Mausam, (1995), **46**, 3, 275-278

633.51 : 632.1

The estimation of cotton yield based on weather parameters in Maharashtra

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(*Received 23 August 1993, Modified 6 May 1994*)

सार — महाराष्ट्र के विदर्भ क्षेत्र के पांच जिलों में 12 वर्षों (1975-1987) के लिए कपास की उपज को सांख्यिकीय-समाश्रयण अध्ययन के लिए प्रयोग किया गया। यह पाया गया कि सितम्बर के पहले पक्ष के दौरान अधिक तापमान, जो कपास के मुकुलन तथा पुष्पन का समय होता है, पहले के लिए अनुकूल है। अक्तूबर के दूसरे पक्ष की शीत रातें, जब फसल फलन अवस्था में होती है, अच्छे फलन के लिए अनुकूल है जिससे कपास की उपज में वृद्धि होती है। जून के अंतिम सप्ताह से जुलाई के पहले सप्ताह तक, जब फसल के अनुकरण का समय होता है, अधिक वर्षा के कारण पानी के जमाव से पौध कम हो जाती है और दिसम्बर के दूसरे पक्ष में वर्षा के दिन अधिक होने के कारण बॉल प्रस्फोटन में असर पड़ता है और इससे कपास की उपज पर विपरीत प्रभाव पड़ता है।

ABSTRACT. The cotton yield of 12 years (1975-1987), for five districts in Vidarbha region of Maharashtra, was taken for statistical-regression study. It is found that the higher temperature during first fortnight of September, which is period of budding and flowering, is favourable for better yield. The cooler nights during second fortnight of October, when the crop is generally in fruiting stage, also help in good increase in final cotton yield. Higher rainfall, during last week of June to first week of July, when the crop is in the germination period, causing logging, reduces the seedling and more number of rainy days in second fortnight of December hamper the boll bursting and thus affecting the cotton yield adversely.

Key words — Physiological, Phenological, Boll, Variance, Sap, Photosynthesis, Vigour, Aeration.

1. Introduction

An attempt has been made in this study to develop a meteorological multiple regression model using historical data as a first step. Location specific models to evaluate the relationship between different weather, physiological and pests/diseases parameters and yield, may be taken as the second step. Later, these may be suitably combined to derive an integrated multiple regression model in which satellite-based spectral data would also be used for large area application.

2. Materials and method

Cotton yield data of 12 years (1975-1987) for five highest cotton growing districts of Vidarbha, *viz.*, Wardha, Akola, Yeotmal, Amravati and Nagpur were chosen. The yield data were collected from Epitome of Agriculture in Maharasthra published by Department of Agriculture, Maharashtra State, Pune. The daily rainfall data from 34 stations and meteorological data from one station in each district were collected from the records of India Meteorological Department (IMD). The distribution of rainfall stations in different districts was 9 in Yeotmal, 8 in Akola, 3 in Wardha, 8 in Amravati and 6 stations in Nagpur district. The period selected for the study was from June to December, which covers approximately all growth stages of cotton from sowing to nearly last effective picking.

The yearly average yields, for the area are calculated from the district yields. The daily averages of the meteorological parameters were calculated for whole region combining data of all stations.

The weather elements considered were rainfall, maximum and minimum temperature, relative humidity and sunshine hours. The derived parameters like mean temperature and rainy days (RD) were worked out as per the criteria used in IMD.

The primary and derived weather parameters were taken as independent variables and cotton crop yield as a dependent parameter. Linear correlations were first calculated between yield and different parameters separately for successive overlapping periods of 7 to 30 days during the whole growing season.

The correlation coefficients (r) for each element were analysed for their statistical and phenological significance. Critical periods when weather exerts

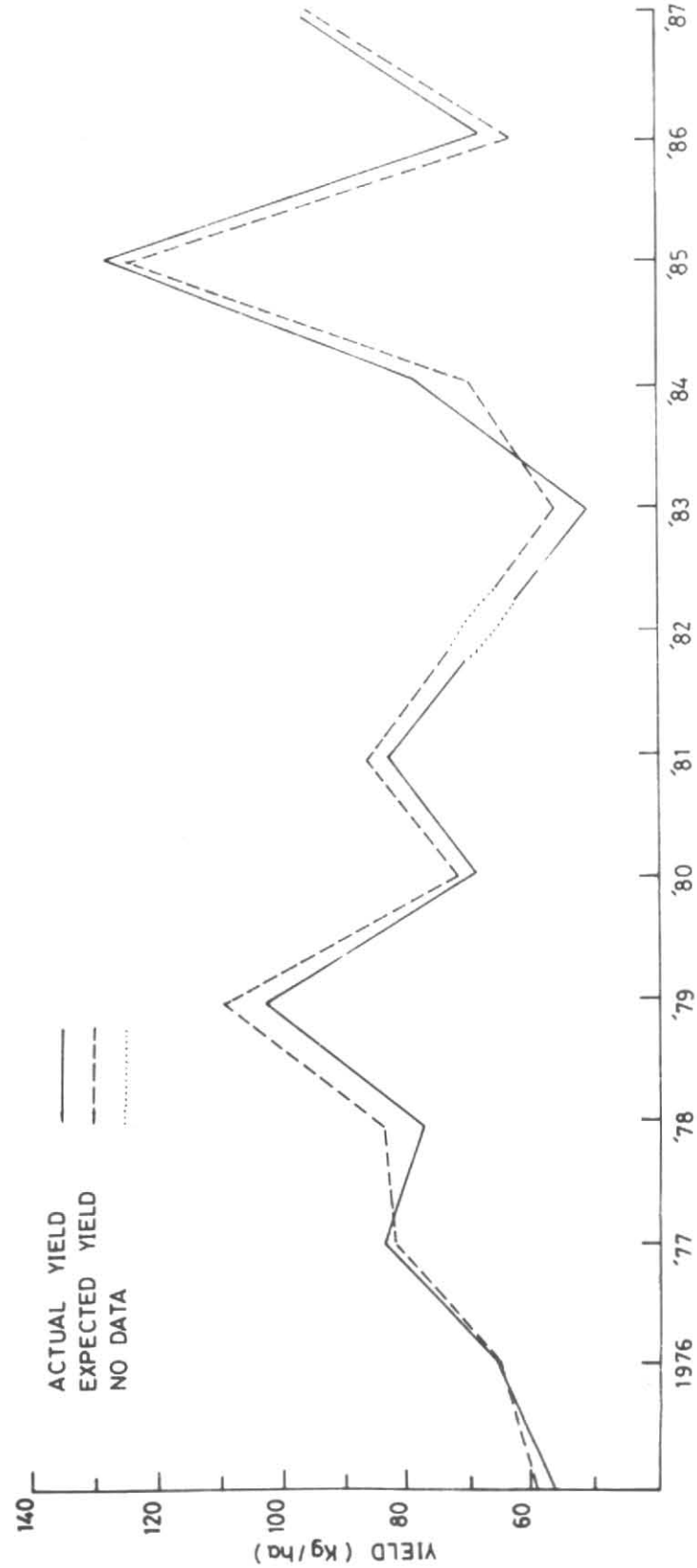

Fig. 1. Comparison between actual (———) and model (– – – –) yield

significant effect on yield were then located. These selected parameters were used to calculate correlation with the yield by subjecting them to step-wise regression analysis as adapted by Draper and Smith (1966). This enabled to reduce the number of independent parameters in the multiple regression.

3. Results and discussion

The indirect effect of temperature, rainfall and relative humidity on the final yield of cotton has been reported by several workers. The boll retention and the time of opening depend on temperature (Kuehl *et al.* 1976, Wallach *et al.* 1978). Flower production and cotton seed yield have positive correlation with moisture content of the atmosphere (Venkatachalam *et al.* 1976).

The parameters finally selected in the present analysis were mean temperature, number of rainy days and the rainfall. The linear multiple regression equation obtained is shown below :

$$Y = -79.5 - 8.2\,x_1 - 259.5\,x_2 - 2.06\,x_3 + 14.7\,x_4.$$
$$(5.20)^{**} \quad (7.23)^{**} \quad (2.85)^{**} \quad (5.42)^{*}$$

$r = 0.97$

The Student's 't' values of these factors are given in bracket.

** Significant at 1% level.

* Significant at 5% level.

where, x_1 — Mean temperature (°C) between 15-28 October

x_2 — Number of rainy days from 17-31 December

x_3 — Rainfall (mm) during the period 25 June-8 July

x_4 — Mean temperature (°C) during 3-16 September

As may be seen, the 't' values of each of the parameters were highly significant. The multiple correlation was also significant and accounts for 94.3 percent of total variation in yield.

From analysis of variance point of view, the most important parameter is the number of rainy days in second fortnight of December as it alone explains 42.5 percent of variance. It is most effective

TABLE 1

Analysis of variance

	SS	DF	MS	'F' Value
Regression	4679.06	4	1169.76	29.00*
Residual	282.33	7	40.33	
Total	4961.39	11		

* Significant at 1% level

in reducing the yield because it hampers the boll bursting which generally takes place during this period. During such weather, sucking pests like aphids, white fly and bollworm also damage the crop causing reduction in yield. Aphids suck the sap of growing plants, interfere with photosynthesis and reduce vigour and further growth of the plant. Heavy infestation causes hopperburn which leads to shedding of fruiting parts. White fly desaps the plant weakening the plants and its physiological process. Shedding of reproductive parts and forced boll bursting is the way of damaging the crop. Bollworms bore the central shoot and cause damage to growing shoot by burrowing inside the stem. After severe formation larvae damage squares, flowers and bolls. This remains on the crop throughout the cropping season.

The mean temperature during second fortnight of October coinciding with fruiting period also has negative effect on cotton yield. According to Reddy *et al.* (1991) plants gain more biomass at 30°C day temperature and 20°C night temperature and partition more of it to reproductive structures, *i.e.,* bolls at the expense of stem, branch, root growth and leaf development at higher nodes. Rainfall during 26th and 27th week (25 June to 8 July), *i.e.,* after germination, shows detrimental effect. This is the period when germination of cotton occurs. Excess rainfall during this period leads to water logging, retarding plant growth and hence the yield. As such soils of good moisture holding capacity, good drainage and aeration are pre-requisite for an optimum harvest. Rainfall in this phase (25 June to 8 July) also causes development of some sucking pest like bollworm which affects germination and finally reducing the yield. During 36th and 37th week (3 to 16) September) which falls in first fortnight of September, cotton is mainly in square to open flowering phase in the area considered. The mean temperature shows positive contribution to the yield meaning thereby that higher temperature helps in budding and flowering.

The analysis of variance is shown in Table 1. The 'F' value was highly significant. The fit between the actual and the estimated yield is shown in Fig. 1 Barring a few cases these two sets of values were found very close to each other. The range of departure of estimated yield from reported yield was between −10 to + 12%. Thus, the model developed can be used for estimating yield with reasonable degree of confidence.

4. Conclusions

Based on this study, the following conclusions may be drawn :

(*i*) The most controlling weather factor reducing the cotton yield is the number of rainy days during boll development or bursting.

(*ii*) During fruiting low mean temperature is favourable for better yield.

(*iii*) Rainfall immediately after germination results in stunted growth and thus has detrimental effect on the yield.

(*iv*) Higher tempereture during square to open flowering helps in better cotton yield.

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