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# Letters to the Editor

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## ESTIMATION OF SUGARCANE YIELD AT PUNE WITH THE HELP OF METEOROLOGICAL PARAMETERS

1. There are numerous studies regarding estimation and prediction of yields of some of the important crops. Two distinct approaches are in practice. In the first case an empirical statistical relationship is established between the crop yield and the crop growth parameters, Sarker *et al.* (1962), Gangopadhyaya and Sarker (1964a, b). While in the second case the relationship is developed between the crop yield and the weather parameters alone (Sreenivasan 1972). The latter approach is simpler as it requires only crop yield and weather data which are generally available.

Sarker (1965), using 16 years data of Pune studied the dependence of sugarcane yield on weather factors during tillering, and tillering along with elongation phases. His studies accounted for 50 per cent of yield variation during tillering phase and 80 per cent during tillering and elongation phases together. Subbaramayya and Rupakumar (1980) using maximum and minimum temperatures and morning relative humidity during tillering phase accounted 62 per cent of the sugarcane yield variation at Anakapalli in Andhra Pradesh. Gupta and Singh (1988, 1989) studied sugarcane yield at Padegaon and Jalandhar accounting 76 per cent and 79.4 per cent of yield variations respectively. They used the period corresponding to maximum correlation value of yield with each weather element as a criteria for identifying the significant period for using the weather data in developing the regression equation. In the present paper an attempt has been made to estimate sugarcane yield at Pune by a similar technique as well as by the phasewise approach and results of two approaches are compared.

2. Sugarcane yield data as well as weekly weather data of maximum and minimum temperatures, duration of sunshine, relative humidity at 0700 IST and 1400 IST, rainfall amount and number of rainy days of a coordinated crop weather scheme station Pune have been collected for the period 1947 to 1972 from the Agricultural Meteorology Division of India Met. Dep., Pune. The data beyond 1972 was not available and that of 1971 was missing.

At Pune the life cycle of sugarcane is about 54 weeks. The data from 1947 to 1969 have been used for developing regression equations and estimating yield while that of 1970 and 1972 have been used for verification or forecast purposes. The study has been performed in two different ways as given below.

3. *Phasewise study* — The life cycle of the crop has been grouped according to phases in the following periods :

(*i*) Planting to commencement of tillering (3rd to 9th standard week),

(*ii*) Commencement of tillering to commencement of elongation (10th to 22nd standard week),

(*iii*) Planting to commencement of elongation (3rd to 22nd week).

Periods beyond this involves harvesting also and have therefore not been considered suitable for forecast purposes.

Multiple linear regression equations have been developed with yield as the dependent variable and the weather parameters of maximum temperature ($x_1$), minimum temperature ($x_2$), duration of sunshine ($x_3$), rainfall amount ($x_4$), number of rainy days ($x_5$), morning relative humidity ($x_6$) and afternoon relative humidity ($x_7$), as independent variables for each of the three periods mentioned earlier.

4. *Maximum correlation method* — Sreenivasan (1972) and Shanker & Gupta (1987, 1988) used correlation coefficient method for identifying significant periods for which the data of weather elements could be used to develop the multiple linear regression equation for estimating paddy yields. In this method first the correlation coefficients were obtained on weekly basis as well as for 2, 3, 4,. . ,15 successive weeks separately. The choice of the period 15 weeks was arbitrary. Out of the total number of correlation coefficients obtained for each element correlation coefficients significant at one per cent level were used. One of the obvious difficulty encountered by them was that for some weather elements there were more than one significant periods for the same weather element and all had to be included in the regression equation. Later on, Gupta and Singh (1988, 1989) used the period corresponding only to the maximum (highest) value of the correlation coefficients for each of the weather elements.

In the present paper the maximum correlation method has been tried for estimating sugarcane yield at Pune on similar lines.

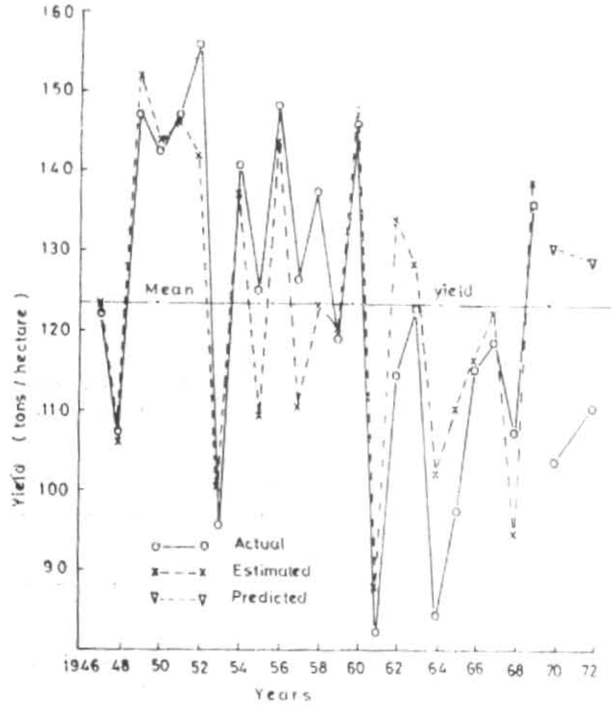


Fig. 1. Showing the actual or estimated and predicted yields at Pune

5. The results of the studies made on the basis of phasewise approach and maximum correlation methods are discussed below. Variables contributing less than one per cent towards the total variation in yield have not been included in the final regression equation for estimating yields.

6. *Results of phasewise analysis* — The regression equations developed, periods for which the respective weather elements have been used and the coefficient of determination ($R^2$) expressed in per cent are given in Table 1. It can be seen from Table 1 that for the phase of sowing to commencement of tillering, the variation in yield accounted is only 24.7 per cent. The multiple correlation coefficient was also not significant at 5 per cent level. For the tillering phase the variation in yield accounted is 40.2 per cent. The multiple correlation coefficient was significant at 5 per cent level. The combination of the first and second phase (sowing to commencement of elongation) accounts for 28.7 per cent variation in crop yield. The multiple correlation coefficient was not significant at 5 per cent level. Thus in phasewise approach, although the tillering phase shows some promise by accounting 40.2 per cent variation in crop yield, the method cannot be considered satisfactory for estimating and forecasting of crop yield, as the yield variation accounted is low.

7. *Results of maximum correlation method* — The weather elements, periods for which maximum correlation coefficients are obtained for each element, the actual values of these maximum correlation coefficients obtained, the final regression equation developed and the coefficient of determination ($R^2$) are shown in Table 2. The partial regression coefficients are tested for their significance. They are found to be significant at one per cent level. Their '$t$' values are also given in parenthesis.

TABLE 1

**Results of phasewise approach of sugarcane yield-weather relations at Pune**

| Period | $R^2$ (%) | Regression equations developed |
|---|---|---|
| 3 to 9 weeks (Sowing to commencement of tillering) | 24.7 | $y = 382.958 - \underset{(0.47)}{6.889x_1} + \underset{(0.68)}{4.720x_2} - \underset{(0.66)}{13.593x_3} - \underset{(1.26)}{1.1225x_4} + \underset{(1.17)}{1.533x_6} - \underset{(1.18)}{3.028x_7}$ |
| 10 to 22 weeks (Commencement of tillering to commencement of elongation) | 40.2 | $y = 129.332 + \underset{(1.29)}{14.814x_1} - \underset{(1.44)}{10.521x_2} - \underset{(2.74)^{**}}{38.543x_3} - \underset{(0.83)}{1.319x_5} + \underset{(0.53)}{0.887x_6} - \underset{(0.30)}{0.635x_7}$ |
| 3 to 22 weeks (Sowing to commencement of elongation) | 28.7 | $y = 324.067 - \underset{(1.68)}{25.923x_3} - \underset{(0.84)}{1.291x_5} + \underset{(1.16)}{1.912x_6} - \underset{(2.67)^{*}}{2.892x_7}$ |

$R^2$ — Coefficient of determination in per cent,
** — Significant at 2 per cent level,
* — Significant at 5 per cent level,
$x_1$ — Maximum temperature, $x_2$ — Minimum temperature,
$x_3$ — Duration of sunshine, $x_4$ — Rainfall amount,
$x_5$ — Number of rainy days, $x_6$ — Morning relative humidity
$x_7$ — Afternoon relative humidity.

TABLE 2

**Results of maximum correlation approach for sugarcane yield-weather relationship for Pune**

| Weather parameters | Periods in standard weeks corresponding to maximum CCs | Maximum CCs value |
|---|---|---|
| $x_1$ Maximum temperature | 19 | 0.4320 |
| $x_2$ Minimum temperature | 33-34 | −0.5155** |
| $x_3$ Bright sunshine duration | 09-23 | −0.5565*** |
| $x_4$ Rainfall amount | 24-26 | −0.5180** |
| $x_5$ Number of rainy days | 21-23 | 0.5145** |
| $x_6$ Relative humidity (morning) | 21-24 | 0.4820** |
| $x_7$ Relative humidity (afternoon) | 22 | 0.5213** |

Regression equation developed :

$$y = 555.177 + \underset{(3.69)^{***}}{5.832x_1} - \underset{(2.94)^{***}}{22.688x_2} - \underset{(2.99)^{***}}{16.335x_3} - \underset{(3.13)^{***}}{0.108x_4}$$

$R^2 = 78$ (per cent)

*** ** and * significant at 1, 2 and 3 per cent level respectively. The values in parenthesis are '$t$' values.

In order to keep number of terms to be included in the regression equation to a minimum and yet not losing much of the accuracy, terms contributing less than one per cent in the total yield variation are not included in the final regression equation shown in Table 2.

The final regression equation as given in Table 2 accounts 78 per cent of the yield variation. The weather data of the years 1970 and 1972 have been used to test the regression equation. The predicted yields from the derived regression equation for 1970 and 1972 are 130.6 tonnes/hectare and 129.0 tonnes/hectare whereas the actual yields for these years respectively are 104.0 tonnes/hectare and 110.5 tonnes/hectare. The actual yields, estimated yields and the predicted yields are graphically represented in Fig. 1. It is seen that in 70 per cent cases the estimated yields are in close agreement lying within $\pm10$ per cent of the actual yields. In 22 per cent cases they lie within $\pm15$ per cent and in remaining 8 per cent they lie between $\pm21$ per cent. The year to year fluctuations of the estimated and actual yields are also seen to be in the same sense. In 1970 the predicted yield lies within 26 per cent of the actual value and in 1972 it lies within 17 per cent of the actual value.

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