather factors (rainfall, temperatures) over all the 52 weeks in the year were taken into consideration.

3. Method of analysis

The data have been processed and analysed by Fisher's Regression Integral, namely,

$$Y = c + \int_0^t ar\ dt$$

where Y is the yield, c is constant, rdt is the rain falling in the element of time dt; the integral is taken over the whole period concerned and a is a *continuous* function of the time t and as such represents the average benefit to the crop per unit of rain falling in time element considered. Prof. Fisher has categorically stated that 'this of course is more than even a daily record of rain can tell us, but owing to relatively *slow changes* in the function of a, we shall find it sufficient to divide the 366 day-year into 61 equal periods of 6 days each' (1924, p. 96). This being so, it will not bring out any sharp changes in weather factor extending over a week or so coinciding with short well defined critical phytophases such as germination and blossoming especially annual crops.

Therefore in addition to regression integral, the regression function for selected periods has been worked out by scanning the weekly weather data for the overlapping periods. The relative

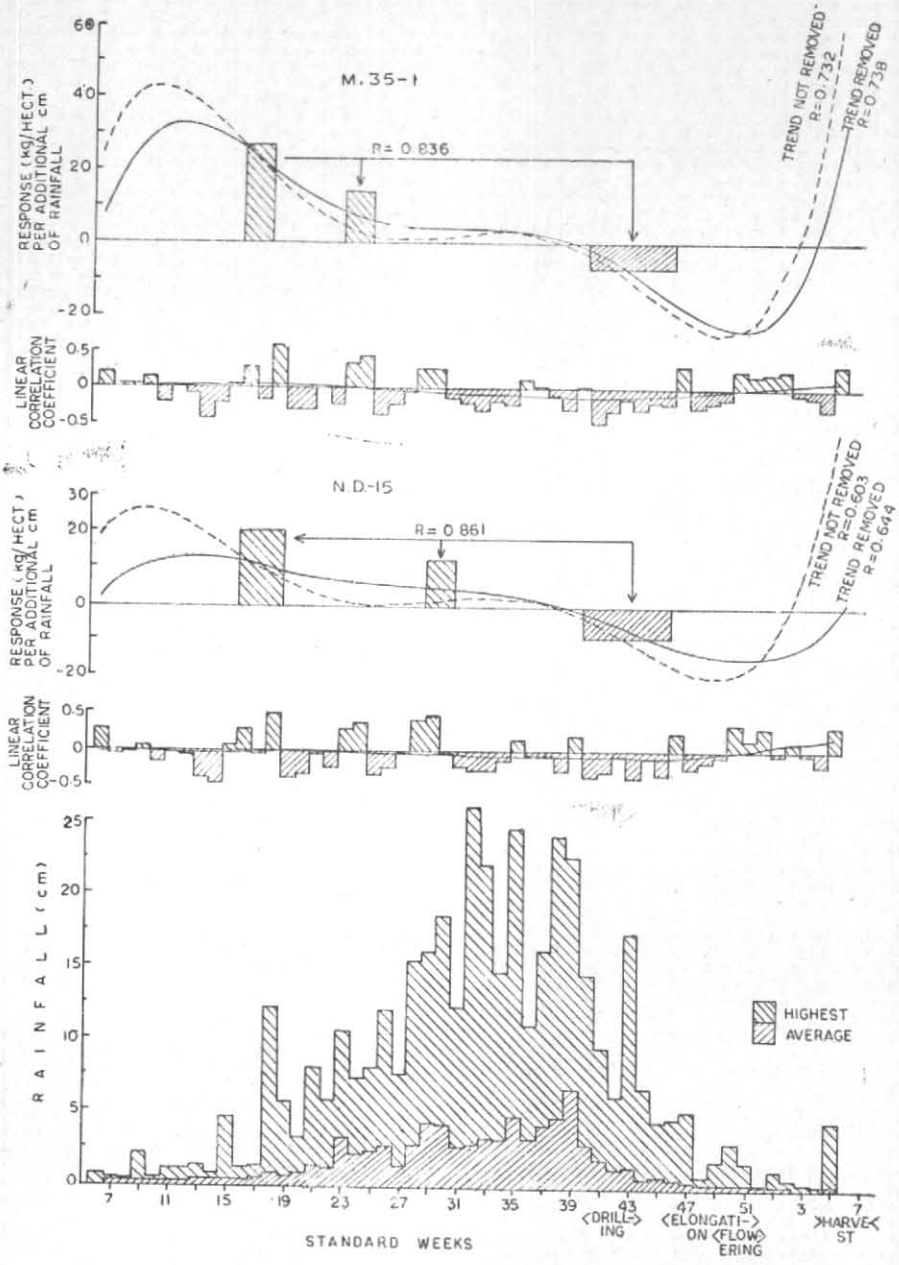

Fig. 1. Sholapur Rabi jowar M 35-1 and ND-15 — Reponse to rainfall

merits of these two techniques have been discussed in an earlier paper on Fisher's regression integral *versus* regression functions of selected weather factors in crop weather analysis (Sreenivasan 1972).

The selected periods regression for rainfall, maximum temperature and minimum temperature were subjected to partial regression analysis.

4. Results

(i) Rainfall

The continuous responses of the two varieties of jowar to weekly rainfall as evaluated by Fisherian technique are indicated by smooth curves in Fig. 1. In the bottom portion of the figure, the weekly rainfall amounts are given as a histogram. Also the linear correlation between the weekly rainfall and final yield are given as histogram for each variety with the trend as a smooth fifth degree polynominal curve.

The multiple correlation R of 0·603 before removal of trend and 0·644 after removal for ND-15 variety and the corresponding values of 0·732 and 0·738 for M 35-1 are not significant except the value of 0·732, the 5 per cent values for significance being 0·701 and 0·790 respectively.

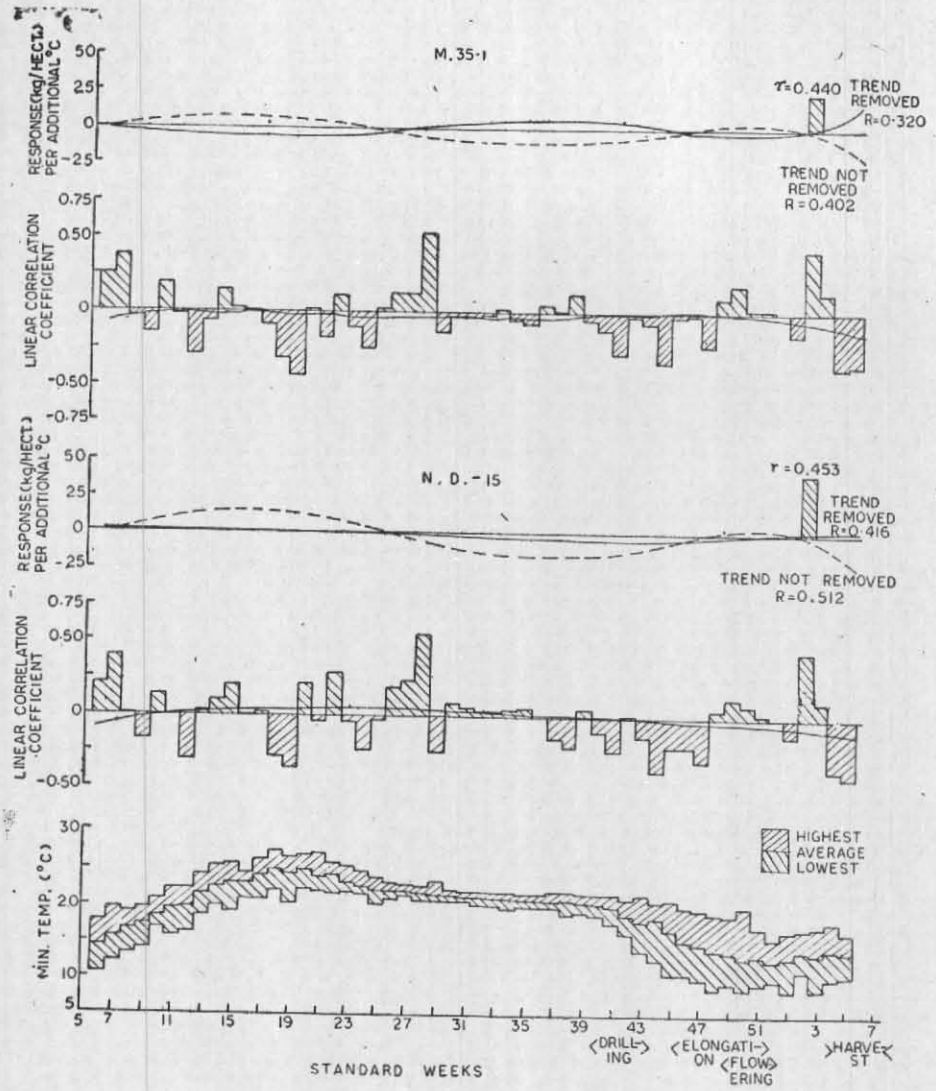

Fig. 2. Sholapur Rabi jowar M 35-1 and ND-15 — Response to minimum temperature

By the selected period method, three periods of rainfall are found to have significant influence on yield. These three periods are indicated as histograms in Fig. 1 itself. The magnitude of multiple correlation R is 0·861 for ND-15 and 0·836 for M 35-1.

(ii) Minimum temperature

The continuous responses of yield to minimum temperature as derived by the Fisherian technique are given in Fig. 2. At the bottom, the histograms of highest and lowest weekly minimum temperature from the normal are drawn.

There is no significant trend in the linear correlation between the weekly minimum temperature and the yield for both the varieties. Also the multiple correlations by regression integral method are not significant.

The selective period method indicates that the minimum temperature for the standard week No. 2 has a positive correlation with yield, the significant r at 5 per cent level of probability being 0·433. The influence of temperature in the second week on yield is indicated by histogram in Fig. 2.

(iii) Maximum temperature

The response curves for maximum temperature are indicated in Fig. 3. Although the magnitude of fluctuations in the weekly maximum temperatures during the cropping season are much less than those of weekly minimum temperatures, the influence of maximum temperature appears to be

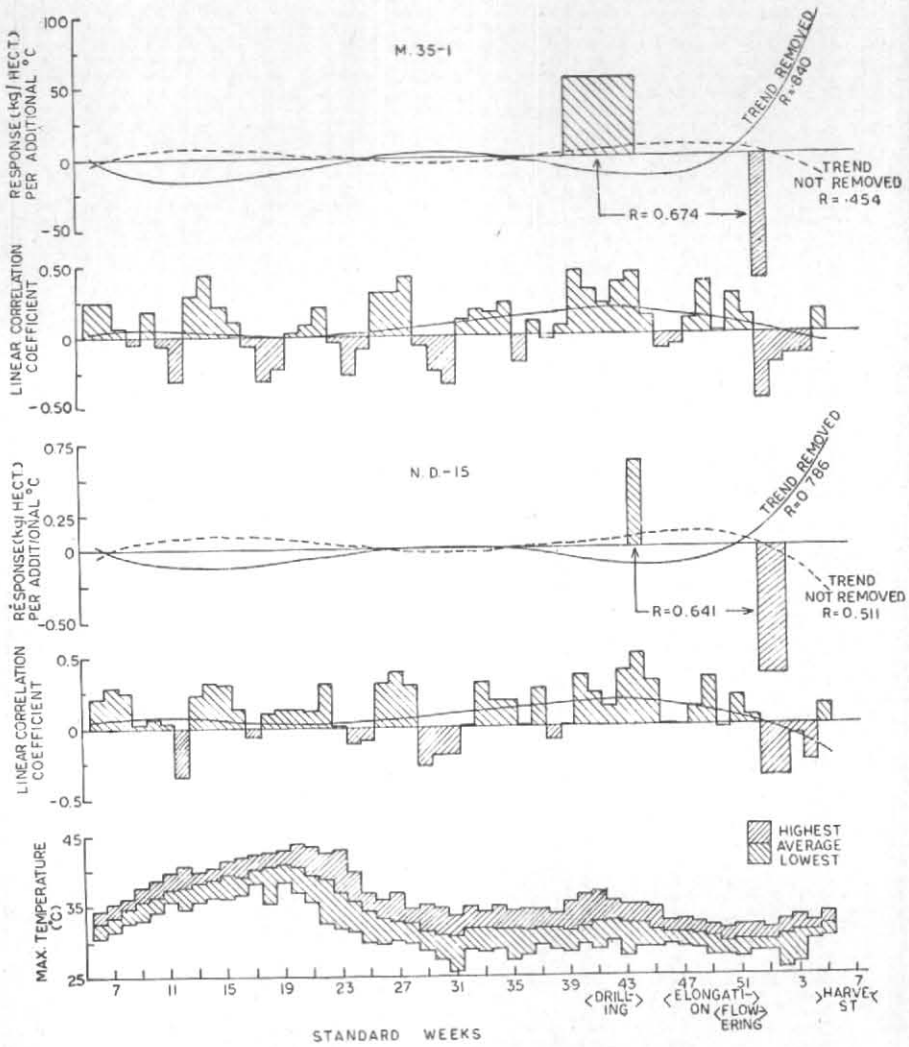

Fig. 3. Sholapur Rabi jowar M 35-1 and ND-15 — Response to maximum temperature

more profound. The multiple correlation R after the removal of trend is of the order of 0·786 for ND-15 and 0·840 for M 35-1 whereas the value of R at 5 per cent level of significance is 0·790.

The analysis of variance by Fisherian technique is given in Table 1.

There is a highly significant trend in the yield. After the removal of trends in yield and maximum temperature, the influence of maximum temperature on yield is found to be significant in M 35-1 and just falls short of 5 per cent level of significance in ND-15.

Fig. 4 gives the actual yield, the polynominal values and the estimated yield. In the years 1954 and 1965 the estimated yield values for both the varieties are less than the actual while in 1967 these are on the higher side.

TABLE 1

Due to	Degree of freedom	Mean square	
		ND-15	M 35-1
Regression	6	14,772	25,407*
Polynominal	5	54,894**	47,485**
Residual	10	5,499	6,347

*Significant at 5% level of probability
** Significant at 1% level of probability

The polynominal trends are very well marked for both the varieties and are similar. The width of the oscillation is about 5 to 6 years and the peak of the values is reached in the year 1966 which is a

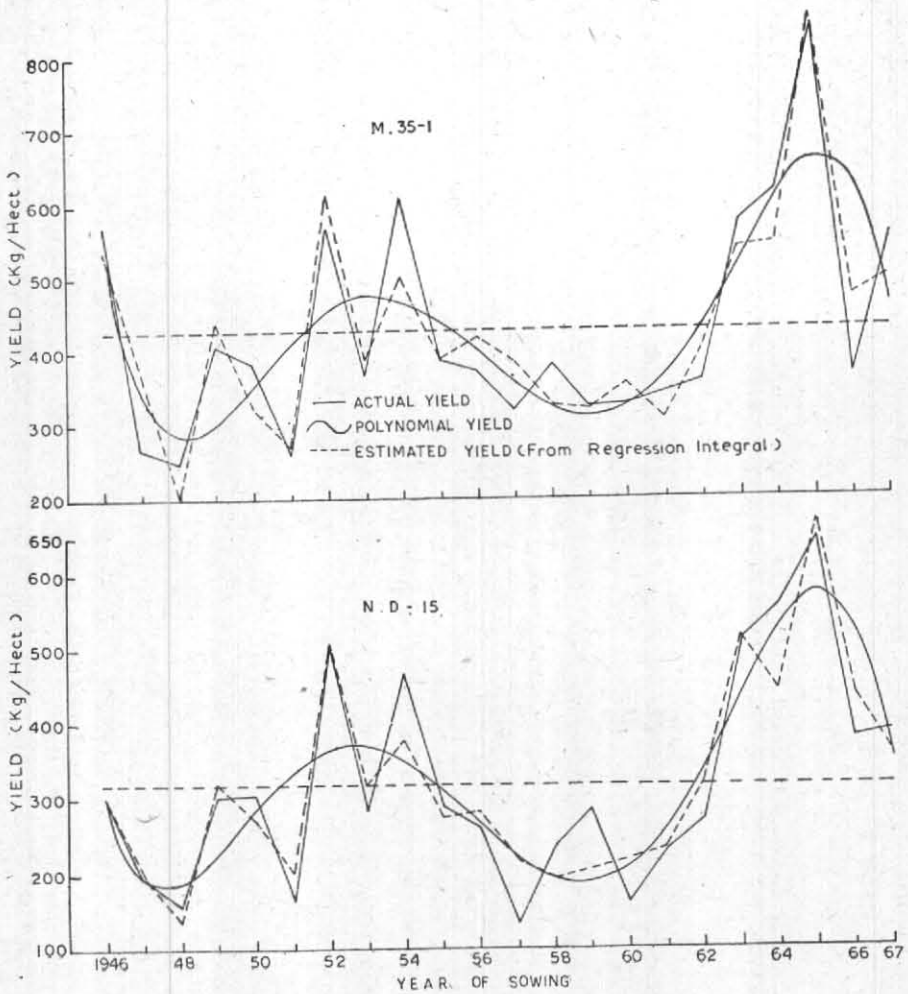

Fig. 4. Sholapur Rabi jowar — Actual and estimated yield

year of partial failure of crops in other parts of India.

The selective period method indicates two periods which influences both the varieties of winter jowar. The magnitudes of regression when taken severally and jointly are given in Table 2.

These two significant periods when taken jointly are indicated in Fig. 3 as boxes. The multiple correlations obtained by considering these two periods only are 0·641 for ND-15 and 0·674 for M 35-1. These values are significant at 1 per cent level of probability.

(iv) Rainfall and temperatures together

For the application of Fisherian technique 22 years data is far from adequate and hence such an analysis is out of question. However, with the selected period method, it will be possible to analyse the joint effect of these elements on crop performance.

TABLE 2

Variety	Period	Severally		Jointly	
		S.R.	t	P.R.	t
ND-15	44	57·4	2·64*	61·0	3·06**
	1–2	—80·1	1·65	—90·4	2·21*
M 35–1	40–44	53·1	2·41*	55·5	2·92**
	1	—83·5	2·29*	—87·5	2·82*

S.R. = Simple regression
P.R. = Partial regression
t = t value for t-test
*Significant at 5% level of probability
**Significant at 1% level of probability

When these significant periods, namely, three periods for rainfall, one for minimum temperature

and two for maximum temperature were taken together, the influence of temperature ceases to be significant.

5. Discussion

Rainfall is a discontinuous phenomenon and influences the crop mostly through the medium of soil. The soil characteristics and conditions determine the intake of rainwater and subsequent retention and loss of soil moisture. The distribution of rainfall in Sholapur is such that the land gets completely parched in the summer months of March to May leading to cracking and development of deep fissures in the black clayey soil. The application of Fisherian technique to this highly discontinuous phenomenon of rainfall in Sholapur may not be appropriate and advisable although Fisher (1924) has justified the application of this technique for analysing this discontinuous phenomenon of rainfall at Rothamoted in United Kingdom where the rainfall occurs in all the months of the year. Therfore, in the present study the alternate method of 'selected period' was found to be advantageous.

As regards temperature, this is a continuous phenomenon and as such the Fisherian technique is quite appropriate. So much so, the regression integral of maximum temperature on yield after the removal of the significant trend in yield was found to be significant in M35-1 and to be just significant in ND-15 variety of jowar. The two selected periods when taken jointly have significant influence on yield.

Table 3 gives the actual and the estimated yield values obtained by (*a*) Fisher's regression integral applied to maximum temperature and (*b*) the selected period method to the discontinuous phenomenon of rainfall.

In a few years both the methods have failed to give a good estimate of yield. Thus in the years 1964 and 1965 the estimated yield values for ND-15 are far below the actual. It is gratifying to note that in the bumper year of 1966, the estimated yield values by both the methods tally excellantly well with the actual. This cannot be said about years of low yield, namely 1947, 1948.

TABLE 3

Actual and estimated yield (kg/ha)

Year	ND-15 variety			M-35 variety		
	Actual	Estimated by		Actual	Estimated by	
		Fisherian technique	Selected period		Fisherian technique	Selected period
1946	298	301	275	575	536	540
1947	196	202	*336*	269	356	470
1948	158	133	*269*	250	203	336
1949	302	323	268	409	436	376
1950	307	275	239	383	325	345
1951	162	201	258	258	271	287
1952	498	510	547	567	607	468
1953	285	320	194	362	387	323
1954	471	*378*	*373*	603	*496*	612
1955	290	277	251	384	387	411
1956	261	285	266	371	413	344
1957	131	220	157	314	381	291
1958	240	194	285	377	324	340
1959	286	202	239	321	319	406
1960	169	217	*286*	324	356	*426*
1961	230	235	215	339	306	338
1962	273	324	284	355	396	421
1964	515	518	462	569	534	*379*
1965	557	446	457	606	538	535
1966	649	674	664	830	842	825
1967	380	442	402	358	467	410
1968	390	361	318	550	492	489
R		0·786	0·861	—	0·840	0·836
D.F.		10	18	—	10	18
No. of variables		6	3	—	6	3
Significant value at 5%		0·790	0·532	—	0·790	0·532
Significant value at 1%		0·859	0·633	—	0·859	0·633

R = Mulitiple correlation coefficient

D.F. = Degrees of freedom

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