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Estimating sugarcane yield at Padegaon in Maharashtra based on weather parameters

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सार — फसल के विकास की कुछ विशिष्ट अवधियों में मौसम प्राचलों का प्रयोग करते हुए पड़ेगांव, महाराष्ट्र में गन्ने की पैदावार के आकलन के लिए बहुरेखीय समाश्रयण समीकरण निकालने के लिए 1950 से 1969 के आंकड़ों का प्रयोग किया गया है। आकलित पैदावार में समाश्रयण समीकरण द्वारा 76% की भिन्नता का पता चलता है। 1970 और 1971 पूर्वानुमानित गन्ने की पैदावार और वास्तविक पैदावार में क्रमश: 8% और 11% का अन्तर देखा गया है।

ABSTRACT. A multiple linear regression equation has been derived for estimating sugarcane yield at Padegaon in Maharashtra, using some of the weather parameters at specific periods of crop growth. The data employed for deriving the actual regression equation is from 1950 to 1969. The regression equation accounts for 76 per cent variation in the estimated yield. The departure of predicted sugarcane yields from actual yields for 1970 and 1971 are observed to be 8 per cent and 11 per cent respectively.

1. Introduction

There are numerous studies regarding crop-weather relationships for estimating sugarcane yield. Raheja (1951) examined sugarcane yield at Peshawar in relation to maximum and minimum temperatures using two years' data only. His study indicated higher juice content with higher daily temperature range in the months of November and December. He also noted better germination in the years of higher temperatures. Gangopadhyay and Sarker (1964) studied growth of sugarcane at Poona in relation to maximum and minimum temperatures and rainfall. According to them, maximum temperature of 30.8° C and minimum temperature of 20° C during elongation period are optimum temperatures for best growth. Later Sarker (1965) studied the dependence of yield on weather factors during tillering phase by a similar technique and accounted 50 per cent of the yield variation by the weather anomalies alone. He mentioned 35° C maximum temperature and 18.3° C minimum temperature as optimum values for growth during this phase. Subbaramayya and Rupakumar (1980) developed a second degree regression equation for Anakapalli in south India. Their model explained 62 per cent variation in sugarcane yield. They used maximum temperature, minimum temperature and morning relative humidity during tillering phase. Rupakumar (1984) studied yield response of sugarcane to weather variations in northeast Andhra Pradesh and tried to fix favourable and unfavourable macrometeorological systems useful for crop output statements.

In the present paper an attempt has been made to develop a linear regression equation for estimating sugarcane yield at Padegaon in Maharashtra based on meteorological factors.

2. Material and method

Yield data of sugarcane (variety CO-419) grown at Padegaon in Maharashtra as well as that of commencement of different phenological stages of sugarcane growth for the period 1950 to 1971, have been collected from the Agricultural Meteorology Division of India Met. Dept., Pune alongwith weekly weather data of maximum and minimum temperatures, duration of sunshine, relative humidities (at 0700 and 1400 IST), rainfall and number of rainy days for this station. As a first step in this analysis correlation coefficients (C.Cs.) between sugarcane yield and individual meteorological parameters, as mentioned earlier have been calculated by considering each meteorological parameter on weekly basis as well as for 2, 3,.. and 15 consecutive weeks separately starting from 1st week, using 18 years of data from 1950 to 1969 (except for 1960 and 1963 for which data were missing). The choice of the period 15 consecutive weeks is arbitrary.

Out of total number of correlation coefficients obtained for each element some are significant at 5 per cent level and a few even at one per cent level. With these high C.Cs. it seems logical that weather elements for the corresponding periods could be employed to derive a helpful regression equation for estimating sugarcane yield. But obviously as their numbers are large all of them cannot be used. A method has to be thought of to limit the number of parameters. A simple method is followed here. Out of the significant correlation coefficients obtained, as mentioned earlier, those having maximum numerical value corresponding to each of the weather parameters under study were selected. The period for which the correlation coefficient has the highest numerical value for a weather element is termed

TABLE 1

The weather parameters and values of the highest correlation coefficients during sensitive periods

Symbol	Weather parameters	Sensitive period in standard week	C.Cs. for sensitive periods
x_1	Max. temp.	Beginning of 25th week to end of 26th week	—0.6043**
x_2	Min. temp.	During 34th week	—0.5828*
x_3	Bright sunshine	Beginning of 24th week to end of 25th week	—0.7010**
x_4	Rainfall	During 30th week	0.6053**
x_5	No. of rainy days	During 39th week	0.6768**
x_6	R. H. (Morning)	During 29th week	0.5037*
x_7	R. H. (Afternoon)	Beginning of 39th week to end of 40th week	0.6008**

*Significant at 5 per cent level. **Significant at 1 per cent level

TABLE 2

Mean values of the meteorological parameters for the sensitive periods [listed under Eqn. (1)] during different years

year	x_1 T_{max} (°C)	x_2 T_{min} (°C)	x_3 SNSH (hr)	x_4 RRRF (mm)	x_5 NRDS	x_6 RHMN (%)	x_7 RHAN (%)	Yield
1950	32.1	21.1	7.7	40.4	3	86.0	55.0	118.5
1951	31.2	21.4	6.0	8.1	2	89.0	44.5	112.0
1952	30.9	21.1	6.1	20.8	2	90.0	57.5	125.7
1953	29.6	20.7	5.3	31.5	3	85.0	56.0	125.5
1954	29.6	19.4	6.1	58.2	2	87.0	51.0	121.7
1955	29.1	21.0	6.2	11.7	5	83.0	67.0	124.7
1956	30.9	19.6	6.3	10.4	3	90.0	67.5	125.0
1957	31.0	21.6	9.2	15.2	1	89.0	42.5	96.7
1958	31.9	21.4	8.2	0.5	0	86.0	44.5	109.0
1959	32.0	21.1	7.7	6.1	2	89.0	55.0	106.7
1961	30.0	21.1	6.7	35.5	2	86.0	59.0	103.7
1962	32.6	20.6	9.3	8.7	0	78.0	42.5	91.3
1964	30.2	20.9	7.8	18.2	2	89.0	61.0	116.7
1965	30.7	21.4	7.4	3.2	3	87.0	34.0	110.7
1966.	31.4	21.0	7.3	37.3	2	91.0	44.0	127.0
1967	29.7	18.8	6.4	102.2	5	93.0	64.0	138.7
1968	31.3	20.8	7.4	7.4	4	84.0	55.5	104.3
1969	32.4	21.5	7.4	11.4	0	88.0	35.0	94.7
Mean	30.9	20.8	7.1	23.7	2.3	87.2	52.0	114.0
S.D.	1.0	0.8	1.1	25.0	1.5	3.4	10.3	13.0

T_{max} —maximum temperature. T_{min} —minimum temperature, SNSH—sunshine duration, RRRF—rainfall, NRDS—number of rainy days, RHMN—morning relative humidity and RHAN—afternoon relative humidity. A rainy day is defined as a day having 2.5 mm or more rainfall; SD—standard deviation.

TABLE 3

Intercorrelation coefficients between meteorological parameters during respective sensitive periods

	T_{max}	T_{min}	SNSH	RRRF	NRDS	RHMN	RHAN	With yield
T_{max}	1.0000	0.4283	0.6469**	—0.4537	—0.6454**	—0.1670	—0.5600*	—0.6043**
T_{min}		1.0000	0.3776	—0.7207**	—0.4527	—0.2145	—0.5294*	—0.5828*
SNSH			1.0000	—0.3421	—0.5544*	—0.2951	—0.4743*	—0.7010**
RRRF				1.0000	0.4229	0.3999	0.3432	0.6053**
NRDS					1.0000	0.1721	0.6563**	0.6768**
RHMN						1.0000	0.1352	0.5037*
RHAN							1.0000	0.6008**

*Significant at 5 per cent level, **Significant at 1 per cent level, Note—For abbreviations see Table 2

as 'sensitive period' for that weather element. It is observed that these periods are different for different weather elements. The values of highest correlation coefficients obtained for each element alongwith their respective periods are shown in Table 1.

The mean values of the meteorological parameters for each year for the sensitive periods are shown in Table 2. The purpose of showing this data is to get some idea as to how the meteorological parameters varied from year to year during the sensitive periods of crop growth.

A multiple linear regression equation was tried using weather parameters for the sensitive periods shown in Table 1. In Table 3 are shown the inter-correlation coefficients of the weather parameters during the sensitive periods. It is clear that most of the weather parameters are interrelated. The regression equation was tried with factors x_1 to x_7 as shown below :

$$y = a + b_1x_1 + b_2x_2 + .. + b_7x_7 \quad (1)$$

where, y is the yield in tonnes per hectare (dependent variable), a is a constant and $b_1, b_2, b_3, \ldots, b_7$ are the regression coefficients and $x_1, x_2, x_3, \ldots, x_7$ are the independent weather parameters during sensitive periods. The factors used and corresponding sensitive periods are given below :

x_1 : maximum temperature (mean value in °C for the period 25th to 26th week, *i. e*, 18 June to 1 July).

x_2 : minimum temperature (mean value in °C for the 34th week, *i.e.*, 20-26 August).

x_3 : bright sunshine (mean duration in hours for the period 24th to 25th week, *i.e.*, 11-24 June).

x_4 : rainfall (total in mm for 30th week, *i.e.*, 23-29 July).

x_5: number of rainy days (total for 39th week, *i.e.*, 24-30 September).

x_6 : morning relative humidity (mean value for 29th week, *i.e.*, 16-22 July).

x_7 : afternoon relative humidity (mean value for the period 39th to 40th week, *i.e.*, 24 Sep to 7 Oct).

3. Results and discussion

When the factors were included in the order x_3, x_4, x_5, x_6, x_7 the contributions of the different terms to the total of explained variance are : x_3 48.4 per cent, x_4 an additional 15.3 per cent, x_5 an additional 6.0 per cent, x_6 an additional 4.8 per cent and x_7 an additional 1.7 per cent. x_2 gave only an additional 0.365 per cent and x_1 an additional 0.001 per cent. In order to keep the number of parameters to a minimum and yet not losing much of the accuracy the terms contributing less than one per cent additional variation, x_1 and x_2, have been left out and the final regression equation is as follows :

$$y = 40.08370—3.85081x_3+0.12048x_4+2.08678x_5+ +0.94394x_6+0.22122x_7 \quad (2)$$

Multiple correlation coefficient $R = 0.87$

The total percentage variation accounted for by the above equation is 76 per cent. The degrees of freedom of regression equation is 12. In the present model technological terms have not been included as the station belongs to one from a coordinated crop weather scheme where this influence is supposed to be uniform. Also since the data did not show any trend the term pertaining to trend has also not been included. The crop weather data for 1970 and 1971 have been used for testing the regression equation. The predicted values are 120.1 and 128.4 tonnes/hectare while the actual values are 134.3 and 138.3 tonnes/hectare respectively. The estimated, actual and predicted yields are shown in Fig. 1. It is seen from this figure that the estimated and actual yields for the period 1950 to 1969 (except for 1960 and 1963 for which the data were missing) are in close agreement. The predicted yields for 1970 and 1971 are within 8 per cent and 11 per cent of the actual yields respectively.

4. Conclusion

The study shows that maximum and minium temperatures, sunshine duration, rainfall, number of rainy days and relative humidities (at 0700 and 1400 IST) during the respective sensitive periods of mid-elongation phase are significant although the first three are negatively correlated with sugarcane yield. Using these weather elements alone (omitting temperatures) during the mid-

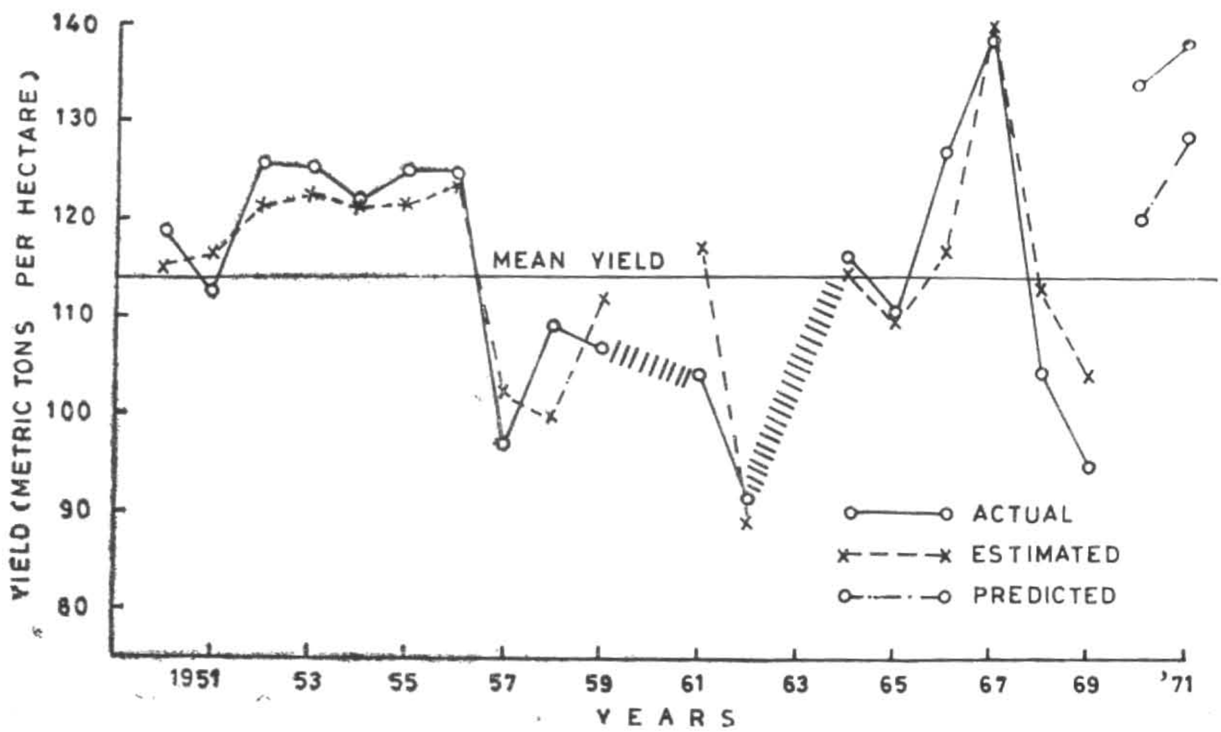

Fig. 1. Actual, estimated and predicted yields of sugarcane at Padegaon

elongation period a linear regression equation has been developed to estimate sugarcane yield at Padegaon to a fairly good approximation; the variation explained is 76 per cent. It is recognised that the study is based on limited data of 18 years and the results may, therefore, be regarded as indicative of the weather parameters in mid-elongation phase which significantly affect yield.

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References

Gangopadhyay, M. and Sarker, R.P., 1964, "A curvilinear study of yield with reference to crop characteristic—Sugarcane", *Indian J. Met. Geophys.*, **15**, 2, pp. 201-214.

Gangopadhyay, M. and Sarker, R.P., 1964, "Curvilinear study of the effect of weather on the growth of sugarcane", *Indian J. Met. Geophys.*, **15**, 2, pp. 215-226.

Raheja, P.C., 1951, "I: Analysis of sugarcane yields, II: Relative influence of season, irrigation intervals, methods of planting and nitrogen doses on yield and quality of cane", *Indian J. Agric. Sci.*, **21**, pp. 203-214.

Rupakumar, K., 1984, "Yield response of sugarcane to weather variations in northeast Andhra Pradesh, India", *Archives for Met. Geophys. and Bioclim.*, **35**, pp. 265-276.

Sarker, R.P., 1965, "A curvilinear study of yield with reference to weather—Sugarcane", *Indian J. Met. Geophys.*, **16**, pp. 103-110.

Subbaramayya, I. and Rupakumar, K., 1980, "Crop-weather relationships of sugarcane and yield prediction in northeast Andhra Pradesh", *Agric. Met.*, **21**, pp. 265-279.