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Agrometeorological Indices and Correlation Coefficient of *Bt* Cotton Under Different Growing Environment

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A B S T R A C T

A field experiment was conducted during 2012-13 at Department of Agricultural Meteorology, VNMKV, Parbhani (Maharashtra). The agrometeorological indices like GDD and PTU also showed a significant variation among different sowing dates and *Bt* hybrids of cotton. The average growing degree days were recorded among the different sowing dates was 1556 ^{0}days at the base temperature of 15.5^{0}C. The highest number of GDD (1649 ^{0}days) and PTU (20249 ^{0}day hrs) were accumulated in 25th MW sowing followed by 26th MW sowing. The lowest number of GDD (1452 ^{0}days) and PTU accumulation was recorded in 28th MW (1452 ^{0}days). The total number of GDD was significantly influenced by different hybrids. Among *Bt* hybrids the highest number of GDD were accumulated by Ajit-155 and Bunny Bt (1561 ^{0}days) and the average GDD were accumulated in different hybrids was 1556 ^{0}days. The PTU also significantly influenced by different treatments of sowing dates and different hybrids. The highest number of PTU accumulated in 25th MW sowing followed by 26th MW sowing. The lowest number of PTU recorded in 28th MW sowing. Among the hybrids the highest number of PTU recorded in Ajit-155 and Bunny Bt while lowest PTU recorded in Rashi-779. Correlation between weather parameter and growth stages of cotton with seed cotton yield showed that the weather parameters like rainfall, temperature, relative humidity and BSS have significant effect on critical growth stages. Rainfall during square formation and flowering stages showed positive influence on the seed cotton yield of *kharif* cotton. Diurnal temperature range also showed negative correlation with seed cotton yield.

Keywords

GDD, PTU, *Bt*, Cotton, Correlation.

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Introduction

Cotton require a minimum daily temperature of 15.0^{0}C (60 ^{0}F) for germination, 21.0-27.0^{0}C (70-80 ^{0}F) for vegetative growth, and 27.0-32.0^{0}C (80-90 ^{0}F) during the fruiting period. Mauney (1986) stated that all processes leading to square, blossom, and boll initiation, and maturation are temperature dependent. Cool nights are beneficial during the fruiting period, but extremes in temperature (low/high) can result in delayed growth and aborted fruiting sites.

Lint yield is generally reduced because of reduced boll production, primarily of fewer fruiting sites producing bolls but also because of increased fruit abscissions due to various environmental stresses. Plants with highest boll load are the most sensitive to low light intensity due to their increased requirement of photosynthate (Guinn, 1998). Cotton lint yield and fiber quality are also impacted by the amount and quality of solar radiation. Not only is lint production reduced under low light condition, but also the fiber produced is often of inferior quality. Water stress caused by deficiency of water, its damage as reduction in photosynthetic activity and increased in leaf senescence (Constable and Rawson, 1980).

The growth, development and yield of the crop depend on the suitability of solar radiations, temperature; humidity etc. yields are controlled by the weather parameters. Plant character which can be counted/ measured well in advance of harvest with no error or little error should be included in the forecast model. For cotton crop, plant population and number of bolls explained only 35 to 40 per cent of the variation in crop yield but with the inclusion of first picking yield as an additional explanatory variable in the model, the extent of explained variation increased to about 80 per cent. Since the first picking yield becomes available after about 4 months of sowing the crop while its final harvesting is done after 6 months, the cotton yield forecast on this basis is feasible about 2 months before harvesting.

Materials and Methods

The field Experiment was conducted during kharif season 2013-14 on experimental farm of Department of Agricultural Meteorology, College of Agriculture, Dr. Vasantrao Naik Marathawada Krishi Vidypeeth, Parbhani. Geographically Parbhani is situated at 409 MSL (Mean Sea Level), 190 16' North Latitude and 760 47' East longitude and having sub-tropical climatic condition.

The sowing was done with the help of manual labour by dibbling. The seeds of cotton hybrids namely Mallika, Ajit-155, Bunny Bt and Rashi-779 were dibbled with row to row and plant to plant spacing (120 x 45 cm) during 04 different meteorological weeks 25th MW (21-06-2013), 26th MW (28-06-2013), 27th MW (05-07-2013) and 28th MW (12-07-2013). The daily observations on air temperature, relative humidity, precipitation and bright sunshine hours were recorded at meteorological observatory. The weather data were used for the analysis. The information about agro-meteorological indices is depending upon the climate, hybrids and soil type of the region where the crop is grown. The following agro-meteorological indices were computed using the daily meteorological data which were taken from agro-meteorological observatory. The heat unit concept was initially developed to study plant- temperature relationship and to provide a method for more precisely measuring the intervals between growth stages. The daily GDD was worked out by taking the daily average temperature (Tmax + Tmin)/2, and subtracting the base temperature from the daily average temperature. The resulting number is the number of heat units accumulated for that day. The method typically used for calculating accumulated heat units is expressed by following formula (Freeland *et al.,* 2004).

$$\text{Accumulated GDD} = \sum_{ds}^{dh} [(T\max + T\min)/2] - Tb \quad (0C\ \text{day})$$

Where,

T_{base} – base temperature of crop (15.5 ^{0}C or 60 ^{0}F)

ds = Date of sowing

dh = Date of harvest

Day and night is one of the basic factors controlling the period of vegetative growth in a photosensitive crop. The photothermal unit is the product between heat units or GDD and day length. The sum of photo thermal unit for each phenophase was worked out by using the following formula, (Kumar *et al.,* 2012).

Photothermal Unit (^{0}C day h) = ∑ (Heat Units x D)

Where,

D = Day length in hours

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 (1967). The statistical analysis worked out with the help of computer.

Results and Discussion

Growing degree days (degree days)

The data given in the table 1 shows that the number of growing degree days was accumulated during the each phenophase at the base temperature of 15.5^{0}C (60 ^{0}F) and it was obtained 1486 ^{0}days as general mean. The results showed that the growing degree days was significantly affected by different sowing dates and the highest number of growing degree days recorded in 25th MW (1550 ^{0}days) followed by 26th MW (1534 ^{0}days) and 27th MW sowing (1443 ^{0}days). Whereas, the lowest number of GDD was accumulated in 28th MW sowing (1419^0 days) It means that the daily mean temperature is more than number of GDD required less and it might be due this 25th MW sowing required more GDD and least required in 28th MW. The results showed that the average number of heat units accumulated by different Bt hybrids during its life cycle was 1486 ^{0}days while, it was found that Ajit-155 and Bunny *Bt* recorded highest number of heat units (1492 ^{0}days) during its whole life cycle and the lowest number of heat units recorded in hybrid Rashi-779 (1474 ^{0}days).

Freeland *et al.,* (2004) reported similar results and stated that the current Bt hybrids of cotton required GDD between 1195 and 1275 degree days considering base temperature 15.5 ^{0}C. Highest GDD was recorded at boll setting to boll brusting stage (P_6) in all the hybrids with mean GDD 515 ^{0}days and lowest GDD recorded at flowering to boll formation stage (P_5) as the less number of days required for complete this phenophases.

Photothermal unit (^{0}C day hours).

Photo thermal unit is the agro meteorological indices that mean how much quantity of heat energy to be used by the plant during the day. It is calculated by multiplying the daily heat units or GDD with the length of day. The no. of photo thermal units to be accumulated by the crop during its life cycle at different phenophases are given in the table 2. The photo thermal units are was influenced by the number of days required for reaching to each phenophase or to complete life cycle, daily average temperature and length of the day.

The data given in the table 2 showed the number photothermal units was accumulated during the each phenophase at the base temperature 15.5^{0}C was significantly influenced by different sowing dates. The data revealed that average photothermal units accumulated during different sowing dates was observed 18880^{0}C day hrs. whereas, the highest number photothermal units was recorded in 25th MW sowing (20249^{0}C day hrs) followed by 26th MW sowing (19396^{0}C day hrs) and 27th MW sowing (18413^{0}C day hrs) and the lowest in 28th MW sowing (17465^{0}C day hrs).

While, the highest number of PTU were recorded in 25th MW sowing at all the phenophases and the lowest in the 28th MW sowing. However, within all crop growth stages the highest number of PTU recorded at boll setting to boll brusting stage (P_6). The lowest no. of PTU was accumulated at flowering to boll setting (P_5) in all the sowing dates. However, amongst the different Bt hybrids the photothermal units were significantly influenced by different Bt hybrids and the mean photothermal units accumulated was observed 19001^{0}C day hrs while, it was found that the highest number of photothermal unit was recorded in the Ajit-155 and Bunny *Bt*. (19392^{0}C day hrs) and in Mallika lowest (18898 ^{0}C days hrs), in Rashi-779 in all the sowing dates 18806^{0}C day hrs.

Table.1 Phenophase wise accumulated GDD (^{0} days) as influenced by different treatments

Phenophases Treatment	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	Mean
Dates of sowing											
25th MW	75	272	91	170	53	521	201	101	66	99	1550
26th MW	84	260	86	176	48	528	186	86	80	65	1534
27th MW	69	236	85	161	59	512	171	69	81	81	1443
28th MW	55	243	88	168	62	498	144	59	102	33	1419
Mean	70	252	87	168	55	514	175	78	82	69	1486
Bt hybrids											
Mallika	71	255	87	167	56	517	174	78	83	63	1488
Ajit-155	71	255	87	173	56	518	173	76	83	69	1492
Bunny Bt	71	255	87	173	56	518	173	76	83	69	1492
Rashi-779	71	245	88	162	54	508	182	85	79	77	1474
Mean	71	252	87	168	55	515	175	78	82	69.5	1486

Table.2 Phenophase wise accumulated photo thermal units (^{0}C day hrs) as influenced by different treatments

Phenophases Treatment	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	Mean
Dates of sowing											
25th MW	990	3579	1188	2133	665	6331	2302	1145	737	1179	20249
26th MW	988	3381	1108	2174	584	6364	2146	1011	846	794	19396
27th MW	911	3068	1068	2008	734	6103	1939	778	906	898	18413
28th MW	728	3125	1102	2081	760	5868	1627	665	1119	390	17465
Mean	904	3288	1116	2099	685	6166	2003	899	902	815	18880
Bt hybrids											
Mallika	904	3323	1113	2090	692	6172	1990	893	910	811	18898
Ajit-155	969	3387	1113	2194	648	6291	2105	950	854	881	19392
Bunny Bt	969	3387	1113	2194	648	6291	2105	950	854	881	19392
Rashi-779	904	3186	1126	1989	672	6146	2078	962	861	882	18806
Mean	936	3320	1116	2116	665	6225	2069	938	869	863	19122

Table.3 Correlations between weather parameters and different growth stages of cotton with seed cotton yield

Weather parameters	Phenophases									
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}
Rainfall (mm)	-0.357	**0.499***	**0.521***	**0.522***	**0.636****	**-0.522***	**-0.520***	**-0.570***	-0.389	-0.081
Rainy Day	0.097	0.471	-0.263	0.446	0.171	-0.376	**-0.506***	0.287	-0.460	0.493
T-Max (^{0}C)	0.155	**0.566***	**0.558***	**0.694****	**0.584***	**-0.502***	**-0.528***	**-0.548***	-0.361	0.407
T-Min.(^{0}C)	-0.031	**0.669****	**0.510***	**0.531***	**0.518***	**-0.500***	**-0.538***	**-0.607***	-0.444	0.417
T-Mean (^{0}C)	0.138	**0.570***	**0.541***	**0.537***	**0.664****	**-0.612****	**-0.611***	**-0.584***	-0.446	0.430
RH-I (%)	-0.125	**0.537***	**0.534***	**0.521***	**0.502***	-0.178	0.431	0.297	-0.499	-0.372
RH-II (%)	-0.100	**0.658****	**0.631****	**0.673****	**0.535***	0.190	**0.498***	0.396	**-0.499***	0.451
RH avg (%)	-0.118	**0.594***	**0.520***	**0.501***	**0.508***	0.033	0.471	0.418	**-0.500***	0.441
EVP. (mm)	0.180	0.458	0.428	0.139	-0.191	**-0.571***	**-0.517***	**-0.567***	0.318	0.310
B.S.S. (hrs)	0.017	0.377	-0.300	0.271	-0.144	-0.448	-0.457	0.129	0.442	-0.451
WV (km h-1)	0.238	0.154	0.449	0.488	0.425	**-0.498***	**-0.583***	**-0.543***	-0.342	0.473

*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 Pick

Correlation studies

The correlation study between seed cotton yield and weather parameters (abiotic factor) prevailed at different sowings and different phenophases are given in table 3. The most critical growth stages deciding the cotton seed yield are square formation to flowering (P_4), flowering to boll setting (P_5) and boll setting to boll bursting (P_6). 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 the on growth stages of the crop and finally reflected in to the 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 i.e. seedling stage to flowering setting stage (P_2 to P_4) and significantly negatively correlated during flowering to boll setting (P_6 to P_8). While, it was found positively and highly significant at boll formation stage (P_5). However, the results on rainy days showed negatively significant correlation at 1st picking stage (P_7). It means that the rainfall distribution was affecting on yield throughout the growing period of cotton and at boll brusting and harvesting negative impact was observed (Anonymous (2006). The rainfall was significant at seedling stage (P_2) and the results are inconformity with those reported by Freeland *et al.*, (2004).The rainfall found to be statistically significant with positive direction from planting to leaf development and boll maturity phase.

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. The data in table 3 revealed that the maximum, minimum and mean temperatures was positively correlated during the early growth stages i.e. from seedling stages to boll setting and significantly negatively correlated at P_6 to P_8 stages. However, the highly positively significant correlation was found in maximum temperature at square formation stage to flowering; in minimum temperature at emergence to seedling stage (P_1 to P_2) as well as highly significant negative at boll setting to boll brusting stage (P_5 to P_6).

While, morning relative humidity (RH-I) showed that the positively significant correlation at P_2 – P_5 and afternoon relative humidity (RH-II) showed positively highly significant at P_2 – P_4 and positively significant at P_5 – P_7. However, RH-II was found negatively significant at $P_{9.}$ However, it was found positively significant at P_2 – P_5 and negatively significant at P_9 in average relative humidity (RHavg). The evening relative humidity was positively highly significant at seedling stage, boll setting to 1st picking stage (P_5 to P_7) and negatively significant at 3rd picking stage (P_9). Sawan (2013) also reported that minimum relative humidity had a positive correlation with flower and boll formation. It means that the correlation analysis results revealed that the, evaporation and wind velocity negatively significant correlated at P_6 to P_9.The similar results were reported by Sawan (2013) revealed that the evaporation shows the negative correlation with flowering to boll brusting because of the evaporation rates could result in water stress that would slow growth and increase shedding rates of flowers and bolls.

Wind speed can also stress the cotton plant enough to reduce yield, although some wind may beneficial in very hot humid conditions. Wind modifies the temperature and humidity gradient around the cotton plant which in turn changes the evaporative demand. The results of analysis showed that the bright sunshine hrs was not significantly influence the crop growth stages during the crop growing period of 2013.

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