

## Effect of weather on growth and yield of cotton grown in the dry farming tract of peninsular India

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**सार** – इस शोध पत्र में प्रायद्वीपीय भारत के वर्षाधीन खेती के क्षेत्र में तीन अलग-अलग केन्द्रों में कपास की बढ़ोतरी पर मौसम वैज्ञानिक प्रचालों के प्रभाव का विवेचनात्मक अध्ययन किया गया है। इस अध्ययन के अधीन विशेषकर पौधे की बढ़वार और फूल आने की अवस्थाओं में न्यूनतम तापमान (सामान्य से अधिक) में वृद्धि कपास की तीनों किस्मों (ए. एच. एच.-468, एम. सी. यू.-9 और एम. सी. यू.-10) की पैदावार के लिए अनुकूल पाई गई हैं। फूल आने और बीज कोष के विकसित होने की अवस्थाओं में अधिकतम तापमान की कमी, अकोला में कपास की किस्म ए. एच. एच.-468 की अत्याधिक पैदावार के लिए संवाही पाई गई हैं। सामान्यतः अकोला में ए. एच. एच.-468 की किस्मों और कोविलपट्टी में एम. सी. यू.-10 की किस्मों की पैदावार के लिए सापेक्षिक आर्द्रता सकारात्मक रूप से सहसंबंधित थी। अकोला में कपास की बढ़ी हुई पैदावार के लिए पौधे की बढ़वार और फूल आने की अवस्था के दौरान तेज धूप के घंटों (5 घंटों से कम) के न्यूनतम मान सहायक पाए गए हैं। ऋतु की आरम्भिक वर्षा की पैदावार के लिए अनुकूल पाई गई है।

**ABSTRACT.** In the present study the effect of meteorological parameters on cotton growth at three different stations in the dry farming tract of peninsular India were studied critically. Increase in minimum temperature (above normal) particularly at vegetative and flowering stages favoured the yield of three varieties of cotton (AHH - 468, MCU - 9 and MCU - 10) under study. Decrease in maximum temperature at flowering and boll development stages was found to be conducive for the higher yield of AHH - 468 variety of cotton at Akola. In general, relative humidity was positively correlated with the yield of AHH - 468 varieties at Akola and MCU - 10 varieties at Kovilpatti. Lower values of bright sunshine hours (<5 hours) during vegetative and flowering were found to be helpful for increased yield of cotton at Akola. Rainfall at the beginning of the season favoured the yield of the crop.

**Key words** – Cotton, Growth stages, Yield, Weather parameters, Interrelation.

### 1. Introduction

Cotton (*Gossypium spp*) is one of the main cash crops in the country and plays an important role in the industrial and agricultural economy of the country. Nearly one-third of India's export earnings are from textile sectors of which cotton alone constitutes nearly 70% of raw material. The estimated cotton production target for the domestic and export requirement set for 2020 AD is 23-24 million bales compared with 10.09 million bales at present (Directorate of Economics and Statistics 2003). Extensive research and developmental efforts are being made to achieve this goal. One of the core issues is to establish the cotton weather relationship for the adaptability and higher yield of a specific variety of the crop for the agroclimatic zones of the country.

Besides, the interrelation between crop and weather could be used as a guiding tool for forecasting the yield prior to the harvest of the crop.

Cotton is cultivated in three distinct agro-ecological regions of the country-northern, southern and central zone. Considerable variations exist in the climatic conditions in the different zones. In northern zone, extreme climate with frequent frost and rainfall are met with whereas temperature is more equable and rainfall is moderate in central and southern zones. It has been established with fair degree of accuracy that favorable distribution of different agroclimatic variables is the deciding factors for the increased cotton production. A number of workers (Srinivasan and Banerjee 1958, Singh *et al.* 1970, Rao *et al.* 1971, Singh and Singh 1971, Tiwari

**TABLE 1**  
**Agroclimatic zones, soil characteristics, period of study and location of different stations**

| Items                     | Coimbatore                           | Akola                                | Kovilpatti  |
|---------------------------|--------------------------------------|--------------------------------------|---|
| Agroclimatic zones*       | Southern plateau and hill region (X) | Western plateau and hill region (IX) | Eastern coast plains and hill region (XI)             |
| Data studied              | 1981-82 to 1988-89 (8 years)         | 1990-91 to 1993-94 (4 years)         | 1985-86, 1987-88, 1989-90, 1991-92, 1993-94 (5 years) |
| Soil characteristics      |                                      |                                      |   |
| (i) Texture               | Clay loam                            | Clay                                 | Clay  |
| (ii) Field capacity (%)   | 26                                   | 26.2                                 | 35  |
| (iii) Wilting point (%)   | 12.5                                 | 10.2                                 | 15  |
| (iv) Bulk Density (gm/cc) | 1.3                                  | 1.18                                 | 1.25  |
| Latitude/Longitude        | 11° 00' N<br>76° 58' E               | 20° 42' N<br>77° 02' E               | 09° 12' N<br>77° 53' E                                |

\* As per Planning Commission, Govt. of India (1989)

and Bisen 1972, Srinivasan 1973, Kueht *et al.* 1976, Venkatachalam *et al.* 1976, Wallach 1978, Reddy *et al.* 1991) studied the sensitivity of weather parameters to different varieties of crop grown in various agroclimatic zones of the country.

A number of methods have earlier been applied to workout the interrelationship between cotton growth/yield with that of weather parameter. Kalamkar and Satakopan (1940) used Fischer and statistical technique to study the effect of rainfall on the yield of cotton at Governmental Experimental Farm at Akola and Jalgaon. Similar technique was used by Shaha and Banerjee (1975) to examine the effect of meteorological parameters on the yield of cotton at Coimbatore. Dubey *et al.* (1995) developed weather based regression equations for the prediction of cotton yield in Maharashtra. The objectives of the present study is to study the effects of the different weather factors at different phenological stages on the growth and yield of three varieties of cotton cultivated at different places of the country.

## 2. Data and methodology

Three evapotranspiration observatories of India Meteorological Department located at Akola, Coimbatore and Kovilpatti in the dry farming tract of the country (average rainfall: 40-100 cm) were selected for the present study. Details of the stations, *i.e.*, location, latitude, longitude and soil characteristic including study period and varieties of the crop grown at different stations are mentioned in Table 1. Information about the crop *i.e.*, date of sowing, date of harvest and the duration of different phenological stages in the years under study period at different stations is presented in Fig. 1. Meteorological parameters such as rainfall (RFL), maximum (TMAX) and minimum (TMIN) temperature, relative humidity

[0300 GMT (RH<sub>1</sub>) and 1200 GMT (RH<sub>2</sub>)], bright hours of sunshine (SSH) recorded at different stations during the crop growth stages were obtained from the National Data Centre, India Meteorological Department, Pune.

Both statistical tools and graphical superimposition techniques were used to workout the interrelationship between the yield of crop and the meteorological variables at different weeks during the growth stages of the crop. Statistical studies were made using Sigma Statistical Software Version 2.0 for Windows 95 developed by Jandel Scientific Software, USA. 't' test was applied to test the significance of these correlations at 5% level. Anomalies of meteorological parameters at different stages of the crop between good and bad years in respect of average yield were worked out to understand the sensitivity of the weather elements to the growth of the crop. The variations of meteorological variables during the growth period were also analyzed to find out the critical values of the same conducive for the growth of the plant. The plotted curves based on actual meteorological parameters were compared with the normal values (IMD, 1991).

## 3. Result and discussion

The interrelations of the crop growth in their phenophases with the weather are discussed separately. The varieties selected for the three stations are different as:

### 3.1. Weather and cotton (Variety : AHH-468) at Akola

Correlation coefficients between the meteorological parameters (maximum and minimum temperature, humidity, sunshine and rainfall) at different growth stages

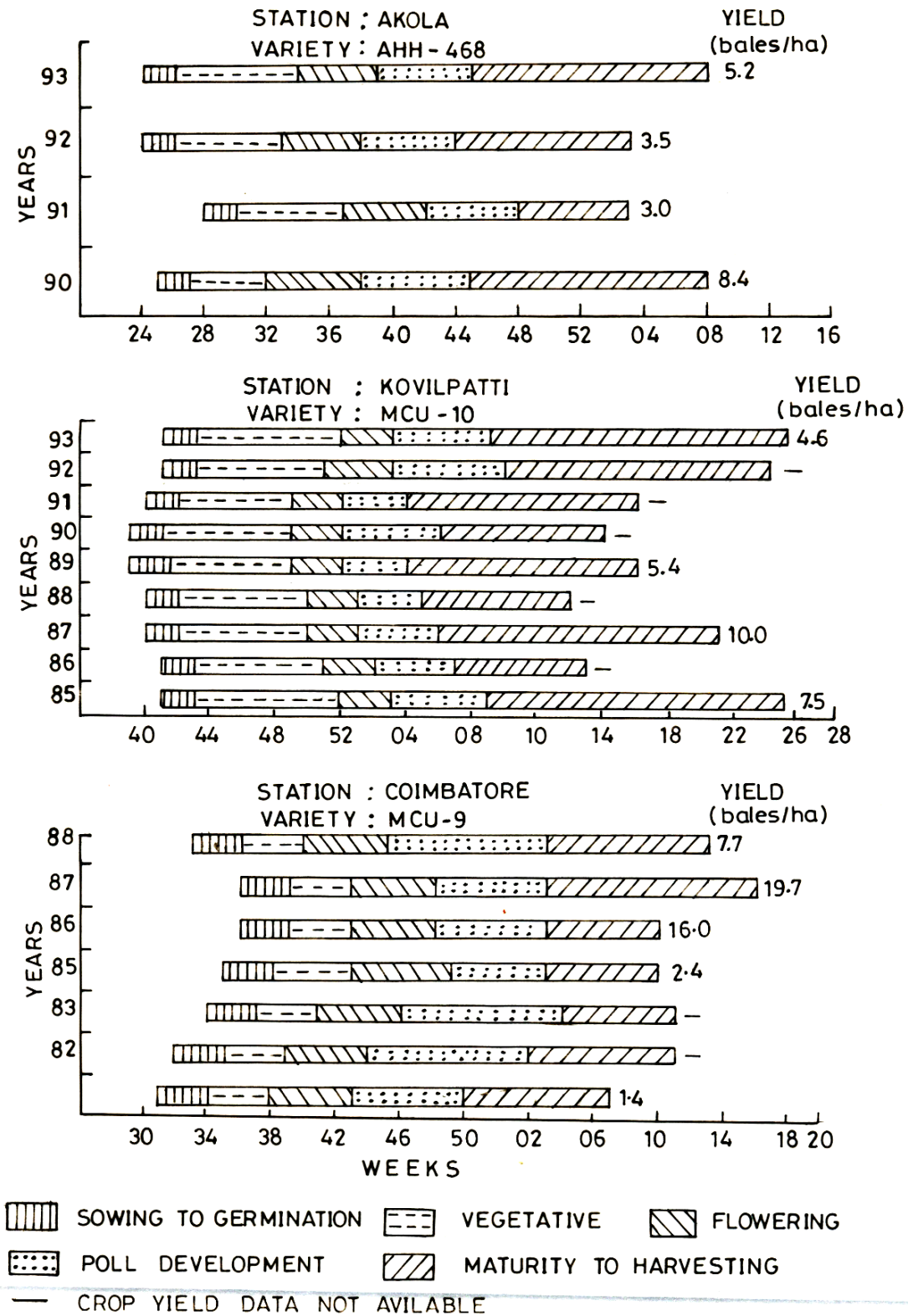


Fig. 1. Variety, yield and duration of growth stages of cotton in different years at Akola, Kovilpatti and Coimbatore

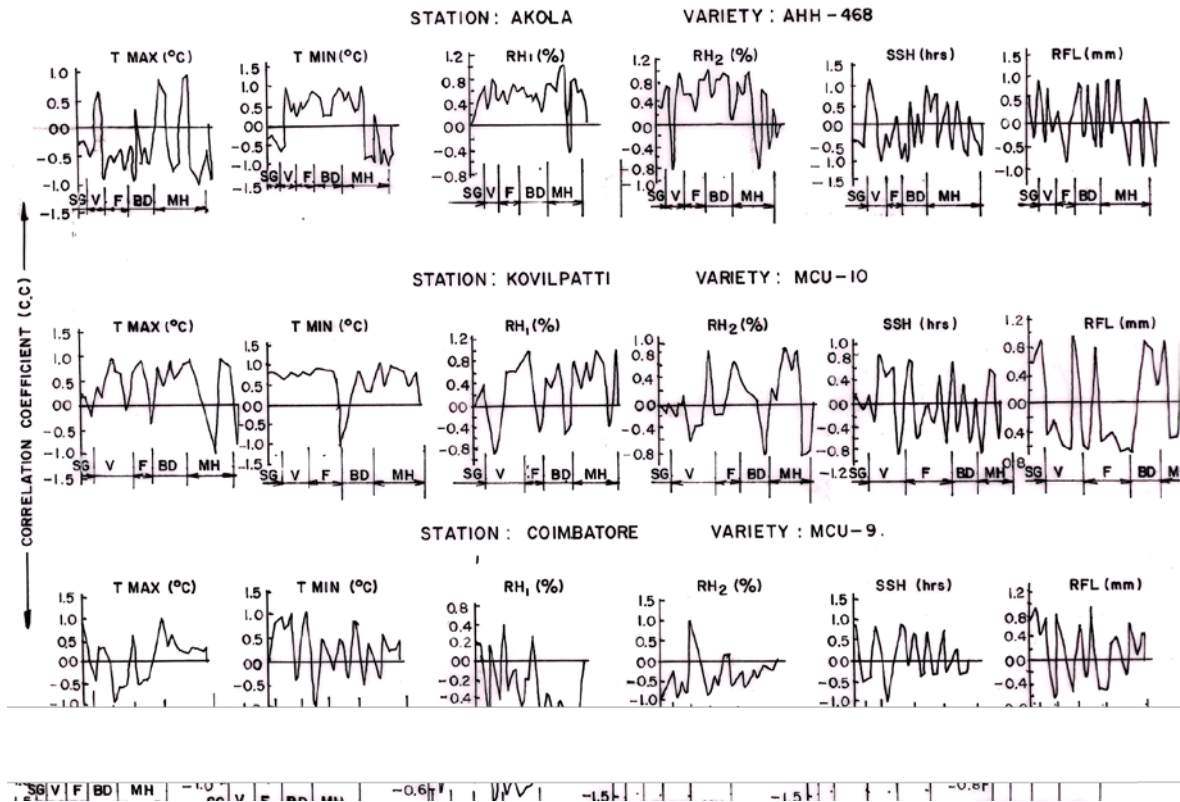


Fig. 2. Correlation Coefficients (C.C.) between different meteorological variables at various growth stages with the yield of cotton

with the yield of cotton for the three stations under study are presented in Fig. 2.

### 3.1.1. Temperature and growth of crop

Maximum temperature showed negative correlation at sowing to boll development phase with yield. Even significant correlation (0.95) at 5% level between maximum temperature during boll development and yield was also observed. In 1991, a bad year (yield : 3.0 bales/ha), at flowering stage maximum temperature ranged from 35.7 to 37.7 whereas it was ranged from 29.0 to 32.7 °C (below normal) in 1990, a good year (yield : 8.4 bales/ha).

Though minimum temperature at sowing to germination showed negative correlation with yield, minimum temperature from vegetative to boll development showed positive correlation. Though insignificant but high positive correlation (0.90) was observed between minimum temperatures at vegetative stage. Anomaly values (Fig. 3) showed that there was a positive departure of minimum temperature of about 3.7 to 8.6 °C during flowering stage between 1990 and 1991. In 1990, minimum temperature was found to be less than

1991 throughout the crop season. At maturity stage minimum temperature rose up to minimum 21.6 °C in 1990 while it was below 11.8 °C in 1991. (Fig. 3).

### 3.1.2. Humidity and growth of crop

In general, relative humidity throughout the life cycle of the crop was found to be positively correlated with the crop yield. A number of weeks from boll developments to maturity stage, the correlation coefficients between afternoon humidity and final yield were above 0.9. Afternoon relative humidity during boll development was found to be significantly ( $r = 0.95$ ) and positively correlated with the yield. In most of the weeks up to boll development afternoon relative humidity was found to be above normal value (Fig. 3). Anomaly values between the two contrasting years (good and bad) showed that there was a positive departure of 30 to 50% of relative humidity particularly during flowering to boll development stages. Shaha and Banerjee (1975) observed that above normal relative humidity from the beginning of November, *i.e.*, commencement of elongation and branching was beneficial to the cotton grown at Coimbatore.

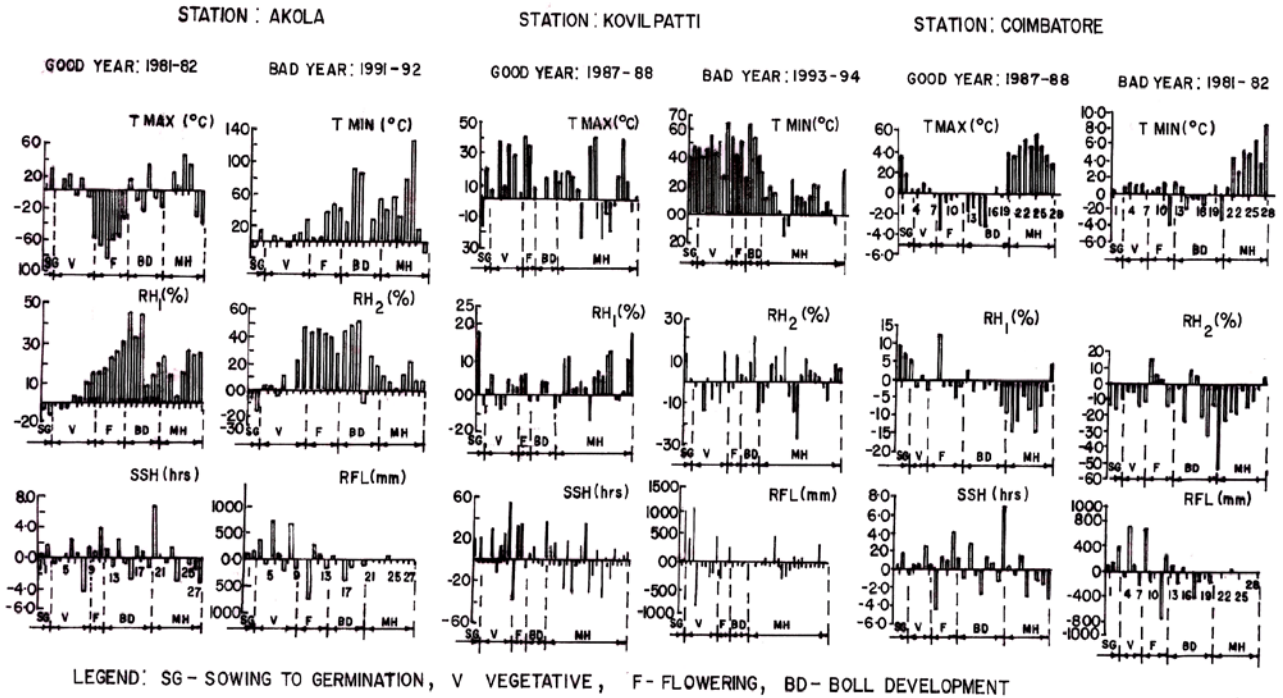


Fig. 3. Anomalies of different meteorological variables during the crop growth stages in good years and bad years in respect of crop yield

3.1.3. *Bright hours of sunshine and growth of crop*

Less sunshine from the last phase of vegetative growth to boll development was found to be favourable for cotton yield. In number of weeks in vegetative and flowering stages bright hours of sunshine were significantly and negatively correlated ( $r = 0.95$ ) with the crop yield. In 1991 sunshine hours were more than 8 hrs during flowering stage while in 1990 in three weeks sunshine hours ranged from 3.7 to 4.5 hrs at the same stage of the crop.

3.1.4. *Rainfall and growth of crop*

Except flowering and last phase of maturity, by and large, rainfall was positively correlated with the crop yield. At vegetative stage, it was significantly positively correlated ( $r = 0.96$ ) with the yield. Compared to 1991 the station received more rain (above normal) in 1990 at vegetative stage. Saha and Banerjee (1975) also reported that up to the end of vegetative stage (up to December) rainfall was beneficial while it had negative effect during flowering at Coimbatore. Dubey *et al.* (1995) also reported that rainfall during boll bursting (second fortnight of December) reduced the yield. Santharam (1981) reported that rainfall during boll opening and harvesting was harmful. Greater rainfall was detrimental during boll

formation (Mallick *et al.* 1960). According to the authors heavy rain by the end of September or early part of October (boll development) depressed the yield of cotton grown at Akola and Jalgaon in Maharashtra.

3.2. *Weather and cotton (Variety : MCU-10) at Kovilpatti*

3.2.1. *Temperature and growth of crop*

Except maturity stage, both maximum and minimum temperature, in general, throughout the growth period showed positive correlation with the crop yield at Kovilpatti (Fig. 2). Maximum temperature showed significant and positive correlation ( $r = 0.98$ ) at vegetative stage while minimum temperature showed significant positive correlation ( $r = 0.99$ ) both at boll development as well as maturity to harvest stage. Dubey *et al.* (1995) found that mean temperature during budding and flowering (3<sup>rd</sup> to 16<sup>th</sup> September) had positive effect while the same during fruiting (second fortnight of October) had negative effect on cotton growth in the districts of Vidarbha region of Maharashtra. Maximum positive departure of both maximum (up to 4.1 °C) and minimum temperature (up to 6.4 °C) from vegetative to flowering stage between 1987 and 1993 was observed (Fig. 4). In 1987 there were number of weeks in vegetative and

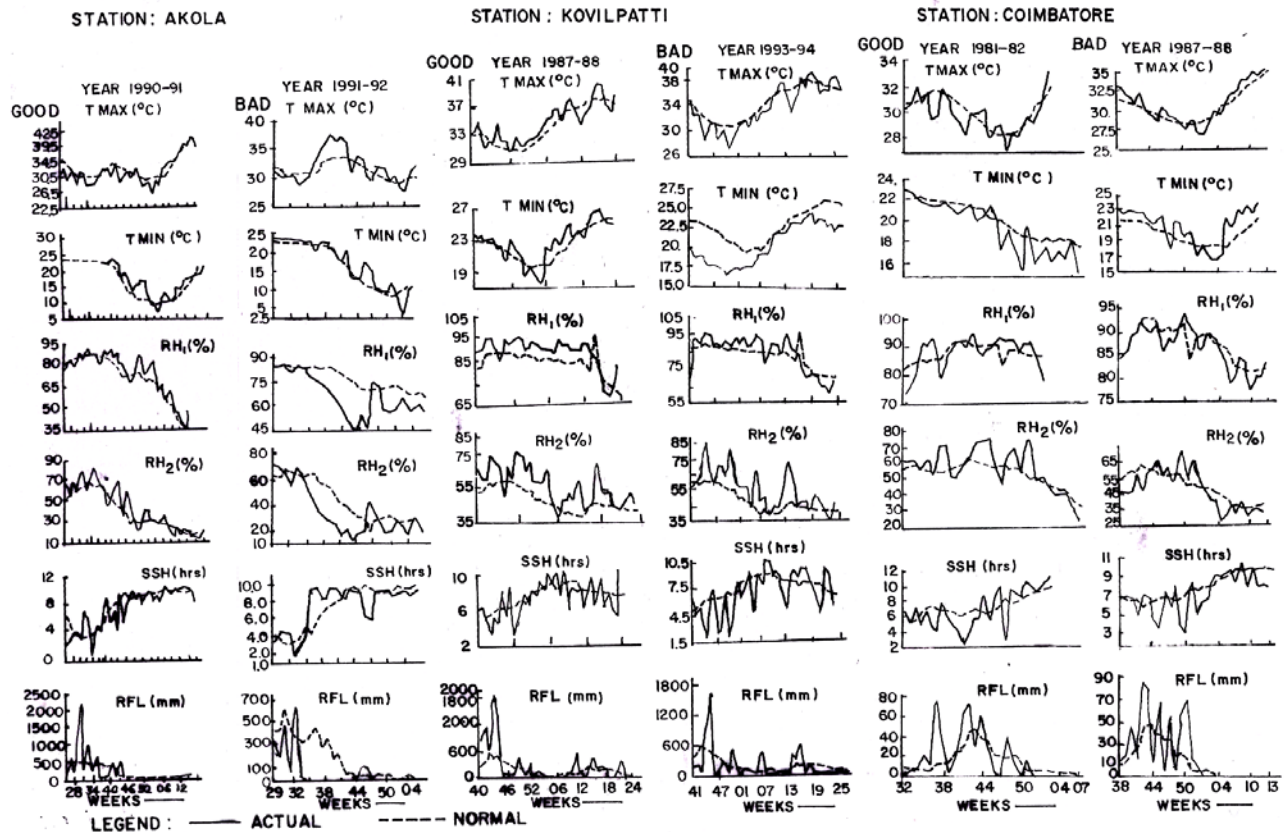


Fig. 4. Variations of different meteorological variables during the crop growth stages in good years and bad years in respect of crop yield

flowering where maximum temperature were 30 °C whereas during the same crop growth stage in 1993 it ranged from 26.8 °C to 29.0 °C (below normal). Minimum temperature in 1987 was observed above 20 °C in number of weeks during the crop growth period (Fig. 4).

### 3.2.2. Humidity and growth of crop

Except sowing to germination and vegetative stage relative humidity showed positive correlation with the yield of the crop. At the flowering stage morning relative humidity was significantly and positively correlated ( $r = 0.96$ ). 13 - 20% positive departure of afternoon relative humidity was found from the end of flowering to boll development between 1987 and 1993. In 1987, afternoon relative humidity ranged from 59 to 75% (normal: 46-54%) at these stages of the crop.

### 3.2.3. Bright hours of sunshine and growth of crop

There was no consistent correlation of sunshine with the yield at this station.

### 3.2.4. Rainfall and growth of crop

Rainfall during sowing to germination, early vegetative plus boll development to the beginning of maturity was positively correlated. In 1987 first six consecutive weeks rainfall figures were 80.5, 125.1, 57.2, 183.9 and 71.4 cm (normal : 24.3, 34.2, 59.7, 41.0, 54.1 cm) while in 1993 rainfall figures for the same weeks were 24.4, 24.0, 8.0, 75.8, 160.6 and 1.0 cm (normal: 34.2, 59.7, 41.0, 54.1 and 50 cm).

### 3.3. Weather and cotton (Variety : MCU-9) at Coimbatore

#### 3.3.1. Temperature and growth of crop

At Coimbatore, maximum temperature showed negative correlation during flowering and boll development stage. Gupta and Pandey (1991) found that maximum temperature during flowering period was significantly negatively correlated to the cotton yield at Surat. Bhargawa and Bharadwaj (1969) also reported that for summer cotton, high temperature reduced the number of flowers.

On the contrary minimum temperature showed positive correlation from sowing to flowering. Both at vegetative and flowering minimum temperature was significantly positively correlated ( $r = 0.94, 0.95$ ) with the cotton yield. Except maturity stage the anomaly of maximum temperature between two contrasting years was comparatively less (Fig. 4).

### 3.3.2. Humidity and growth of crop

Morning and afternoon relative humidity showed negative correlation throughout the entire growing season. Relative humidity was observed to be less of the order of 15 to 55 % at the growth stages between 1987 and 1993. Qureshi (1972) observed that high humidity lowered the value of lint index of the *arboreum* cotton, variety 'Gaoran' at Mudhol in Andhra Pradesh. According to the author about 55% relative humidity and 15 °C minimum temperature, during boll bursting was helpful to get long fibre.

### 3.3.3. Bright hours of sunshine and growth of crop

No consistent correlation of sunshine hours at different stages of the crop with the crop yield was found.

### 3.3.4. Rainfall and growth of crop

Rainfall at sowing to germination and vegetative growth was found to be positively correlated with the cotton yield.

## 4. Conclusion

(i) Increase in minimum temperature, particularly at vegetative and flowering stages favoured the yield of all the three varieties of crop under study.

(ii) Though decrease in maximum temperature at flowering and boll development were conducive for better growth of AHH-464 variety of cotton at Akola and MCU-9 at Coimbatore, increase of the same at the same stages increased the yield of the crop.

(iii) In general, relative humidity during the entire growth stages positively correlated with the yield of AHH-464 at Akola while it was negatively related to the yield of MCU-9 variety of the crop at Coimbatore. At Kovilpatti except sowing to the vegetative stage relative humidity in most parts of the growth period were positively correlated with the yield of MCU-10.

(iv) No significant correlation of bright hours of sunshine with cotton yield was observed in none of the stations.

(v) Rainfall during the beginning of the crop growth to the first phase of vegetative phase was favoured the cotton yield in all the varieties of the crop.

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