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Original Research Article

Impact of Drought Weather Condition on *Bt* Cotton Growth, Development and Yield

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A B S T R A C T

The correlation study during drought weather condition revealed that the weather parameters significantly influenced on the crop growth and development and finally reflected into significant variation in the *Bt* cotton seed yield. The significant difference within the different sowing dates and amongst the different *Bt* cotton hybrids was observed as changing the sowing time and variety. Significantly highest seed cotton yield was obtained with 24th MW sowing (675.62 kg ha^{-1}) followed by 25th MW sowing (666.53 kg ha^{-1}), which was at par with earlier sowing and lowest seed cotton yield was recorded in 27th MW sowing (178.86 ha^{-1}). Compared to three hybrids, significantly highest yield was recorded in Ajit-155. Prolonged dry spell may occurred initially or at mid-season or terminally which generates moderate to severe drought condition and which coincides at least one critical physiological stage of cotton. It causes distinguished reduction in seed yield of rainfed *Bt* cotton. Hence, for the sustainable seed yield for adaptation of changing climatic condition required at least two supplement irrigation facilities during crop growing *kharif* season in the Marathwada region of Maharashtra.

Keywords

Sowing dates, *Bt* cotton hybrid and Correlation

Introduction

India occupies the largest area under cotton in the world, representing 20 to 25 percent of the total global area. It ranks third in terms of production next to China and USA. The area under cotton in India is 126.55 lakh hectares with production of 400.00 lakh bales and productivity is 537 kg lint ha^{-1} during 2014-15 (Anon., 2015). Cotton ranks as one of the important commercial crops in India contributing nearly 70 per cent of the fibre consumption by the Indian textile industry. In Indian economy, cotton often referred to as the white gold, has been in cultivation for more than five thousand years. The different sectors of the Indian textile industry jointly account for 20% of the total industrial production, 7.5% of the GDP and employ about 27 million people. The textile industry contributes about 32% of the foreign exchange earnings of the country. Cotton is grown over an area of about 9 million hectares and gives the livelihood of over 4 million farming families in India. Various allied activities like ginning, yarn and fabric production, textile processing, garment manufacture, marketing etc., provide further employment to several million people. India tops in terms of cultivated area (around one fourth of the world's acreage). Almost the entire cotton

production is concentrated in nine major cotton growing States; Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu. About 243 × 105 bales of cotton are produced in about 89.2 105 hectares in these cotton growing states [Anon (2006)].

Cotton crop in Maharashtra is mainly cultivated as a rainfed and grown during *kharif* season. The growth, development and yield of the cotton crop are considerably affected by abiotic factors, i.e. air temperature, cloud cover, relative humidity, rainfall and radiation (Jadhav, 2014). Annual variation of rainfall (i.e. quantity) and rainy days (quality of rainfall) and trend was affected plantations, productivity and production of crops (Jaybhaye *et al.*, 2016). Since last one and half decade onset and distribution of monsoon are showing irregular behaviour and it was very difficult to coincide with appropriate sowing time. One of the most important agronomic adaptations to overcome abiotic stress is to select an appropriate sowing time for cotton crop for optimising yield and quality. Hence, present investigation was carried out with an object to find out effect of weather parameters on growth attributes of *Bt* cotton.

Materials and Methods

A present field experiment was conducted during *kharif* season 2015 at experimental farm of Department of Agricultural Meteorology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth. The experimental site agro-climatologically comes under assured rainfall zone and belonging to sub-tropical zone. The precipitation is assured for *kharif* season with maximum amount of rainfall are receiving from South West monsoon. The experimental plot soil type is deep cotton black and soil taxonomical class is chromusterts with soil texture clay. The topography of the field is uniform and levelled the soil is well drained and depth of the soil varied from 2 to 3 meter. The experiment was laid out in split plot design with four sowing dates i.e. 24th MW, 25th MW, 26th MW and 27th MW as main plot and three hybrids *viz.*, Mallika, Ajith-155 and Rasi-779 as sub plot with three replications. Land preparation was done as per package of practices. The data on emergence count, plant height, plant width and number of branches plant^{-1} were recorded from randomly selected three plants from each plot. Seed cotton yield were taken after harvest from all plots in the treatment. The data recorded were statistically analyzed by using technique of ANOVA i.e. analysis of variance and significance was determined as given by Panse and Sukhatme (1985).

During the experimental period i.e. crop growth period (24th MW to 52th MW) prevailed weather elements *viz.*, rainfall, rainy days, air temperature, relative humidity, evaporation, bright sunshine hours and wind velocity were discussed. The total precipitation was received was 381.1 mm in 24 rainy days; maximum temperature (T_{max}) and minimum temperature (T_{min}) during crop growth period (24th MW to 52nd MW) ranged in between 29.9 to 36.2 ^{0} C and 13.8 to 25.8 ^{0}C, respectively. While, seasonal mean of maximum and minimum temperature (T_{avg}) was recorded 33.43 ^{0}C and 20.76 ^{0}C respectively. Whileit was observed mean relative humidity of morning (RH-I) and afternoon hours (RH-II) between 77 and 43 %, respectively; the mean evaporation 6.0 mm day^{-1}; the mean bright sunshine hours 7.3 hrs day^{-1} and the mean wind velocity 5.4 km hr^{-1}. The experimental year was experienced as a severe drought year in the Marathwada region of

Maharashtra and the rainfall was received annually 574.8 mm, 381.1 mm in crop growing period (24th MW to 52th) and 13.6 mm during 26th MW to 30th as against normal of 925.0 mm, 632.8 mm and 169.9 mm, respectively (Jaybhaye *et al.,* 2016; Mohite, 2012).

The received rainfall was observed below normal as compared to annual 38 %, crop growing period 40 % and during severe dry spell period (26th MW to 30th) 92 %. Considering above narrated drought weather condition and relatively observed crop growth, development and yield are being discussed in this paper.

Results and Discussion

Phenological attributes

Number of days required for attaining various phenophases

The sequential study of development stages (i.e. crop growth stages) of the crop is known as phenology. The duration (days) taken for commencement of different phenological events *viz.*, square formation (P_1), flowering (P_2) boll formation (P_3) and boll bursting (P_4) for different date of sowing of the cotton crop is given in Table 1. Perusal of data revealed that 24th MW sowing required significantly highest number of days (110 days) for attaining various phenophases and lowest (88 days) in 26th MW sowing. Whereas, due to this shorter duration in late sown crop seems to have affected the seed cotton yield as well as total biomass production and it was reflected in the obtained data. The data also showed that the mean number of days required for attaining various phenophases in respect to different *Bt* hybrids was also influenced by varietal characters. The variety mallika was recorded highest days (98 days) for attaining various phenophases than other varieties and lowest (95 days) in Ajit-155. It was found may be due the genotypic variation in *Bt* cotton and which were expressing differently to similar weather condition. While, the mean emergence count in per cent was observed significantly influenced by different date of sowings and significantly highest emergence count was recorded in 24th MW sowing (97.44 %) and lowest in 26th MW sowing (56.56 %). It was due to severe dry spell observed during 26th to 30th MW which was resulted into insufficient soil moisture and crop germination was hampered. These results are also corroborate with Freeland *et al.*, (2004) who observed that adequate soil moisture conditions at planting are necessary to ensure proper seed germination and crop emergence. Amongst the *Bt* hybrids, highest emergence count was recorded in Mallika, compared to rest of *Bt* hybrids and may be due genotypic variation.

Growth attributes

Perusal of data (Table 1) revealed that significantly highest plant height, plant width and mean number of branches were recorded in 24th MW sowing which was found at par with 25th MW and 26th MW at harvest. Whereas, the lowest plant height was observed in 27th MW sowing. It may be due to moisture stress observed during delayed sowing dates which may resulted into reduced plant growth and finally it was reflected into stunted growth and development of plants. The number of nodes and length of internodes are influenced by the genetics, biotic, abiotic and nutritional stress. The development rate of a new node is significantly slower when the plant is water stressed. Typically this produced shorter stature plants (Anon., 2016). The similar results were also reported by Awan *et al.,* (2011) and Patil *et al.,* (2009).

Table.1 Number of days required attaining various phenophases and growth attributes in cotton

Treatments	Emergence to Square formation stage	Square formation to flowering	Flowering to boll formation	Boll formation to boll bursting	Emergence count	Plant height (cm)	Plant width (cm)	No. of branches	Seed yield (kg/ha)
24th MW	33	20	4	53	97.44	62.75	60.43	15.94	675.62
25th MW	32	19	4	47	62.45	58.89	45.95	13.99	666.53
26th MW	28	17	3.5	34	56.56	56.48	39.73	12.07	194.20
27th MW	25	18	4.7	42	60.10	48.62	39.35	9.52	178.86
SE	0.54	0.77	0.16	2.01	5.52	1.91	1.28	0.53	40.28
CD	1.87	2.69	NS	6.9	19.13	6.62	4.45	1.64	139.42
Varieties									
Mallika	30	18	3.7	46	70.82	57.63	45.01	12.76	426.47
Ajit-155	30	19	3.8	42	69.34	59.08	49.03	13.41	487.0
Rasi-779	29.5	19	3.8	44	67.25	53.81	44.60	12.25	373.0
SE	0.31	0.80	0.12	1.66	1.50	1.09	1.33	0.34	21.19
CD	0.94	2.41	0.36	NS	NS	3.2	3.99	1.09	63.54
DxV interaction									
SE	0.63	1.61	0.24	3.32	3.01	2.21	2.66	0.73	42.38
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gmean	29.72	18.44	3.80	44.05	69.14	56.7	46.30	12.84	428.80

Table.2 Correlations between weather parameters and different growth stages of cotton with cotton seed yield

Weather parameters	Emergence to Square formation stage	Square formation to flowering	Flowering to boll formation	Boll formation to boll bursting
Rainfall (mm)	-0.971**	-0.936**	0.889**	0.886**
Rainy days	-0.974**	0.028	0.902**	0.940**
Max. T (°C)	0.940**	0.665*	-0.955**	-0.962**
Min. T (°C)	0.952**	0.942**	0.904**	0.966**
T Mean	0.942**	0.599*	0.159	0.946**
R.H. I (%)	-0.956**	-0.509	0.929**	0.961**
R.H. II (%)	-0.932**	-0.530	0.926**	0.964**
R. H. Mean	-0.943**	-0.492	0.746**	0.964**
Evp (mm)	0.936**	0.883**	-0.864**	-0.966**
B.S.S (HRS)	0.489	-0.909**	-0.942**	-0.959**
W.V (Kmph)	0.952**	0.967**	0.905**	0.933**

*Significant at 5 % level (0.567), ** Significant at 1% level (0.708)

The increase in number of branches might be due to the fact that the early sown crop has higher growth rate and branching pattern due to availability of soil moisture, congenial temperature and humidity for its vegetative growth.

However, in late sown crop the vegetative growth was restricted due to non-congenial weather parameters conditions as discussed above. These results are in conformity with those reported by Patil *et al.,* (2009) Wright *et al.,* (2015) and Munk (2001).

Amongst the hybrids, Ajit-155 recorded significantly highest plant height, plant width and mean number of sympodial branches at harvest over all the rest of hybrids. However, in Mallika it was found at par with each other at harvest. It was observed the significant difference in growth attributes within the hybrids because of final plant height also a function of main stem nodes and within cotton varieties the seasonal total number of main stem nodes strongly influenced by determinacy and growing environment (Ali *et al.,* 2012).

Cotton seed yield

The results revealed that the significantly highest cotton seed yield was recorded in 24th MW sowing (675.62 kg ha^{-1}) and lowest in 27th MW sowing (178.86 kg ha^{-1}) amongst sowing dates (Table 1). Seed yield variation was found may be due to delayed sowing coincided with moisture stress condition during the crop growth period. It was influenced significantly on emergence, physiological growth, reproductive growth and which showed relatively significant impact on seed yield. Among the hybrids, highest seed cotton yield (487.0 kg ha^{-1}) was recorded by Ajit-155. Whereas, lowest was produced by Rashi-779 (373 kg ha^{-1}). These results are agreement with the results reported by Patil *et al.,* (2009).

Correlation between weather parameters and different phenophases of cotton with seed cotton yield

The correlation study in between seed cotton yield and weather parameters (abiotic factor) prevailed at different sowings and different

phenophases are presented in Table 2. The critical growth stages deciding the cotton seed yield are square formation to flowering (P_2), flowering to boll formation (P_3) and boll formation to boll bursting (P_4). 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. While, the correlation results revealed that the weather parameters significantly influenced on the growth stages of the crop and finally reflected into the seed yield. The result revealed that the rainfall was highly significantly negatively correlated to early growth stages i.e. P_1 (-0.971**) and P_2 (-0.936**) and highly significantly positively correlated at P3 (0.889**) and P4 (0.886**). However, the results on rainy days showed highly negative significant correlation at P_1 (-0.974**) and highly positive correlation at P_3 (0.902**) and P_4 (0.940**). These results are in conformity with the results of Emmanuel (2012).

Temperature also plays a major role in deciding the length of growth stages. The very high and very low temperature causes the detrimental effect on the crop growth and development. Results showed that the maximum temperature was highly positively correlated during the early growth stages i.e. P_1 (0.940**) and P_2 (0.665*) and significantly highly negative correlation at P_3 (-0.955**) and P_4 (-0.962**) stages. The minimum temperature was significantly highly positive correlation at P_1 (0.952**), P_2 (0.942**), P3 (0.904**), and P_4 (0.966**). Similar results were given in the annual research report (Anon., 2010). While, morning relative humidity (RH-I) showed that significantly highly negative correlation at P_1 (-0.956**) and highly positive correlation at P_3 (0.929**) and P_4 (0.961**). Evening relative humidity (RH-II) showed negatively highly significant at P_1 (-0.932**) and positively significant at P_3 (0.926**) and P_4 (0.964**). However, it was found negatively highly significant at P_1 (-0.943**) and positively highly significant at P_3 (0.746**) and P_4 (0.964**) in average relative humidity (RH avg). Similar results reported by Sawan (2013a).

Evaporation was positively highly significant at P_1 (0.936**) and P_2 (0.883**) and highly negative correlation at P_3 (-0.864**) and P_4 (-0.966**). Similar results reported by Sawan (2013). BSS was negatively highly significant at P_2 (-0.909**), P_3 (-0.942**) and P_4 (-0.959**). Similar results were stated by Sawan (2013b).Wind velocity was highly positive correlation at all the stages i.e. P_1 (0.952**), P_2 (0.967**), P_3 (0.905**) and P_4 (0.933**).

The obtained experimental data and results discussed above can be concluded that-

The 24th MW sowing and the *Bt* hybrid Ajit-155 is suitable for getting more yield under Parbhani condition.

Correlation between weather parameter and growth stages of cotton with seed cotton yield showed that the weather parameters like rainfall, temperature, relative humidity, evaporation and BSS are significantly influencing the critical growth stages of cotton.

Rainfall during square formation and flowering stages have a negative influence on the seed cotton yield of *kharif* cotton.

Variation with high magnitude in diurnal temperature range also showed negatively significant influence on cotton seed yield.

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