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DEVELOPMENT OF A MULTIPLE LINEAR MODEL TO FORECAST COTTON YIELD WITH REFERENCE TO WEATHER ELEMENTS AT JALGAON

K.K. SINGH AND R. S. SINGH[1]

Department of Geophysics, Banaras Hindu University,
Varanasi, U.P. - 221 005

ABSTRACT

Multiple linear models were developed to predict the cotton yield under semi-arid conditions of Jalgaon (Maharashtra). The influence of weather factors was considered in three sub-periods corresponding to different phenological stages. Weather factors during the sub-period I (sowing to commencement of branching) alone accounted for 66.5% of the variations in the yield. These factors, when combined with the weather factors of sub-period II (branching to commencement of flowering) and sub-period III (commencement of flowering to end of flowering) accounted for about 8% of the variations in cotton yield. The low maximum temperature, lower sunshine and low humidity during germination phase are beneficial to the cotton crop. During the elongation and branching period, higher maximum temperature benefits the yield. During the flowering period higher sunshine favours the crop yield.

INTRODUCTION

In India, there are very few studies on the influence of weather on cotton yields. Saha and Banerjee (1975), using the statistical techniques developed by Fisher (1924), observed that minimum temperature played the most important role in explaining about 72% of the total variations in cotton yield. In the present study an attempt has been made to develop the multiple linear model for estimating cotton yield, under semi-arid conditions of Jalgaon, based on meteorological factors.

MATERIAL AND METHODS

Yield data of rainfed cotton grown at Jalgaon, Maharashtra and commencement of different phenological stages of the crop growth for the period 1950 to 1974 were collected from the India Meteorological Department, Pune alongwith weekly data of maximum and maximum temperatures, duration of sunshine, relative humidities (at 0700 and 1400 IST), rainfall and number of rainy days.

The weather factors were examined for a 20-week period from sowing, standard Meteorological Week (SMW) 26 to the end of flowering period, SMW 45. On the

[1]Scientist S-1, Central Arid Zone Research Institute, Jodhpur-342 003

basis of commencement of different phenological stages of the crop, 3 sub-periods were considered :

I. Sowing to the comencement of branching (SMW 26-32)

II. Commencement of branching to the commencement of flowering (SMW 33-35)

III. Commencement of flowering to the end of flowering (SMW 36-45)

All the relevant weather factors e.g. (i) average daily maximum temperature, (ii) average daily minimum temperature (iii) sunshine (hours), (iv) mean relative humidity, morning, (v) mean relative humidity, afternoon, (vi) total rainfall (mm) and (vii) number of rainy days during each sub-period were worked out. The multiple linear regression equations were worked out for all the 3 sub-periods as prescribed by World Meteorological Organization (1982). Data of yield and weather factors for 1950 to 1971 were used to develop the linear models in all cases.

RESULTS AND DISCUSSION

In Jalgaon region the cotton is sown from the middle of June to the middle of July. The elongation period (commencing at about 6 weeks after sowing) is of about 9 weeks and branching (starting simultaneously) continues for about 11 weeks. Flowering (commencing 10 weeks after sowing) continues for 10 weeks and the crop is harvested by the end of December to the beginning of January (total crop period of 27 weeks).

In the multilinear regression equations derived (df = 19), Y is the yield of cotton, X denotes the corresponding weather parameters serially numbered as X_1 to X_7 for the sub-period I, X_8 to X_{14} for the sub-period II and X_{15} to X_{21} for the sub-period III.

Multiple linear model derived for the sub-period I explained for 66.5% of variations in yield, taking into account the sunshine hours (X_3) and afternoon RH (X_7) as independent variables :

$$Y = 5261.92 - 279.513\ X_3 - 55.241\ X_7 \ldots\ldots (1)$$

Multiple correlation coefficient (m.c.c.) 0.816, significant (at 1% level)

The model for the sub-period II explained for about 29% of variations in yield, taking into account maximum temperature (X_9), minimum temperature (X_8) and sunshine duration (X_{10}).

$$Y = 1393.96 + 176.66\ X_8 - 256.955\ X_9 - 81.321\ X_{10} \ldots\ldots (2)$$

m.c.c. = 0.58, ns

The model derived for the sub-period III explained for about 15% of variations in yield, taking into account morning R.H. (X_{20}) and afternoon RH (X_{21}) :

$$Y = -474.322 + 40.146\ X_{20} - 48.213\ X_{21} \ldots\ldots (3)$$

m.c.c. = 0.387, ns

Evidently, weather during sub-period I (including germination phase) is more important to determine the yield than the weather in the other two subperiods, and variation explained for is 66.5 %. Equation 1 also depicts that humidity above normal as well as sunshine hours above normal, during the germination period, are detrimental to the yield of cotton.

Association of weather factors of sub-period I with those of sub-period II gave the following regression equation :

$$Y = 4537.31 - 270.31\ X_3 - 52.61\ X_7 + 16.494\ X_8 \ldots\ldots (4)$$

m.c.c. = 0.818, significant (at 1% level)

This model explained for 66.9% of the variations in yield, with almost no substantial improvement to account for variations in the yield over equation 1. This may be due to the significant inter-relationship between humidity (X_7) of sub-period I and maximum temperature (X_8) of sub-period II.

Overall consideration of the weather factors of all the sub-periods (X_1-maximum temperature of sub-period I, X_{17} —duration of sunshine in sub-period III, X_3, X_7 and X_8 as in equations 1 and 2) gave the regression equation :

$$Y = 7549.94 - 98.08\ X_1 - 355.97\ X_3 - 62.08\ X_7 + 5.58\ X_8 + 186.52\ X_{17} \ldots (5)$$

m.c.c. = 0.889, significant at 1% level, df = 16

This model explained for about 80% of variations in yield.

It can be inferred from equation 5 that maximum temperature should be below normal during germination and higher during elongation and branching phase for getting better yields. Sunshine duration, during the following periods and later stage of elongation as well as branching, should be above normal for better crop performance.

Out of the five models, two models (equations 1 and 5) can successfully be used for estimation and prediction of cotton yield; one gives the yield forecast by middle of August and the other gives an improved forecast about one and a half months before harvest. These two models were tested using the crop weather data of three years 1972, 1973 and 1974. In the first model, the predicted values are 658, 592 and 296 kg/ha, respectively, while the actual values are 598, 325 and 173 kg/ha, respectively. In the last model the predicted values are 700, 503, 221 kg/ha, respectively. The estimated and predicted yields for both the models with the actual yields are shown in figure 1 which shows that the departures of predicted values in the last model from actual values are less than those in the first model.

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