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EFFECT OF WEATHER PARAMETERS ON GROWTH AND YIELD IN *Bt* COTTON UNDER PUNE REGION

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Abstract: *An experiment was conducted during Kharif 2015-16 and 2016-17 at Department of Agricultural Meteorology Farm, Centre of Advanced Faculty Training (CAFT) in Agricultural Meteorology, College of Agriculture, Pune (Maharashtra). Amongstthe weather parameters maximum temperature (T_{max}) and minimum temperature (T_{min}) contributed positive effect on growth parameters. The positive effect was observed between the weather parameters and growth characters on plant height (T_{max} 0.806* and T_{min} 0.790**), number of leaves (T_{max} 0.806** and T_{min} 0.790**), leaf area (T_{max} 0.721**), Leaf area index (T_{max} 0.739** and T_{min} 0.726**), dry matter, maximum temperature,(0.513*), minimum temperature (0.513*) and sympodial branches (T_{max} 0.806** and T_{min} 0.790**). Whereas, during flowering to boll setting (P_5) stage, T_{min} (0.515*) was positively correlated with crop growth. However, the relative humidity, bright sunshine hours, rainfall and evaporation showed the positive impact on seed cotton yield in relation to the weather parameters.*

Key words: *Weather parameters, Cotton, Phenophases, growth.*

Cotton, popularly known as white gold or the 'king of the fiber'provides livelihood to 60 million peoples of India by way of support in agriculture, processing and textiles. It accounts for 75 % of the fiber used in textile industry and contributes 5 % of the GDP. Cotton is the world's most important fiber crop and the second most oilseed crop. Cotton lint is still a principle economic raw material from the cotton plant, provides a high quality fiber for the world's textile industry. The cotton seeds, the primary by product of lint production is an important source of oil and a high protein meal used as livestock feed. The waste after ginning is used as fertilizer and the cellulose from the stalk can be used for manufacturing and cardboards.

Climate affects crop growth interactively, sometimes resulting in unexpected responses to prevailing conditions. Many factors, such as length of the growing season, climate (including solar radiation, temperature, light, wind, rainfall, and dew) affect cotton growth (El-Zik, 1980). The balance between vegetative and reproductive development can be influenced by soil fertility, soil moisture, cloudy weather, spacing and perhaps other factors such as temperature and relative humidity (Guinn, 1982). Weather, soil, cultivars, and cultural practices affect crop growth interactively, sometimes resulting in plants responding in unexpected ways to their conditions (Hodges*et al.* 1993).Environment for optimum plant growth and development plays a vital role in realizing crop growth and yields. The time of sowings as varied growth condition for various crops differs depending on climate. Knowledge on effects of various elements of environment on crop growth, development and yield is important for agronomists and crop production specialists. Cotton experiences temperature fluctuations ranging from 5 to 45°C during the season which adversely influence growth and yield of crop growth and development (Reddy, *et al.* 1994). It was also indicated that the high temperatures combined with water stress resulted in boll shed, small boll size and leaf damage (Hake and Silvertooth, 1990). Quantitative information regarding plant responses to weather change, soil and management condition essential to design crop adaptation mechanisms and improving productivity. So far, many researches were undertaken under controlled environment conditions and sowing dates

at field conditions Dong*et al.* (2006) compared yield, quality and leaf senescence of cotton of late planting production system and normal planting production system. Bange (2007) studied on cotton growth and development. However, these studies did not reveal the relationship among the climatic factors under field situations with yield and yield components. Changes in yields attributed to a single factor such as temperature is not possible due to the confounding effects like rainfall and solar radiation during crop growing period. Furthermore, controlled environment studies often underestimate yield losses from temperature effects at different phenology of a crop that would occur under field conditions. Furthermore, studies of crop management practices accompanied with weather conditions plays vital role to provide valuable information for producers. Therefore, this study was designed to identify the critical weather parameters affecting the yield and yield components on cotton.

Material and Methods

The field experiment was conducted for two consecutive years on the Department of Agricultural Meteorology Farm, College of Agriculture, Pune during *Kharif* 2015-16 and 2016-17.

The topography of the experimental field was of Pather series. It was uniform and leveled. The soil was well drained having depth up to 90 cm. In order to study the physical and chemical properties of soil, the soil samples from 0-30 cm depth at 10 different randomly selected locations were collected from the experimental area before laying out the experiment. The soil of experimental site was sandy clay loam in texture.

Pune is situated in the Sub Tropical region (Plain Zone) on the latitude 18^0 22' N and longitude $73^0$51' E and having an altitude of 557.7 m above the mean sea level. The average annual rainfall of Pune is 675 mm which is distributed from second fortnight of June to second fortnight of October. Out of total rainfall, about 75 per cent is received from June to September from South-West monsoon, while remaining is received from north-east monsoon during October and November.

The maximum temperature during the month of April and May ranged between 34ºC and 40ºC. but on the onset of monsoon, it drops down to 27ºC. In the month of July and August, it ranged between 26 and 30ºC.

The minimum temperature varied from 6 to 10ºC in winter season from November to middle of February. Humidity during monsoon period i.e. from June to September was quite high in morning (about 85 to 93 per cent). The evening humidity generally ranged between 43 to 83 per cent. During summer season, morning and evening humidity decreased and it ranged between 49 to 51 per cent, respectively. In Pune, thus mostly dry and medium hot weather prevails during the summer season.

The details of the treatments along with symbols are presented in Table 1.

a. Season : *kharif*, 2015-16 and 2016-17
b. Experimental design : Split plot design
c. Number of replications : Three
d. Treatments : 1. Main plot : Cotton hybrids
2. Sub plot : Sowing windows
e. Spacing : 90 cm x 90 cm
f. Plot size : **i Gross** : 7.2 m x 5.4 m^2
ii Net : 5.4 x 3.6 m^2
g. Place of research work : Department of Agricultural Meteorology Farm, College of Agriculture, Pune.

Table 1: Treatments details with symbols

Sr. No.	Treatment details	Symbol used
A.	**Main plot treatments: Cotton hybrids**	
1	Vitthal	V_1
2	Bhakti	V_2
3	Ankur-3028	V_3
4	US-4746	V_4
B.	**Sub plot treatments: Sowing windows**	
1	24 MW (11^{th} -17^{th} June)	D_1
2	25 MW (18^{th} -24^{th} June)	D_2
3	26 MW (25^{th} June-1^{st} July)	D_3
4	27 MW (2^{nd} -7^{th} July)	D_4

Results and Discussion

The correlation results revealed that the weather parameters significantly influenced on phenophases of the crop and finally reflected into seed yield. These weather parameters and their influence on different growth stages are illustrated below. The result revealed that the rainfall was significantly positively correlated to early growth stages.

The most critical growth stages deciding the cotton seed yield are square formation to flowering (P4), flowering to boll setting (P5) and boll setting to boll bursting (P6). The data observed during the growing season of cotton crop under study period, weather parameters *viz.,* rainfall, maximum, minimum and mean temperatures, morning relative humidity and evening relative humidity were positively correlated during early stage i.e. from seedling stage to boll setting.

Effect of weather parameters on growth parameters

Temperature also played a major role in deciding the length of Phenophases of the cotton crop. The very high and very low temperature caused the detrimental effect on the crop growth and development. The data in Table 2 revealed that the maximum and minimum temperatures was positively correlated during the growth stages *viz.,*plant height, number of leaves, LAI, Leaf area, dry matter, sympodial branches and number of bolls.

The data presented in Table 2 showed that the weather parameters namely maximum temperature (T_{max}) and minimum temperature (T_{min}) contributed positive correlation among the weather parameters on growth parameters during 2015-16 and 2016-17 at 35^{th} MW.

The positive correlation was observed between the weather parameters and growth characters like plant height (T_{max} 0.806* and T_{min} 0.790**), leaves (T_{max} 0.806** and T_{min} 0.790**), Leaf area index (T_{max} 0.739** and T_{min} 0.726**), leaf area (T_{max} 0.721** and T_{min} 0.701**),dry matter (T_{max} 0.513***** and T_{min} 0.513*****),number of sympodial branches (T_{max} 0.806** and T_{min} 0.790******) and number of bolls (T_{max} 0.504* and T_{min} 0.512*).These results supported withReddy *et al.* (1999) reported a significant decrease in boll growth followed by fruit shed within 3 to 5 days after blossom when there was an increase in temperatures over 32ºC. Hake and Silvertooth (1990) indicated that the high temperatures combined with water stress resulted in boll shed, small boll size and leaf damage. Reddy *et al.*(1999) reported a significant decrease in boll growth followed by fruit shed within 3 to 5 days after blossom when there was an increase in temperatures over 32ºC. Rhayan*et al.* (2005) conducted experiment on cotton boll maturation affected by temperature variation at Central Research Station, Clayton and reported that boll maturation period has been shown to increase with advance of the growing season because of the gradual reduction of temperature during the season. Jadhav (2010) found that weather parameters namely maximum, minimum and mean temperatures were positively correlated during early stage i.e. from germination to square formation stage.

Table 2: Effect of weather parameters on growth parameters during 2015-16 and 2016-17 (Pooled)

	Correlation coefficient (r) for growth parameters						
Weather parameters	**Plant height**	**Number of leaves**	**Leaf area index**	**Leaf area**	**Dry matter**	**Number of sympodial branches**	**No. of bolls**
Tmax (^{0}C)	0.806**	0.806**	0.739**	0.721**	0.513*	0.806**	0.504*
Tmin (^{0}C)	0.790**	0.790**	0.726**	0.701**	0.513*	0.790**	0.512*
R.H- I (%)	-0.800	-0.800	-0.733	-0.716	-0.500	-0.800	-0.468
R.H -II (%)	-0.797	-0.797	-0.729	-0.718	-0.498	-0.797	-0.478
WS (kmh^{-1})	0.688	0.688	0.637	0.602	0.468	0.688	0.496
Rainfall (mm)	-0.745	-0.745	-0.678	-0.682	-0.459	-0.745	-0.450
Epan (mm)	0.804	0.804	0.738	0.716	0.511	0.804	0.493
BSS (hrs day^{-1})	0.801	0.801	0.735	0.715	0.516	0.801	0.516

****** Correlation significant at the 1 % level

***** Correlation significant at the 5%level.

Table 3: Correlation between weather parameters and phenophases of cotton with seed cotton yield

Weather parameter	**Phenophases of cotton hybrids**									
	P_1	**P_2**	**P_3**	**P_4**	**P_5**	**P_6**	**P_7**	**P_8**	**P_9**	**P_{10}**
T_{max} (^{0}C)	0.402	0.699*	0.267	0.564*	-0.524*	-0.552*	0.511*	0.515*	0.531*	0.303
T_{min}.(^{0}C)	0.698**	0.473	0.584*	0.530*	0.515*	0.545*	0.535*	0.550*	-0.538*	0.502*
RH-I (%)	-0.235	-0.488	-0.523*	-0.197	0.397	-0.488	0.509*	0.466	-0.270	-0.518*
RH-II (%)	-0.566*	-0.510*	-0.528*	0.028	0.530*	0.469	0.528*	0.513*	-0.389	0.365
WS (km h^{-1})	0.037	0.294	0.072	-0.240	0.523*	0.501*	0.488	-0.433	-0.543*	0.511*
B.S.S. (hrs)	0.119	0.519*	0.326	-0.227	-0.502*	-0.456	-0.491	-0.152	0.283	-0.432
Rainfall (mm)	0.000	0.138	-0.351	-0.504*	-0.220	0.252	0.509*	-0.422	0.420	0.433
E_{pan} (mm)	0.381	0.490	0.207	-0.282	0.449	-0.473	0.144	0.390	0.354	0.504*

*****Significant at 5 % level (0.497), ****** Significant at 1% level (0.623)

P_1 - Sowing to emergence, P_2 - Emergence to Seedling stage,

P_3– Seedling stage to Square formation P_4 – Square formation to Flowering,

P_5- Flowering to boll setting, P_6 –Boll setting to Boll Bursting

P_7- Boll Bursting to 1st Picking, P_8-1st Picking to 2nd Picking,

P_9- 2nd Picking to 3rd Picking P_{10}-3rd Picking to 4th Picking.

Effect of weather parameters on seed cotton yield

The pooled analysis of correlation study between the seed cotton yield and weather variables at different phenophases for *Bt*cotton for the years 2015-16 and 2016-17 directly influenced on the seed cotton yield (Table 3).

Effect of maximum temperature:

Data revealed that maximum temperature for (P_2) emergence to seedling stage, P_4 – square formation to flowering, P_7- boll bursting to 1st picking, P_8-1st picking to 2nd Picking, and P_9- 2nd picking to 3rd picking Showed the positive correlation, whereas, P_5- flowering to boll setting and P_6 –boll setting to boll bursting phenophases showed significant negative correlation with seed cotton yield.

Effect of minimum temperature:

The minimum temperature showed the positive correlation for all phenophases except P_2 - emergence to seedling stage and P_9- 2nd picking to 3rd picking.

Effect of morning relative humidity:

The morning relative humidity for P_7- boll bursting to 1st picking, showed positive correlation for P_3– seedling stage to squareformation and P_{10}-3rd

picking to 4th pickingit showed significant negative correlation.

Effect of evening relative humidity:

The evening relative humidity for P_5- flowering to boll setting, P_7 and P_8 showed the positive correlation at the same time for P_1 - sowing to emergence, P_2 - Emergence to seedling stage, and P_3 it was significant negative correlation.

Effect of BSSH

The BSSH for P_2- emergence to seedling stage andshowed positive significant correlation a P_5- flowering to boll setting, showed significant negative correlation.

Effect of rainfall:

The rainfall for P_7- boll bursting to 1st picking, phenophase showed significant positive and P_4 – square formation to flowering, showed significant negative correlation with seed cotton yield. The pan evaporation indicated that positive correlation for P_{10}-3rd picking to 4th pickingphenophase. These weather variables showed a good association with crop growth, development and seed cotton yield for the various phenophases during its life cycle. These results were more or less similar with earlier workers (Anonymous, 2006). Changes in yields attributed to a single factor such as temperature was not possible due to the confounding effect like rainfall, during crop growing period.

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