Research Article

Assessment of the Consequences of Heat Changes on Cotton Cultivars Growth, Phenology and Yield at Different Sowing Regimes

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Abstract | Temperature is the main climatic factor that influences the yield just as entire development of farming crops. All periods of phenology of crops are temperature sensitive. Hence, information on appropriate temperature for best yield is significant so as to get maximum production. In current examination, a field test was directed to evaluate the phenology, relative development, ideal sowing time, comparative growth just as yield execution of three cultivars of Bacillus thuringiensis Cotton (Bt. Cotton) at different sowing systems during summer 2015 at cotton research station Regional Agriculture Research Institute Bahawalpur (RARI) Pakistan. The test was directed in an irregular complete block design (RCBD) with a split-plot course of action comprising of three replications. One factor comprised of six planting dates (for example April15 and 30, 15 and 30 May, 14 and29 June) and other factor comprising of three Bt. cotton cultivars (BH-184, MNH-886 and CIM-598). The after effects of the test indicated that both sowing dates and cultivars fluctuated fundamentally for development, phenology and yield. Highst leaf area index (LAI) 4.38, total dry matter (TDM) 1033 g m^{-2}, leaf area duration (LAD) 275.6 days and mean harvest development rate 6.51g m^{-2} day^{-1} were recorded on April 30 sowing. Yield contributing boundaries like opened boll, average boll weight and 100-seed weight altogether shifted and highest seed cotton yield 3847 kg ha^{-1} was acquired by cv. MNH-886 when it was planted on April 30.

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Introduction

Cotton (*Gossypium hirsutum* L.) is a direct non-food cash yield of the world, comprehensively utilized in cloth producing industries (Iqbal *et al*., 2019). Additionally, it is widely used for fiber creation and oil extraction. Pakistan is the fourth in the rundown of significant cotton-producing countries and acquires a

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big amount of foreign trade. Cotton assumes a crucial job in the agrarian economy of Pakistan. It includes about 7% of the incentive in farming and 1.5% in GDP (Gross Domestic Product) (GoP, 2018). Prior, genetic engineering procedures were utilized to change Bt. Cotton quality extricated from bacteria *Bacillus thuringiensis* (Bt.). Single protein of this quality is harmful for the biting vermin. Because of obstruction against biting bugs, there might be very nearly a 30% increase in cotton yield and henceforth additional pay to helpless ranchers. The fundamental point of the Bt. cotton is to abstain from biting vermin assault for example American bollworm, budworm, army and spotted bollworm (GoP, 2018). Sowing time assumes significant job in yield potential (Arshad *et al*., 2007). Cotton crop is exceptionally receptive to natural conditions and developed in tremendous scope of environmental zones. Numerous elements, for example, the idea of cultivars, planting date, supplements and water the board rehearses plant protection measures are engaged with getting a gainful yield (Ali *et al*., 2005). Every one of these variables is for the most part influenced by light, soil dampness, moistness and wind speed.

Picking the best sowing time in a specific district is regularly troublesome (Bilal *et al*., 2019). Too soon and exceptionally late sowing makes the crop helpless to various maladies like cotton leaf curl virus (CLCV) (Nawaz *et al*., 2019). Thusly, ideal planting time for an assortment in a zone is likewise viewed as a reasonable factor in cotton crops (Bozbek *et al*., 2006). Low yield of late planted cotton might be credited to the brief term of the flowering stage, all the more shedding of blossoms, pre-experienced blooming and boll shedding and over the top attack of viral infections like CLCV. Seed cotton yield was improved with extending of blossoming period before the beginning of any natural stress and by improving the utilization of dampness and supplements during boll advancement and development stages (Bilal *et al*., 2019; Ullah *et al*., 2019). Design of cultivars varies which decides the ideal dispersing required for a cultivar for gainful yield. All out occasional light capture increments with narrow line dividing that possibly increased cotton yield (Steglich *et al*., 2000).

Short season cultivars are yielding more dry issue than cultivars of long-seasons because of more noteworthy radiation use efficiency (RUE) and light block attempt (Bange and Milory, 2000). Postponement in plantings from April, the time basic for the plant to create floral buds and blossoms is diminished, because of the hot and long days. This late planting of cotton cultivars influences the shedding power henceforth the last cotton yield (Rahman *et al*., 2016). Fruiting period is shortened and naximum development time is late because of postponed planting. Be that as it may, following the season, delay planting drives boll improvement into the cooler climate, increase the number of days required from blooming to boll opening. The seed cotton yield enormously dropped in the mid and end June planting dates (Muhammad *et al*., 2002; Rahman *et al*., 2018). Any delay in planting time excessively affects boll shedding force and at last seed cotton yield (Tahira *et al*., 2007).

The motivation behind current investigation is to evaluate the ideal planting time for supportable cotton production in regions of dry atmosphere so as to maintain a strategic distance from hot and cold anxieties. The speculation of the examination was to evaluate phenology, relative development just as yield attributes of three cultivars of *Bacillus thuringiensis* Cotton (Bt. Cotton) at different sowing times.

Materials and Methods

A field experiment was conducted at Cotton Research Station, Regional Agricultural Research Institute (RARI), Bahawalpur using randomized complete block design (RCBD) in split-plot arrangements keeping sowing dates (April 15, April 30, May 15, May 30, June 14 and June 29) in main plots and Bt. cotton cultivars (i.e. BH-184, MNH-886 and CIM-598) in subplots. In the Bahawalpur region, the study area, sand type is sandy loam whereas climate here is semi-arid. Moreover, no rainfall was observed during the experiment period. Climatic variables (temperature ranges, relative humidity and rainfall) of the experimental area from last five year are given in Table 1. The net plot size was 6 m x 4.2 m keeping row to row distance of 75 cm and plant to plant distance of 30 cm. The crop was sown with a seed rate of 20 kg ha^{-1}. All other standard culture practices such as hoeing, irrigation and plant protection measures were kept for the growing crop. All the state of the art procedures and protocols were carried out to take the required data from the field. Procedure of Gardner *et al*. (1985) were used to calculate net assimilation rate and leaf area index.

Table 1: *Long term (from last 5 year) climatic data of experimental site.*

Years	Month	T_{max} (°C)	T_{min} (°C)	$T_{average}$ (°C)	RH (%)	Rainfall (mm)
2011	April	38.4	23.4	30.9	66.4	-
	May	44.9	27.3	36.1	60.2	0.4
	June	48.7	31.1	40	67.3	-
	July	45.3	33.2	39.25	68.4	0.5
	August	40.8	24.6	32.7	70.5	-
	September	36.2	22.9	29.55	72.1	0.6
2012	April	39.1	29.3	34.2	62.2	0.1
	May	45.3	34.2	39.75	58.3	-
	June	52.4	36.4	44.4	55.2	-
	July	44.3	33.7	39	67.3	0.4
	August	43.2	31.2	37.2	66.1	-
	September	38.4	26.3	32.35	73.4	-
2013	April	35.4	22.4	28.9	66.4	-
	May	45.9	28.3	37.1	60.2	0.3
	June	47.7	32.1	39.9	67.3	-
	July	44.3	34.2	39.25	68.4	0.7
	August	41.8	25.6	33.7	70.5	-
	September	37.2	21.9	29.55	72.1	0.8
2014	April	40.1	32.3	36.2	62.2	0.3
	May	46.3	33.2	39.75	58.3	-
	June	51.4	38.4	44.9	55.2	-
	July	45.3	33.7	39.5	67.3	0.2
	August	42.2	33.2	37.7	66.1	-
	September	37.4	27.3	32.35	73.4	-
2015	April	39.4	20.4	29.9	66.4	-
	May	46.9	28.3	37.6	60.2	-
	June	47.7	33.1	40.4	67.3	-
	July	44.3	36.2	40.25	68.4	0.1
	August	41.8	29.6	35.7	70.5	-
	September	37.2	25.9	31.55	72.1	-

T_{max}: maximum temperature; T_{min}: minimum temperature; $T_{average}$: average temperature; RH: relative humidity.

Statistical analysis

The collected data were analyzed statistically by employing Fisher's Analysis of Variance Technique (Steel *et al*., 1997) and treatment means were compared using Tukey's HSD test at a 5% probability level.

Results and Discussion

Phenological parameters

Number of days from planting to first floral bud initiation: The outcomes in Table 2 demonstrating that the planting date varied fundamentally for first floral bud inception and the maximum number of days (34.78) from planting to first flower bud commencement was recorded for Mid-April planted Bt. Cotton followed by April 30, mid - May, May30, June14 and 29, one by one. These increased April days were because of lower degree day aggregation in April than in May planting. Cultivars additionally altogether fluctuated for first flower bud inception and a higher number of days for a first floral bud (32.44) was recorded in cv. CIM-598 that was measurably at standard with cv. BH-184. The mean value for various long stretches of first botanical bud commencement for various cultivars for example cv. BH-184, cv. MNH-886 and cv. CIM-598 was 31.78, 31 and 32.44 days individually (Table 4). It has been accounted for that temperature was the primary factor for influencing crop improvement and inception of the principal square and its advancement was temperature and cultivar subordinate (Bilal *et al*., 2019; Ullah *et al*., 2019). It has been likewise revealed that botanical bud inception and development were influenced by photoperiod and commencement of squaring was utilized for the choice of early genotype (Godoy, 1994). Mid-March and April planting could be refered to a higher number of days for first flower bud inception when contrasted with May planting of cotton (Sarwar *et al*., 2012). Figure 1 uncovered the powerless positive regression connection (r^2=0.54) between days to first botanical bud inception and seed cotton yield kg ha^{-1}.

Number of days from planting to very first flower

The information relevant from days to initial flower as exhibited in Table 2, indicated the Mid April planting required additional days (63.78) from planting to absolute first blossom followed by April 30, May15and 30, June 14 and 29 separately. These additional days required for blossoming in April planting were because of low degree days amassing during April than May and June planting. This appearance of the absolute first blossom was photoperiod subordinate (Sarwar *et al*., 2012). The essential factor influencing crop advancement was the temperature (Bilal *et al*., 2019; Ullah *et al*., 2019). Among cultivars, the thing that matters was minor for a considerable length of time to the primary blossom (Table 4). Sarwar *et al*. (2012) revealed that mid-March planting took extra days for the primary blossom when contrasted with mid-May planting and days taken to absolute first bloom was not altogether changed with cultivars.

Table 2: *FFBH, NNFB, DFB, DFF, DFBO, BMP, LAI, LAD, TDM, CGR and NAR as affected by sowing dates and cultivars.*

Treatment	FFBH	NNFB	DFB	DFF	DFBO	BMP	LAI	LAD	TDM	CGR	NAR
Sowing dates											
15-Apr	24.96A	9.71A	34.78A	63.78A	111.11A	47.3A	4.15AB	264.70AB	1073.5A	5.98	3.62BC
30-Apr	24.22AB	9.07AB	33.89AB	62.44AB	106.33B	43.9AB	4.38A	275.86A	1033.99A	6.51	3.84AB
15-May	23.91ABC	8.53ABC	31.78ABC	61.44B	101.78C	40.3BC	3.87BC	263.83AB	901.93B	5.92	3.96A
30-May	23.44BC	7.76BCD	30.78BC	59.33BC	97.56D	38.2BC	3.64CD	244.31B	840.18B	5.51	3.31CD
14-Jun	22.91C	7.58CD	29.78C	55.80CD	93.00E	37.2C	3.55D	216.8C	783.49B	5.32	3.18D
29-Jun	22.82C	7.16D	29.44C	52.80D	87.67F	34.9C	3.48D	197.67C	726.76C	5.19	3.15D
HSD%	1.16	1.36	3.851	4.411	2.808	6.017	0.439	23.86	99.745	0.301	0.325
Cultivars											
BH-184	23.87	8.22	31.77AB	60.01	100.50	40.5	3.86A	243.2AB	893.59A	5.76	3.56
MNH-886	23.52	8.36	31.00B	59.39	99.22	39.8	4.00A	251.93A	927.58A	5.89	3.52
CIM-598	23.74	8.31	32.44A	58.40	99.00	40.6	3.68B	236.46B	858.78B	5.56	3.45
HSD%	ns	ns	1.209	ns	ns	ns	0.287	11.18	ns	0.05	ns

*Means sharing different letters differ significantly at $p \leq 0.05$. Significant changes are highlighted by an asterisk (*); *P ≤ 0.05, **P ≤ 0.01; ns: non-significant; *FFBH: First fruiting branch height(cm); NNFB: node number from first fruiting branch; DFB: Days taken to first floral bud initiation; DFF: Days taken to first flower; DFBO: Days taken to first boll opening; BMP: Boll maturation period (days); LAI: Leaf area index; LAD: leaf area duration (days); TDM: total dry matter (g); CGR: crop growth rate (g m^{-2} day^{-1}); NAR: Net assimilation rate (g m^{-2} day^{-1}).*

Table 3: *Plant height, sympodial, monopodial, opened bolls, average boll weight, 100-seed weight, seed cotton yield and Ginning out turn as affected by sowing dates and cultivars.*

Treatment	PH	Sympod	Monopod	O.B	ABW	100-SW	S.C.Y	GOT%
Sowing dates								
15-Apr	142.87A	23.84AB	2.47	35.2A	2.81B	6.78	3265.83AB	39.03AB
30-Apr	131.73B	25.49A	2.49	39.4A	2.78B	6.94	3681.09A	39.46A
15-May	124.04C	23.20AB	2.56	35.2AB	2.85AB	7.17	3310.83A	39.54A
30-May	107.78D	20.67BC	2.49	30.9BC	2.86AB	6.65	2871.62B	38.57AB
14-Jun	98.16E	18.84CD	2.53	27.8CD	2.91A	7.21	2236.64C	37.90AB
29-Jun	88.47F	15.73D	2.40	26.4D	2.82AB	6.84	1850.98C	37.38B
HSD%	5.64	3.813	ns	4.315	0.09	ns	438.37	2.07
Cultivars								
BH-184	116.40A	21.42	2.57A	32.1B	2.85B	7.04A	2867.85AB	38.68A
MNH-886	117.74A	21.92	2.62A	34.1A	2.89A	7.24A	3040.11A	39.47A
CIM-598	112.37B	20.54	2.28B	31.2B	2.78C	6.52B	2700.54B	37.79B
HSD%	2.24	ns	0.24	1.631	ns	0.41	221.35	0.89

*Means sharing different letters differ significantly at $p \leq 0.05$. Significant changes are highlighted by an asterisk (*); *P ≤ 0.05; **P ≤ 0.01; ns, non-significant; *PH: plant height (cm); Sympod: sympodials; monopod: monopodials; O.B: opened boll; ABW: Average boll weight (g); 100-SW: 100-seed weight (g); S.C.Y: Seed cotton yield (kg ha^{-1}) and GOT%: Ginning out turn.*

Figure 1 uncovered the solid positive regression relation (r^2=0.82) between days taken to initially bloom and seed cotton yield kg ha^{-1}.

Number of days from planting to first boll opening

From the perception in Table 2, it is clarified that 15 April planting needs more number of days (111.11) from planting to first boll opening than other planting dates. The higher number of days taken to boll opening in April planting was because of low degree day aggregation during April when contrasted with May and June planting. Cultivars demonstrated insignificant results (Table 4). Early developing cultivars opened their boll sooner than late-developed

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cultivars (Panhwar *et al*., 2002). Mid-March and April planting indicated more bolls from planting to first boll opening when contrasted with May planting and cultivars was not essentially differed for the quantity of days taken from planting to first boll opening (Sarwar *et al*., 2012). Figure 1 uncovered the solid positive regression relation (r^2=0.77) between days taken to first boll opening and seed cotton yield kg ha-1.

Boll maturation period (days)

From the information given in Table 2, it is uncovered that very boll development length significantly fluctuated with various planting dates while cultivars and collaboration discovered undistinguished. Maximun number of days (47.3) for boll development was recorded on April15 planting of cotton followed by April 30, May15and 30, June 14 and 29 individually. Sarwar *et al*. (2012) additionally found that cultivars and its connection demonstrated negligible outcomes and mid-March planting dates required additional days for boll development when contrasted with May planting. It has been accounted for that boll size and boll development period diminished as temperature increased (Reddy *et al*., 1999). Shrinking of bolls because of temperature brings about quick development. Figure 1 uncovered the positive regression realtion (r^2=0.59) between boll development and seed cotton yield kg ha^{-1} (Table 4).

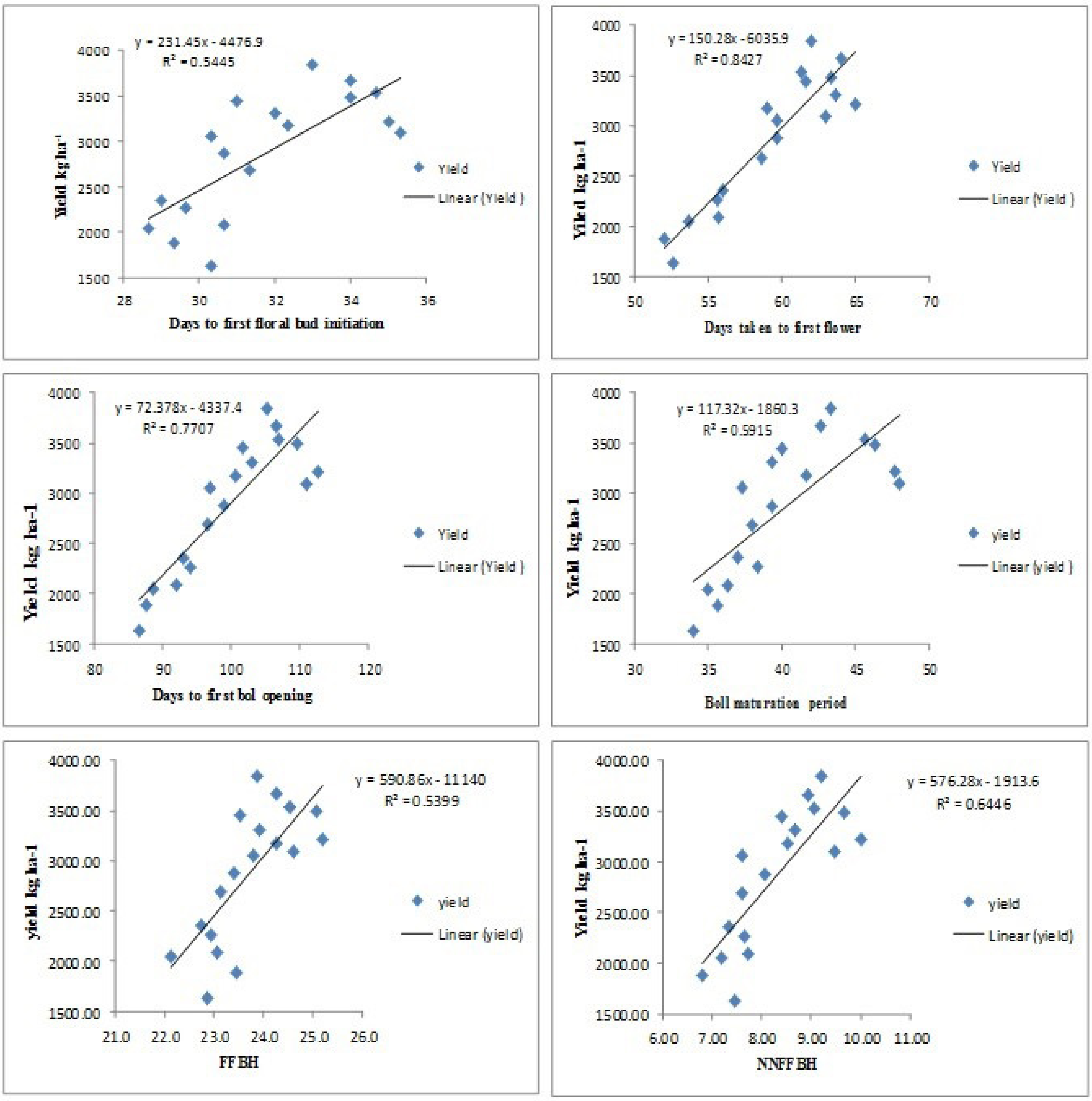

Figure 1: *Relationship of seed cotton yield with First fruiting branch height, node number from the first fruiting branch, days to first floral bud, days to first flower initiation, days to first boll opening and boll maturation period.*

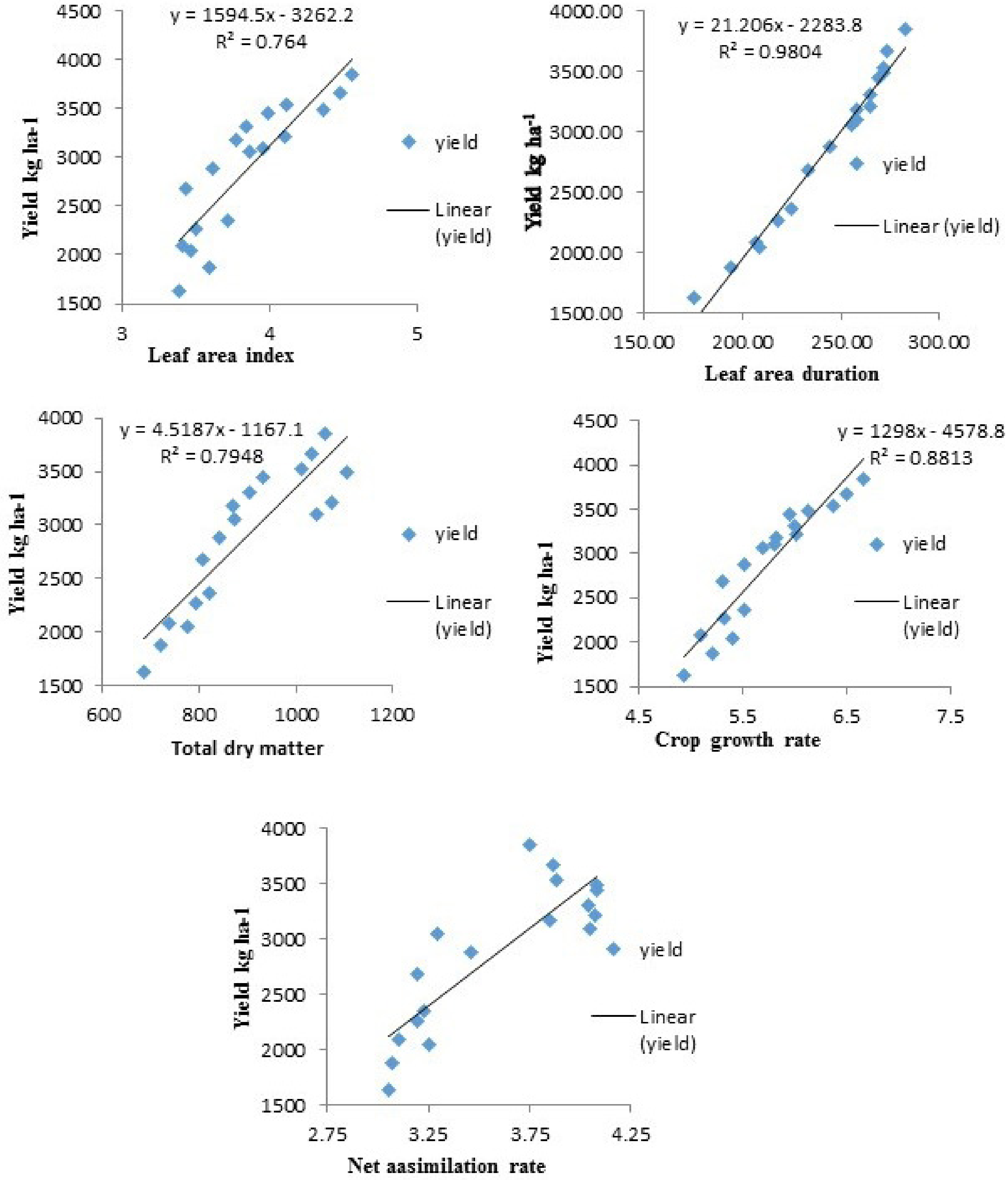

Figure 2: *Relationship of leaf area index, leaf area duration, Total dry matter, Crop growth rate and net assimilation rate with Seed cotton yield.*

Growth parameters

Leaf area index: Leaf area index is the fundamental physiological determinant of crop development and yield. Information introduced in Table 2 indicated that LAI fundamentally shifted during the season at various planting dates and cultivars. Highest LAI approached the estimation of (4.38) of April 30 planting. While for another situation of cultivars greatest LAI (4.00) was seen in cv. MNH-886 followed by cv. BH-184 and cv. CIM-598. Arshad *et al*. (2007) likewise revealed that LAI changed essentially at various planting dates and cultivars.

Fig.2 uncovered the solid positive regression relation (r^2=0.76) between leaf area index and seed cotton yield kg ha^{-1}. Due to rise in temperature speed of cell division is stifled so development of leaf is checked outcomes, which at last prompts decline in leaf area index (Table 4).

Total dry matter (g m^{-2})

The information interpreted in Table 2, exhibit that complete dry matter is clearly influenced by various planting dates and cultivars. On account of planting dates most extreme TDM (1073.5gm^{-2}) was seen of April 15 planting. TDM was fundamentally changed with cultivars and most extreme TDM (927.58 g m-2) was seen in cv. MNH-886 followed by cv. BH-184 and cv. CIM-598. Bilal *et al.* (2019) and Ullah *et al.* (2019) saw that all out dry matter was fundamentally shifted with planting dates and cultivars and their connection likewise demonstrated enormous outcomes. Iqbal (2010) observed that complete dry matter amazingly changed with various planting dates and cultivars and early planting have more absolute dry matter aggregation. Figure 2 uncovered the solid positive regression relation (r^2=0.79) between all out dry issue and seed cotton yield kg ha^{-1}. Leaf area index which is in this manner subject to temperature likewise influence complete dry matter. Lower the leaf area index lower is the complete dry matter.

Leaf area duration (days)

The experimental values in Table 2, indicating that leaf area duration quite fluctuated at various planting dates and cultivars while the connection was found non-critical. Highest LAD (275.86) was observed in 30 April planting of cotton. The mean estimation of the leaf area span at various planting dates for example April 15 and 30, May 15 and 30, June 14 and 29 was 264.70, 275.86, 263.83, 244.31, 216.8 and 197.67 individually. Most extreme LAD was seen in MNH-886 followed by BH-184 and CIM-598. The mean estimation of leaf area span for cultivars for example BH-184, MNH-886 and CIM-598 were 243.2, 251.93 and 236.46, individually. Another investigation revealed that the LAD of cotton crops changed essentially with various planting dates and cultivars (Arshad *et al.*, 2007). He saw that early planting demonstrated more leaf area span when contrasted with the late planting of cotton. This is a direct result of ideal temperature and expanded number of developing days. The higher temperature invigorates quick fruition of vegetation cycle. Figure 2 uncovered the solid positive regression relation (r^2=0.98) between leaf region span and seed cotton yield kg ha^{-1}. It unmistakably portrays the reliance of cotton yield on leaf area index.

Crop growth rate (g m^{-2} day^{-1})

The crop development rate is on the basic pointer of development during various time cuts of the yield season. Perceptions in Table 2 clarify that the relation of planting dates and cultivars for mean CGR was critical. Highest mean CGR was seen in MNH-886 (6.65gm-2day-1) at April 30 planting of cotton followed by BH-184 and CIM-598 separately. Iqbal (2010) detailed that mean CGR was essentially influenced by planting dates and cultivars and their interactions. He additionally found that early planting had indicated a higher estimation of mean CGR when contrasted with the late planting of cotton. Figure 2 uncovered the solid positive regression relation (r^2=0.88) between crop development rate and seed cotton yield kg ha^{-1}which was additionally announced by Iqbal (2010). Ideal temperature favors increased growth rate of cotton and supports the planting of the harvest at the ideal time (Table 4).

Net assimilation rate (g m^{-2} day^{-1})

The information presented in Table 2, advising that the net integration rate apparently varied at various planting dates while cultivars and association were discovered unremarkable. The highest estimation of NAR (3.96gm-multi/day) was watched on May 15 planting of Bt. cotton followed by April 30 and 15, May 30, June 14 and 29 while least NAR (3.15 g m-multi day-1) was seen on June 29 planting of Bt. Cotton. It has been accounted for that NAR scarcely changed with various planting dates and cultivars (Arshad *et al.*, 2007). Bilal *et al.* (2019) found that the individual and joint impact of planting dates and cultivars for net absorption rate was minor. Figure 2 uncovered the solid positive regression relation (r^2=0.72) between net incorporation rate and seed cotton yield kg ha^{-1} (Table 4).

Yield related parameters

Plant height (cm): It is discovered from the information in Table 3 that plant tallness influenced essentially by various planting dates and cultivars while interaction indicated insignificant outcomes (Table 5). Maximum plant height (142.87cm) was seen of April 15 while least plant height (88.47 cm) was recorded of June 29 sowing of Bt. Cotton, while on account of cultivars, highest plant height (117.74 cm) was seen in MNH-886 that was measurably at standard with BH-184. It has been seen that early planting of cotton demonstrated most extreme plant height than the late planting of cotton because of a more drawn out term accessible for the solid development of cotton crop (Bilal *et al*., 2019). Cotton plant height was influenced by various cultivars and indicated critical outcomes that were comparative and have been accounted for by (Ehsan *et al*., 2008; Bilal *et al*., 2019). Growth potential and yield of cultivars relies upon the genetic makeup of the cotton cultivars.

Number of plants per plot

The information from Table 3, showing that the intuitive impact of planting dates and cultivars have a significant outcome. At early planting, every variety demonstrated more number of plants per plot when contrasted with late planting. On April 15, planting maximum number of plants 103.3 was seen with MNH-886 and at 29 June less number of plants (68) was seen in CIM-598. It has been accounted for that various plants per plot demonstrated significant contrasts (Table 5) among both planting dates and cultivars and these outcomes were steady with the discoveries of Arshad *et al*. (2007). Early planting favors the plant germination and formative help. Along these lines, plants had more appropriate time in less harsh atmosphere in early planting. While in late planting, plants couldn't grow and stand well in harsh temperature condition.

Number of monopodial branches per plant

The data laid out in in Table 3, shows that monopodial branches changed essentially by various cultivars while planting dates and cooperation was found non-significantly. Among three cultivars MNH-886 produced the most extreme number of monopodial branches (2.63) that is factually at standard with BH-184 while CIM-598 delivered a base number of monopodial branches (2.23). It has been accounted for that the quantity of monopodial branches was altogether influenced by various cultivars (Ullah *et al*., 2019; Bilal *et al*., 2019; Sarwar *et al*., 2012).

Number of sympodial branches per plant

The indicated values in Table 3, clarify that number of sympodial branches altogether contrasted by various planting dates while assortments and interaction were found non-critical. The maximum estimation of sympodial branches saw on 30th April planting of that was factually at standard with 15 April and 15 May planting of Bt. Cotton while least sympodial branches were recorded on June 29, planting. It has been accounted for that early planting of cotton in March and April delivered more sympodial branches than late planting because of ideal temperature at early development phases of cotton (Ullah *et al*., 2019; Bilal *et al*., 2019).

Opened bolls number per plant

From the given information in Table 3, it is seen that planting dates and cultivars significantly affect the number opened of bolls per plant of cotton while the connection was found non-significant. Most extreme opened bolls were seen in 30 April planting of cotton because of ideal natural conditions followed by April 15, May 15 and 30, June 29 and 14, individually. The mean an incentive for the quantity of opened bolls per plant of cotton at various planting dates was 35.2, 39.37, 35.15, 30.88, 27.78 and 26.43 separately. Arshad *et al*. (2007) detailed that early planting of cotton delivered more number of opened bolls that was because of ideal natural condition. The mean an incentive for opened of bolls per plant for various cultivars for example MNH-886, BH-184 and CIM-598 were 34.08, 32.13 and 31.19, individually. Bilal *et al*. (2019) and Ullah *et al*. (2019) likewise saw that the quantity of opened bolls per plant essentially varied by cultivars.

Average boll weight (g)

Table 3 shows that highest boll weight was seen on June14 followed by May 30 and 15, June 29, April 15 and 30 respectively. The mean estimation of normal boll weight for various planting dates was (2.81, 2.78, 2.85, 2.86, 2.91 and 2.82) separately. While, on account of cultivars normal boll weight quite differed (Table 5). The most extreme boll weight was recorded with MNH-886 followed by BH-184 and CIM-598. The mean an incentive for cultivars for example BH-184, MNH-886 and CIM-598 were (2.85, 2.89 and 2.78). It has been accounted for that season assumes a significant role in cotton production and uncommonly boll weight and results indicated that maximum boll weight was gotten between 1st May to 15 June planting of cotton while early and late planting of cotton decreased boll weight (Rahman *et al*., 2019). It has been accounted for that the boll weight of cotton plants was fundamentally varied with various cultivars because of various genetic makeups. These outcomes were like the discoveries of (Hebbar *et al*., 2007; Arshad *et al*., 2007).

Table 4: *Analysis of variance of FFBH, NNFB, DFB, DFBO, BMP, LAI, LAD, TDM, CGR and NAR.*

SOV	DF	FFBH	NNFB	DFB	DFF	DFBO	BMP	LAI	LAD	TDM	CGR	NAR
Rep	2	0.5511	1.4044	9.148	1.59	42.48	57.37	0.2991	126.3	208613	0.0279	0.04248
Sd	5	30.1600**	42.8511**	215.037*	805.26**	3354.54**	948.76**	5.7934**	42504.3**	854774**	10.9381**	5.40451**
Error Rep × Sd	10	5.0222	6.9378	55.519	72.85	29.52	135.52	0.7219	2135.3	37236	0.1302	0.39641
Cv	2	1.0978ns	0.1911ns	18.815*	23.81	23.59ns	6.37ns	0.8884*	2166.2**	42069*	1.0095**	0.10618ns
Sd × Cv	10	4.5022ns	1.7644ns	1.185ns	33.96	24.41ns	38.52ns	0.2675ns	240.8	2775ns	0.1172*	0.18831ns
Error Rep × Sd × Cv	24	9.2800	13.0311	50.667	190.89	366.670	663.11	2.8576	4328.2	63727	0.1170	0.66424
Total	53	50.6133	66.1800	350.370	1128.37	3841.20	1849.65	10.8279	51501.4	1209735	20849.4	6.80213

*Means sharing different letters differ significantly at $p \leq 0.05$. Significant changes are highlighted by an asterisk (*); *P ≤ 0.05, **P ≤ 0.01; ns, non-significant. *FFBH: First fruiting branch height(cm); NNFB: node number from first fruiting branch; DFB: Days taken to first floral bud initiation; DFF: Days taken to first flower; DFBO: Days taken to first boll opening; BMP: Boll maturation period (days); LAI: Leaf area index; LAD: leaf area duration (days); TDM: total dry matter (g); CGR: crop growth rate (g m^{-2} day^{-1}); NAR: Net assimilation rate (g m^{-2} day^{-1}).*

Table 5: *Analysis of variance of plant height, sympodial, monopodial, opened boll, average boll weight, 100-seed weight, seed cotton yield and ginning outturn.*

SOV	DF	PH	Sympod	Monopod	O.B	ABW	100-SW	S.C.Y	GOT%
Rep	2	142.9	40.825	0.12111	13.23	0.00173	0.9775	199811	2.518
Sd	5	19567.7**	585.446**	0.13333ns	1110.38**	0.08948*	2.2407ns	2.20×10^7**	34.054**
Error Rep × Sd	10	119.0	54.435	1.03889	69.69	0.03253	2.2088	719239	16.055
CV	2	271.7**	17.513ns	1.23111**	78.18**	0.09901**	4.7721**	1037794*	25.529*
Sd × Cv	10	45.4ns	31.847ns	0.68889ns	10.94ns	0.00952	2.6506ns	50915.4ns	10.577ns
Error Rep × Sd × Cv	24	173.5	14.573	1.96000	92.10	0.06300	5.7344	1696195	27.033
Total	53	20320.1	871.639	5.17333	1374.51	0.29528	18.5841	2.574×10^7	111.034

*Means sharing different letters differ significantly at $p \leq 0.05$. Significant changes are highlighted by an asterisk (*); *P ≤ 0.05, **P ≤ 0.01 ns, non-significant. *PH: plant height (cm); Sympod: sympodials; monopod: monopodials; O.B: opened boll; ABW: Average boll weight (g); 100-SW: 100-seed weight (g); S.C.Y: Seed cotton yield (kg ha^{-1}) and GOT%: Ginning out turn.*

100-cotton seed weight (g)

Cultivars showed incredible changes for 100-cotton seed while planting dates and connection were discovered immaterial. The highest estimation of 100-cotton seed weight (7.24g) was seen in MNH-886 that was measurably at standard with BH-184. The mean value for cultivars i.e.BH-184, MNH-886 and CIM-598 were 7.02, 7.24 and 6.52g, individually (Table 3). It has been accounted for that 100-seed weight essentially contrasted by various cultivars. Bilal *et al.* (2019) likewise found that cultivars had altogether influenced by cotton seed weight. Arshad *et al.* (2007) likewise detailed that planting dates and cultivars strikingly altered for 100-cotton seed weight. These outcomes are predictable with the after effects of Hebbar *et al.* (2007) and Bilal *et al.* (2019).

Seed cotton yield (kg ha^{-1})

The information in Table 3 uncovered that seed cotton yield considerably varied with various planting dates and cultivars while the interaction was found non-noteworthy. Greatest seed cotton yield was gotten on April 30 followed by April 15, May15and 30, June 14 and 29 individually. The mean value of seed cotton yield for various planting dates was 3265.83, 3681.09, 3310.83, 2871.68, 2236.6 and 1851kgha^{-1} separately. Higher seed cotton yield was produced from the prior planted cotton crop (Bilal *et al.*, 2019). Planting of cotton from ahead of schedule to mid of May gave more seed cotton yield (Ullah *et al.*, 2019; Bilal *et al.*, 2019; Rahman *et al.*, 2019).

Seed cotton yield unmistakably differed with different cultivars and highest seed cotton yield was produced by MH-886 that was factually at with BH-184. The mean estimation of seed cotton yield for various cultivars for example BH-184, MNH-886 and CIM-598 were 2867.8, 3040.05 and 2700.5kgha^{-1}. Rahman *et al.* (2016) announced that seed cotton yield was essentially varied by various planting dates and May planting of cotton delivered most extreme yield when contrasted with April and July planting. It has been accounted for that cultivars and planting dates have fundamentally influenced seed cotton yield and their association additionally indicated critical outcomes. In late planting of cotton and the yield was diminished because of a brief period for fruiting than typical planting of cotton (Ullah *et al*., 2019; Bilal *et al*., 2019; Rahman *et al*., 2018).

Conclusions and Recommendations

Cotton cultivars grown before April 15 demonstrated late germination with feeble seedlings. While the cultivars planted in the mid season for example April 30 demonstrated ideal production in dry atmosphere of Bahawalpur. Though later planting of cotton during extraordinary hot conditions of June influences adversely both the yield just as phenology of the harvest. Also, unique cotton varieties showed various yields relying upon their genetics qualities under different atmosphere settings. For dry atmosphere MNH-886 planted on April 30 outflanked than different cultivars.

Novelty Statement

Cotton is a major field crop and it is cultivated for fiber and oil purpose. There are lot of studies on late sowing of cotton but very rare on early sowing of cotton and with different cultivars.

Author's Contribution

KMRM, RI, MI, UR, got the idea, managed overall article development, collected observed data. MHR, FA, AN, MS, gave specialized support, facilitated the experimental work provided supervisory help at every phase of research. JS, AW, MTK, MA organized write-up and performed data analysis as well as offered technical writing assistance.

Conflict of interest

The authors have declared no conflict of interest.

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