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Influence of weather parameters on cotton phenology and seed cotton yield

G. K. KATARIA* AND M. G. VALU

Cotton Research Station, Junagadh Agricultural University, Junagadh-362001

**E-mail: gkkataria@jau.in*

ABSTRACT : A field experiment was conducted during three consecutive *kharif* 2015 to 2017 at Cotton Research Farm of Junagadh Agricultural University, Junagadh. The experiment was laid out in split plot design with three sowing dates (S_1-31st May, S_2- 20th June and S_3- 10th July) as main plot and three *Bt* cotton genotypes (G.Cot.Hy 6, G.Cot.Hy 8 and GTHH 49) in sub plot replicated thrice. The results of the experiment indicated that among the three cotton genotypes, G.Cot.Hy 8 produced significantly higher seed cotton yield (2519 kg/ha) than the rest of two genotypes GTHH 49 (2376 kg/ha) and G.Cot.Hy 6 (2242 kg/ha) in all dates of sowing. The crop sown on 31st May gave significantly higher seed cotton yield (2912 kg/ha) which was *at par* with crop sown on 20th June (2565 kg/ha). Early and timely sown crop get more time to develop vegetative and reproductive organs with sufficient rainfall, rainy days and get sufficent time to produce maximum photosynthates (dry weight) that transfer to developing reproductive organs *i.e.* bolls and boll weight increased, resulting produced higher seed cotton yield. In consideration of net return and pink bollworm incident timely sown (20th June) crop find beneficial for farmers.

Key words: Leaf area index, specific leaf weight, sympodia

In Indian agriculture, cotton (*Gossypium hirsutum* L.) possesses a position of major fiber and cash crop, which plays vital role to sustain national economy. It provides the basic raw material (cotton fibre) to cotton textile industry. Cotton in India provides direct livelihood to 6 million farmers and about 40 -50 million people are employed in cotton trade and its processing. Cotton is cultivated on about 33.5 million ha and 118.6 million bales across the world. India having the largest area under cotton cultivation in the world is 12.6 million ha and 25.8 million bales. The yield/ha is however low *i.e.* 446 kg/ha against the world average 771 kg/ha. In India, Gujarat is the largest producer of cotton having 2.60 million ha under cotton cultivation, producing 9.50 million bales and ranks first in production (Anonymous, 2020). Cotton with an indeterminate growth habit and is very responsive to climatic changes and management. The cotton growers have been facing various challenges in its production like pest attack, high variations in temperature, erratic rainfalls and water stresses, since long. The effect of temperature differs at every stage of plant growth. During this any increase in temperature or rainfall will cause greater invasion of pests and flower and boll shedding.

For cotton crop, 21-27 °C temperature is required for proper vegetative growth. Temperature significantly effects leaf expansion, internodes elongation, dry matter production and partitioning of assimilate to different plant parts (Premdeep *et al.*, 2017). Attempt to understand this phenomenon in detail cotton crops was sown on different time interval and the effect of different weather parameter on different growth stages and their relationship on seed cotton yield was studied in the experiment.

MATERIALS AND METHODS

The field experiment was conducted at the Cotton Research Farm of Junagadh Agricultural University, Junagadh, which is situated at altitude of 61m above mean sea level and 21°31'N latitude, 70°33'E longitude, during the three consecutive *kharif* 2015 to 2017 on irrigated cotton. The experiment was layout in split plot design with three sowing dates (S_1-31st May, S_2-20th June and S_3-10th July) as main plot and three *Bt* cotton genotypes (G.Cot.Hy 6, G.Cot.Hy 8 and GTHH 49) in sub plot replicated thrice. All recommended agronomical and plant protection measures were carried out in time to keep the crop in healthy condition.

Five plants from each treatment were selected randomly and tagged for recording various observations on morpho-physiological growth parameters and yield components at periodically and at harvest. Leaf dry weight was used furtherer for computing specific leaf weight (SLW). Top fully expanded (second from top) leaf was used for measuring the chlorophyll content by using chlorophyll content meter (Model CCM -200 Plus). Leaf area index was measured by using plant canopy analyzer LAI-2200C, LI-COR Ltd., Nebraska, USA. Seed cotton yield was worked out from the net plot basis and expressed as kg/ha. The data were analyzed by the analysis of variance method as suggested by Gomez and Gomez (2010).

RESULTS AND DISCUSSION

Plant height (cm) : Data presented in Table 1 indicated that early (31st May) sowing of cotton resulted insignificantly increased height. Data also revealed that at maturity stage cotton sown on 10th July (late) produced significantly lowest plant height over all other sowing dates. Cotton genotype GTHH 49 was significantly superior to G.Cot.Hy 6 and G.Cot.Hy 8 in term of plant height. Cotton genotype GTHH 49 recorded 13.15 and 17.95 per cent higher plant height than G.Cot.Hy 6 and G.Cot.Hy 8, respectively in early (31st May) sown crop.

Specific leaf weight (SLW) (mg/dm2) : Cotton sown early (31st May) produced significantly higher SLW than other sowing time. SLW of cotton sown on 31st May was *at par* with cotton sown timely on 20th June. Genotypes also showed significant differences in SLW at 150 DAS. Genotype G.Cot.Hy 6 recorded significantly higher SLW (779.4 mg/dm^2) than G.Cot.Hy 8 (681.8 mg/dm^2) at 105 DAS and it was *at par* with GTHH 49 (754.5 mg/dm^2) whereas dates of sowing and genotypes interaction difference of SLW were found not significant shown in Table1. Present results are in line with the findings of Herkal and Mummigatti (2018).

Chlorophyll content index :

Table 1. Influence of weather parameters on cotton crop phonological parameters, yield and ancillary observation (Pooled data).

Treatments	Plant height (cm)	CCI (DAS)		LAI (DAS)		SLW (DAS) (mg/dm^2)		Days to matu-rity	Sym-podia	Mono-podia	Seed index	Lint index	Days to 50 per cent boll bursting	Ave-rage boll weight (g)	Bolls/ plant	Seed cotton yield (kg/ha)	Bio-mass (t/ha)	B:C ratio
		120	150	120	50	120	150											
Main plot Mean(Date of sowing)																		
S_1=31st May(Early)	133	22.69	30.89	4.95	5.05	671.6	789.4	220	17.27	2.51	8.29	4.37	125.70	3.96	58.40	2912	9.59	1.97
S_2=20th Jun(Timely)	126	23.81	27.86	4.46	4.77	652.5	731.4	202	15.20	2.50	8.74	4.66	115.67	3.86	52.24	2565	8.73	2.27
S_3=10th Jul(Late)	118	25.48	24.43	3.82	4.18	637.5	695.0	185	15.20	2.19	8.20	4.18	110.00	3.70	44.96	1660	6.53	1.48
S.Em.±	2.3	1.85	0.42	0.25	0.16	26.5	6.0	2.03	0.76	0.17	0.11	0.05	2.39	0.04	2.55	228.96	0.13	-
C.D. (p=0.05)	9.2	NS	1.30	NS	0.63	NS	18.6	7.97	NS	NS	0.35	0.16	9.37	0.13	10.01	898.87	0.41	-
C.V. (%)	3.5	6.37	7.90	11.59	8.23	10.7	4.2	1.60	9.47	13.27	7.08	6.29	1.46	5.91	9.05	11.96	8.25	-
Sub Plot Mean(V)																		
V_1=G.Cot.Hy 6	129	24.39	27.94	4.33	4.77	652.6	779.4	204	16.59	2.32	8.39	4.33	118.30	3.98	46.41	2242	8.52	1.99
V_2=G.Cot.Hy 8	114	23.30	27.83	4.30	4.51	637.4	681.8	197	16.74	2.25	8.50	4.42	115.00	3.49	57.71	2519	7.53	2.22
V_3=GTHH 49	134	24.29	27.41	4.61	4.72	671.6	754.5	206	16.88	2.63	8.32	4.47	118.07	4.06	51.47	2376	8.80	2.11
S.Em.±	3.6	0.40	0.48	0.14	0.21	17.83	13.06	0.56	0.36	0.17	0.17	0.05	1.97	0.05	1.51	126.01	0.21	
C.D. (p=0.05)	14.0	NS	NS	NS	NS	NS	51.27	1.62	NS	NS	NS	NS	NS	0.14	5.93	NS	0.82	-
C.V. (%)	4.5	8.57	9.05	9.42	9.11	8.29	4.93	1.45	11.04	10.22	5.23	6.04	1.95	6.48	9.10	10.16	6.95	-
Inter. Effect (SXV)																		
S.Em.±	1.9	0.69	0.84	0.14	0.14	18.07	12.14	0.97	0.62	0.18	0.15	0.16	2.02	0.08	1.57	80.57	0.19	-
C.D. (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	231.27	NS	-

Significantly higher chlorophyll content index (CCI) at 150 DAS (30.89 mg/dcm^2) was recorded in early sown (31st May) than crop sown timely on 20th June (27.86 mg/dcm^2) and late sown on 10th July (24.43 mg/dcm^2), whereas dates of sowing and genotypes interaction difference of chlorophyll content index was found not significant at 120 DAS.

Leaf area index (LAI) : As evident from the data in Table 1 significant differences in LAI was shown in different sowing dates and genotypes of cotton. Maximum LAI (5.05) at 150 DAS was significantly recorded in early sown (31st May) crop than late sowing in 10th July (4.18). A date of sowing and genotypes differences of LAI was found not significant at 120 DAS.

Number of monopodia and sympodia : The data indicated that there was non-significant effect of sowing time and genotypes on monopodia and sympodia (Table 1). Numerically maximum monopodia and sympodia / plant were recorded in early sown crop.

Days to 50 per cent boll bursting : Data reviled in Table 1 that sowing dates significantly differed for the 50 per cent boll bursting. Days to

Table 2. The incidence of sucking pests and bollworms damage in different dates of sowing and cotton hybrids.

Treatment	Mean population of sucking pests/3 leaves/plant			Average percentage bollworms damage to		
	Jassid TV*	Thrips TV*	Whitefly TV*	Green boll TV*	Open boll TV*	Locules TV*
Date of Sowing						
S_1= 31st May(Early)	2.81	4.02	3.34	**23.39**	**22.54**	**20.83**
S_2=20th Jun(Timely)	2.99	3.53	3.52	20.01	17.57	15.45
S_3=10th Jul(Late)	3.02	3.79	3.43	22.88	18.29	16.24
S.Em.±	0.04	0.14	0.09	0.58	0.63	0.69
C.D. (p=0.05)	0.15	NS	NS	2.29	2.48	2.70
C.V. (%)	3.82	11.49	7.82	7.92	9.74	11.78
Test	*	NS	NS	*	**	*
Variety/ Hybrid						
V_1=G.Cot.Hy 6	2.89	3.94	3.52	24.23	20.22	18.35
V_2=G.Cot.Hy 8	2.69	3.26	3.11	18.09	17.84	15.76
V_3=GTHH-49	3.24	4.15	3.66	23.97	20.33	18.42
S.Em.±	0.09	0.12	0.11	0.37	0.59	0.65
C.D. (p=0.05)	0.27	0.38	0.35	1.13	1.81	1.99
C.V. (%)	9.03	9.89	9.98	4.96	9.07	11.08
Test	**	**	*	**	*	*
Interaction S X V						
S.Em.±	0.15	0.22	0.20	0.63	1.02	1.12
C.D. (p=0.05)	NS	NS	NS	NS	3.14	3.45

TV= Transformed values *= Square root transformed values

50 per cent boll bursting decreased as sowing time was delayed from 31st May to 10th July. The crop sown on 10th July required minimum time for 50 per cent boll bursting (110 days). In case of genotypes difference was found non-significant.

Bolls/plant and average boll weight (g) : The bolls/plant and average boll weight (g) at harvest are an important yield component having the greatest direct effect on yield. The highest bolls/plant (58.4) and average boll weight (3.96 g) was produced significantly in early sown (31st May) crop which was statistically *at par* with the crop sown timely (20th June). Among the cotton genotypes, G.Cot.Hy 8 produced numerically higher bolls/plant (57.71) followed by GTHH 49 (51.47) however, significantly higher boll weight (4.06 g) was found in GTHH 49 followed by G.Cot.Hy 6 (3.98 g). Pre-seasonal *Bt* cotton sowing at 30 May was found beneficial reported by Jadhav and Waskar (2019) and heat use efficiency was highly correlated with bolls / plant (Premdeep *et al.*, 2017).

Seed index and lint index : Sowing dates studied also differed significantly among themselves for seedindex and lint index, however genotypes differences was found not significant (Table 1). The crop sown on 20th June showed significantly highest seed index (8.74) and lint index (4.66). A lower value of seed index indicates more immature seeds reported by Zenebe *et al.*, (2016).

Biomass production (t/ha) : The data indicated that there was significantly higher biomass accumulation at maturity (9.59 t/ha) was recorded in cotton sown on 31st May than crop sown on 20th (8.73 tons/ha) and 10th July (6.53 t/ha). G.Cot.Hy 8 produced significantly lower biomass and more dry matter transported into boll development than G.Cot.Hy 6 and GTHH 49 at harvest.

Incidence of insect pests : The result showed in Table 2 revealed that population of aphids, thriphs and whitefly observed non significant relation to date of sowing. The result found that damage to green boll, open and locule was significantly differences to date of sowing and genotypes. The damage to green boll, open and locule was found significantly highest in early sown (S_1) crop whereas the lowest population was recorded in S_2 and genotype V_2 which was significantly superior to the rest of the treatment.

Table 3. Three year pooled data of total rainfall, effective rainfall, total rainy days, GDD, wet and dry spells of three sowing dates.

Sowing Date	Total rainfall (mm)	Effective rainfall (mm)	Total rainy Days	Total GDD	Wet spell (Day)	Dry spell (Day)
Average of year 2015 to 2017						
S_1=31st May(Early)	890.8	888.6	37	2638	43	177
S_2=20th Jun(Timely)	890.8	850.9	35	2308	41	163
S_3=10th Jul(Late)	890.8	708.8	27	2023	31	155

Seed cotton (kg/ha) : A thorough look on data presented in Table 1 indicated that sowing dates and genotypes had significant effect on seed cotton yield and it was significantly higher (2912 kg/ha) in early sown (31st May) crop which was statistically *at par* with the crop sown timely (2519 kg/ha) on 20th June. Among the cotton genotypes, G.Cot.Hy 8 produced numerically higher seed cotton yield (2519 kg/ha) followed by GTHH 49 (2376 kg/ha) and G.Cot.Hy 6 (2242 kg/ha). The interaction effects between sowing time and genotypes were found significant. G.Cot.Hy 8 produced higher seed cotton yield during sowing of 31st May. Looking to the economics of different dates of sowing and genotypes early sown cost, pink bollworms damage, B:C ratio (2.27), the timely sown crop was found profitable as compared to early and late sown crop (Table 1). Higher seed cotton yield during crop sown on 31st May and 20th June might be due to the higher bolls/plant, boll weight, sympodial branches and sufficient time to develop reproductive phenophase with sufficient GDD (Table 3). Cotton yield decreased with late sowing due to the reduction in season length (Zenebe *et al.*, 2016) which reduced the fruiting branches and bolls. Yield reduction due to late sowing may be attributed to shortening of crop period which adversely affected the reproductive process of crop (Bala *et al.*, (2020) and Kaur *et al.*, (2019).

CONCLUSION

Sowing of *Bt* cotton hybrids on 20th June was found better as compared to 31st May and 10th July of sowing dates in terms of growth parameters, yield attributes, reduce pink bollworm damage, yield of cotton and net return however genotype G.Cot.Hy 8 produced higher seed cotton yield and net return as compared to GTHH 49 and G.Cot.Hy 6 genotypes.

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