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Effect of sowing time on productivity and profitability of Bt and non Bt cotton in climate change situation

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Introduction

- Impact of climate change on cotton crop is gaining momentum because of national economy and providing livelihood security to 60 million people (Sankaranarayanan et al.,2010)

- Analysis of long term weather data of Tamil Nadu found that the minimum temperature has increased significantly in Coimbatore. South-west monsoon has decreased with decreased dispersion while north-east monsoon has increased with increased dispersion (Jayakumara Varadan et al., (2017)

- Cotton plant unlike rice and wheat possesses narrow range of ecological adoptability and is very much influenced by the climatic conditions and sowing seasons (Bradow and Davidonis, 2000).

Objective

- To retesting of optimum times of sowing (15^{th} August) periods under climate changed condition for winter irrigated cotton .

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Climate change and its impact on cotton (*Gossypium* sp.)

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ABSTRACT

The earth temperature has increased by 0.74°C during the last century (1906 to 2005) due to increase in greenhouse gases through anthropogenic emissions as reported by IPCC. Thus, the increase in temperature is likely to be 1.8–4.0°C by the turn of 21st century resulting in anticipated greater instability in food, feed and fibre production. Increase in temperature can reduce crop duration, change pest populations, hasten mineralization in soils and increase evapotranspiration. It is reported that 40 and 50% less biomass is anticipated in cotton (*Gossypium* sp.) at 20/10°C and 40/30°C, respectively, with optimum temperature of 30/20°C. However, increase in atmospheric CO_2 increases the quantum of yield produced photosynthetically, net photosynthesis, biomass production and ultimate output. Besides higher output, increasing inputs-use efficiency in cultivated crops is also realized and the same at much greater pace in C_3 plants (cotton). Study showed that increase in seed cotton yield up to 43% was realized at elevated CO_2 of 550 ppm throughout the crop-growing period. Severe sucking pest problem and dominance of weeds are expected in cotton. Thus, in total, elevated CO_2 favours cotton growth and yield but higher temperature influences these negatively. The effect of climate change on national cotton production system interpreted that increasing CO_2 concentration could help to increase cotton production in all the 3 zones. However, increasing precipitation with decreasing temperature may prolong the vegetative growth and extend the crop duration, which pose difficulties in timely sowing of succeeding *rabi* crops in north zone. The expected increasing of temperature, decreasing rainfall with erratic distribution in central and south zone leads to frequent wet and dry spell with high evapotranspiration demands. Prolonged dry spell during critical crop growth periods may affect yield. The projected waterlogging coupled with drought by increasing intensity of rainfall may further induce reddening in *Bt* cotton. Shortening of crop growth periods induced by increasing temperature may facilitate to fit cotton crop into rice (*Oryza sativa* L.)–fallow cotton system in south zone.

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ORIGINAL PAPER

An exploratory study on occurrence and impact of climate change on agriculture in Tamil Nadu, India

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Abstract This study has been undertaken to examine the occurrence of climate change in Tamil Nadu, the southernmost state of India and its impact on rainfall pattern which is a primary constraint for agricultural production. Among the five sample stations examined across the state, the minimum temperature has increased significantly in Coimbatore while the same has decreased significantly in Vellore whereas both minimum and maximum temperatures have increased significantly in Madurai since 1969 with climate change occurring between late 1980s and early 1990s. As a result, the south-west monsoon has been disturbed with August rainfall increasing with more dispersion while September rainfall decreasing with less dispersion. Thus, September, the peak rainfall month of south-west monsoon before climate change, has become the monsoon receding month after climate change. Though there has been no change in the trend of the north-east monsoon, the quantity of October and November rainfall has considerably increased with increased dispersion after climate change. On the whole, south-west monsoon has decreased with decreased dispersion while north-east monsoon has increased with increased dispersion. Consequently, the season window for south-west monsoon crops has shortened while the north-east monsoon crops are left to fend against flood risk during their initial stages. Further, the incoherence in warming, climate change and rainfall impact seen across the state necessitates devising different indigenous and institutional adaptation strategies for different regions to overcome the adverse impacts of climate change on agriculture.

1 Introduction

Earth's temperature has been relatively constant over many centuries as the incoming solar energy was nearly in balance with outgoing radiation. But after 1750, the unscrupulous industrial emissions and pollutants have altered the energy balance of atmosphere by absorbing the outgoing radiation and made the Earth warmer by 0.85 °C. This trend is going to aggravate as the annual mean surface air temperature is projected to rise up to 3.7 °C by the end of this century based on different Representative Concentration Pathway (RCP) Scenarios (IPCC 2013).

The regional pattern of the observed temperature parameters also substantiates the unequivocal warming. The annual mean temperature over Canada has increased by about 1.5 °C during 1950–2010 accentuated more by the minimum temperature than the maximum temperature, seasonally the greatest warming occurring in winter (Vincent et al. 2012). Contrarily, warming over Mexico was more generalized in maximum temperature than in minimum temperature and in summer than in other seasons (Pavia et al. 2009; Peralta-Hernandez et al. 2009). On the other hand, both the minimum and maxi-

MATERIALS AND METHODS

Place & year of Research	Central Institute for Cotton Research, Coimbatore, Tamil Nadu Fall season (August to February) 2014-15, 2015-16 and 2016-17.
Soil particulars	Clay loam in texture, low in available N (175 kg/ha), medium in available P (14 kg/ha) and high in available K (532 kg/ha) with a pH 8.6 and EC 0.3 dSm^{-1}
Nutrient application	Basal dose of 45 kg of N, 45 kg of P_2O_5 and 45 kg of K_2O per hectare and 45 kg of N per ha - top dressed
Spacing	Mallika BGII (90 X 60 cm) Suraj non Bt (75 X 45 cm)
Fibre quality parameters	HVI, Statex- Fibrotex model
GDD	GDD(^oC) = ((Maxi. Temp.(^oC) + Min.Temp. (^oC))/2)-15.5)
RTD	RTD= ((Max.temp. (^oC) – Min.Temp.(^oC))/ Max. temp. (^oC)) x 100.
RHD	RHD = ((Morning RH (%) – Evening RH (%))/Morning RH (%)) x 100

Effect of sowing time on productivity and profitability of Bt and non Bt cotton in climate change situation

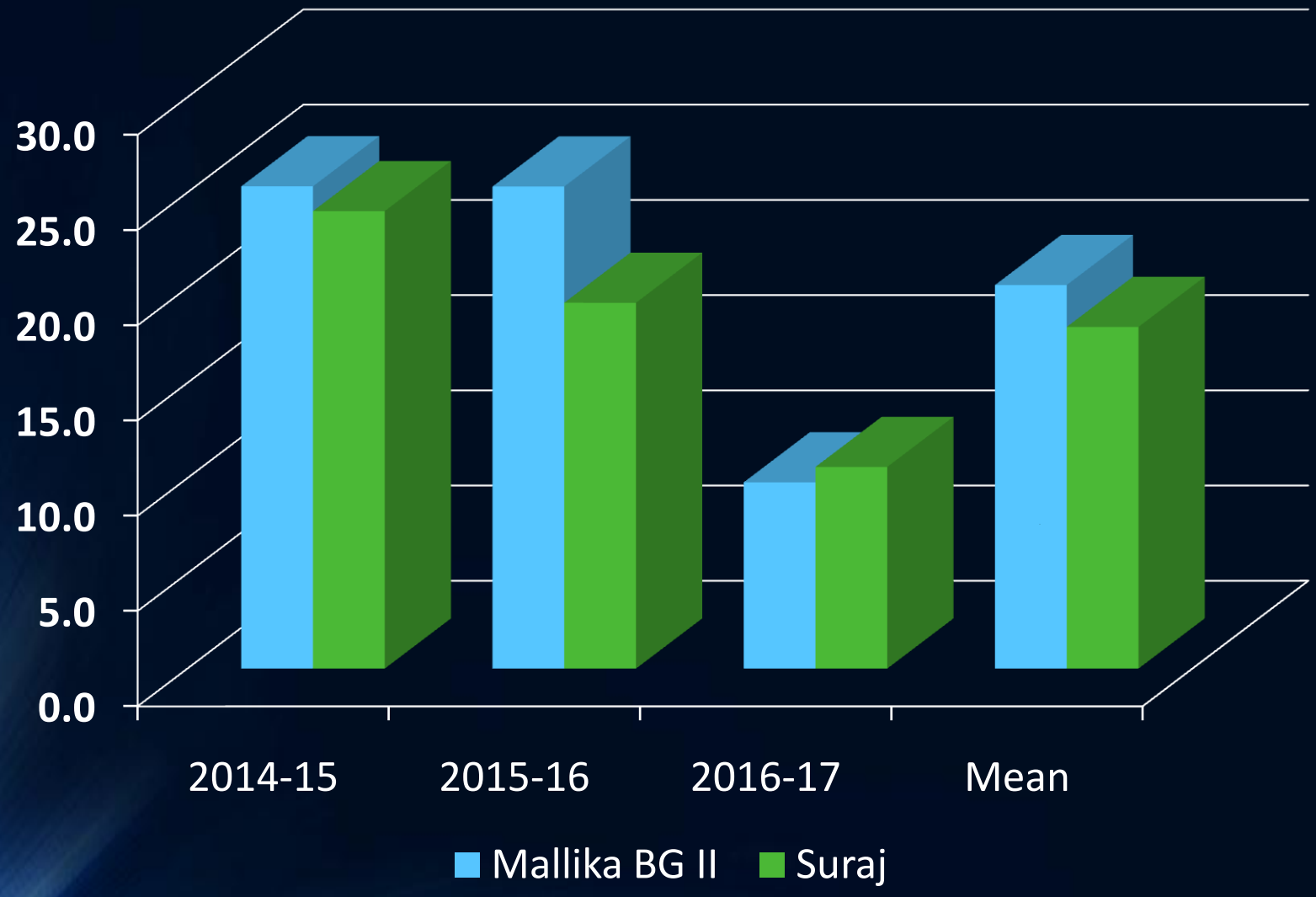
- Retesting of optimum times of sowing periods under climate changed condition for winter irrigated cotton .
- To identify the weather parameters which influences Seed Cotton Yield

Dates of sowing	Genotypes
D1 – 21st July D2 – 28th July D3 – 4th August D4 – 11th August D5 – 18th August D6 – 25th August D7 – 1st September D8 – 8th September D9 – 15th	Mallika BG II & Suraj

Results and Discussion

- Significantly highest mean no of bursted bolls (24.0) and boll weight (4.5g) with Mallika BG II. Suraj recorded respectively of 16.2 and 4.1g of number of busted bolls and boll weight.
- Boll weight was not influenced significantly by dates of sowing
- Significantly highest mean number of bursted bolls (25.4) recorded with 28th July sowing
- Seed cotton levels was differed with different cropping years (2014-15, 2015-16 &2016-17) and poor performance was noticed especially with 2016-17.
- Seasonal rainfall received in first 60 days of crop growth were 184 and 94.3 mm for 2014-15 and 2015-16 respectively as well influenced positively towards better crop growth. High performing sowing treatment received 12.2 mm of rainfall only up to 60 days of growth in the year of 2016-17

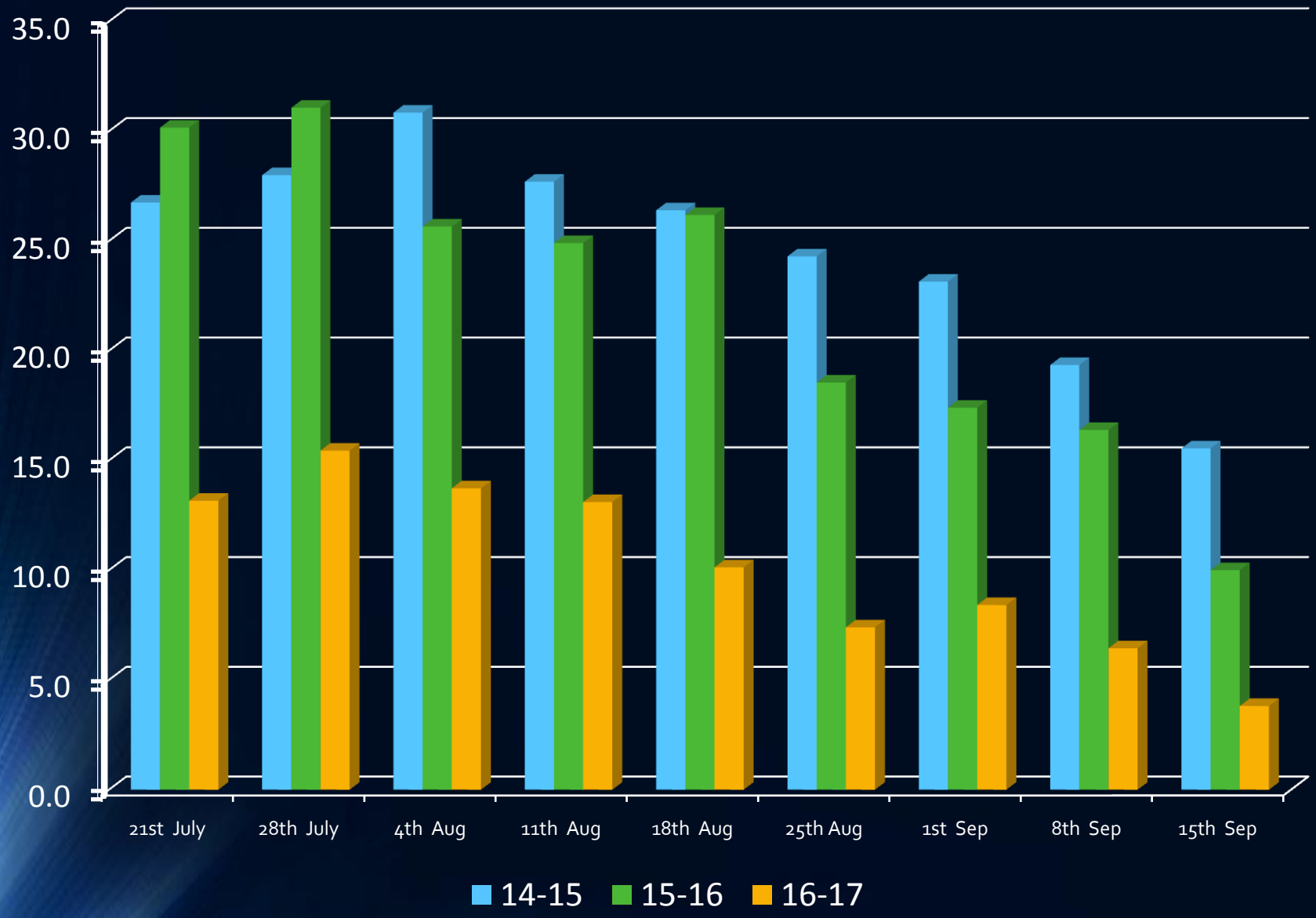
Seed cotton yield (q/ha) of genotypes in different years



Year to Year variation in seed cotton yield (q/ha)

Parameters	2014-15	2015-16	2016-17	CV(%)
Yield (q/ha)	30.85	31.07	15.45	34.7
Max	30.5	31.3	32.0	2.4
Min	22.2	23.0	22.5	1.9
RHI	95.2	87.5	85.7	5.6
RH II	59.5	55.6	54.2	4.9
SSH	765.0	859.8	831.5	5.9
RF	**508.9**	**351.4**	**134.7**	**56.6**
GDD	1325.6	1517.1	1527.4	7.8
RTD	3308.2	3435.3	3831.7	7.7
RHD	4046.7	4773.9	4823.7	9.6
ETC	173.8	222.6	247.1	17.4

Seed cotton yield (q/ha)



- Seed cotton yield was not influenced significantly by genotypes in 2014-15, 2016-17 and pooled data also. However Mallika BG II recorded the significantly highest yield than Suraj in 2015-16

- Sowing on 4th August (30.9q/ha) registered significantly highest seed cotton yield in 2014-15 which was on par with 28th July(28.0q/ha), 21st July (26.8q/ha), 11th August(27.7q/ha), 18th August(26.4q/ha) and 25th August (24.3q/ha)

- In 2015-16 , 28th July sowing(31.07q/ha) registered significantly highest seed cotton yield which was on par with 21st July (30.17q/ha),4th August(25.66q/ha),and 18th August(26.19q/ha)

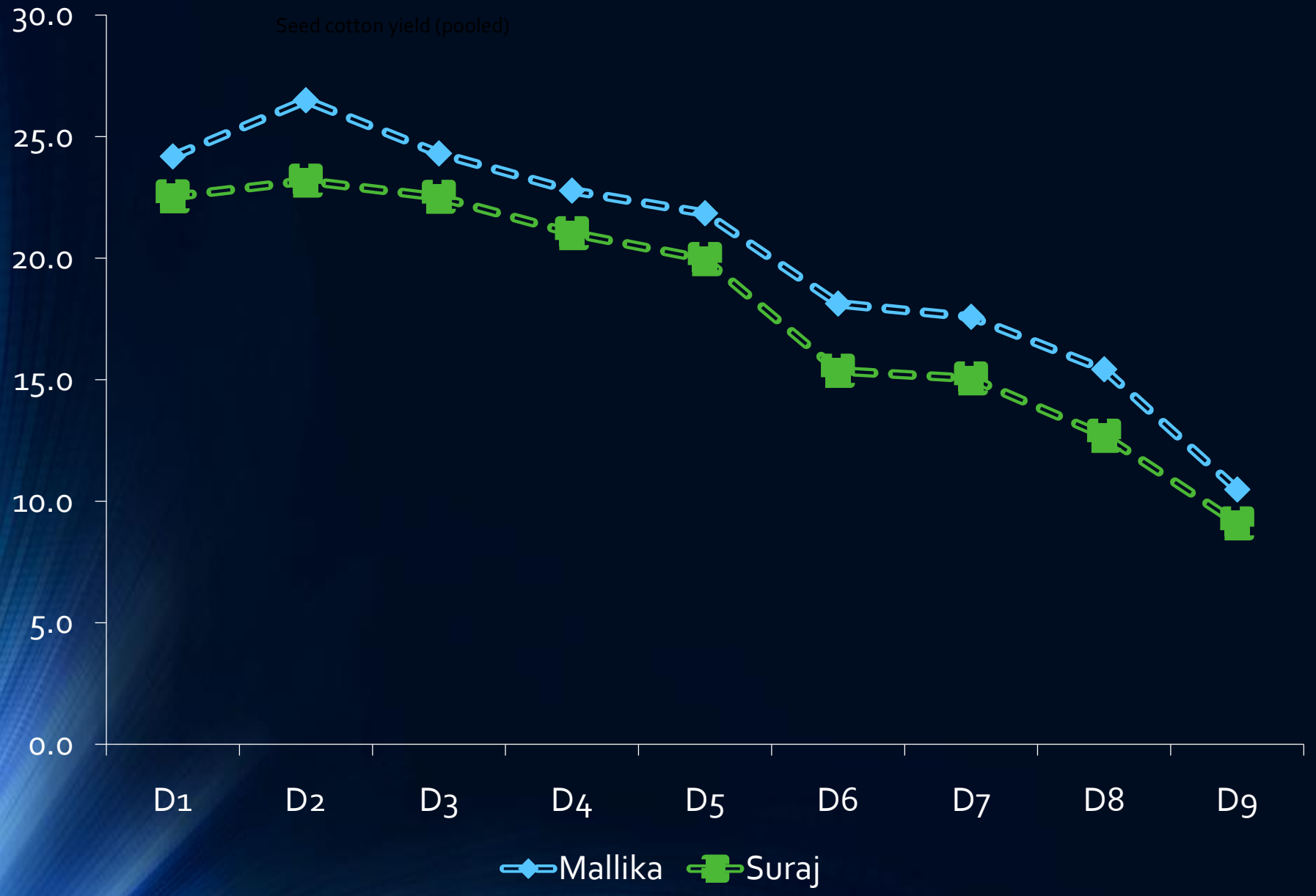
- Similar trend of 2015-16 was observed in 2016-17 and the results of pooled data also.

Mean Seed cotton yield (Kg/ha) influenced by Genotypes and Sowing Dates

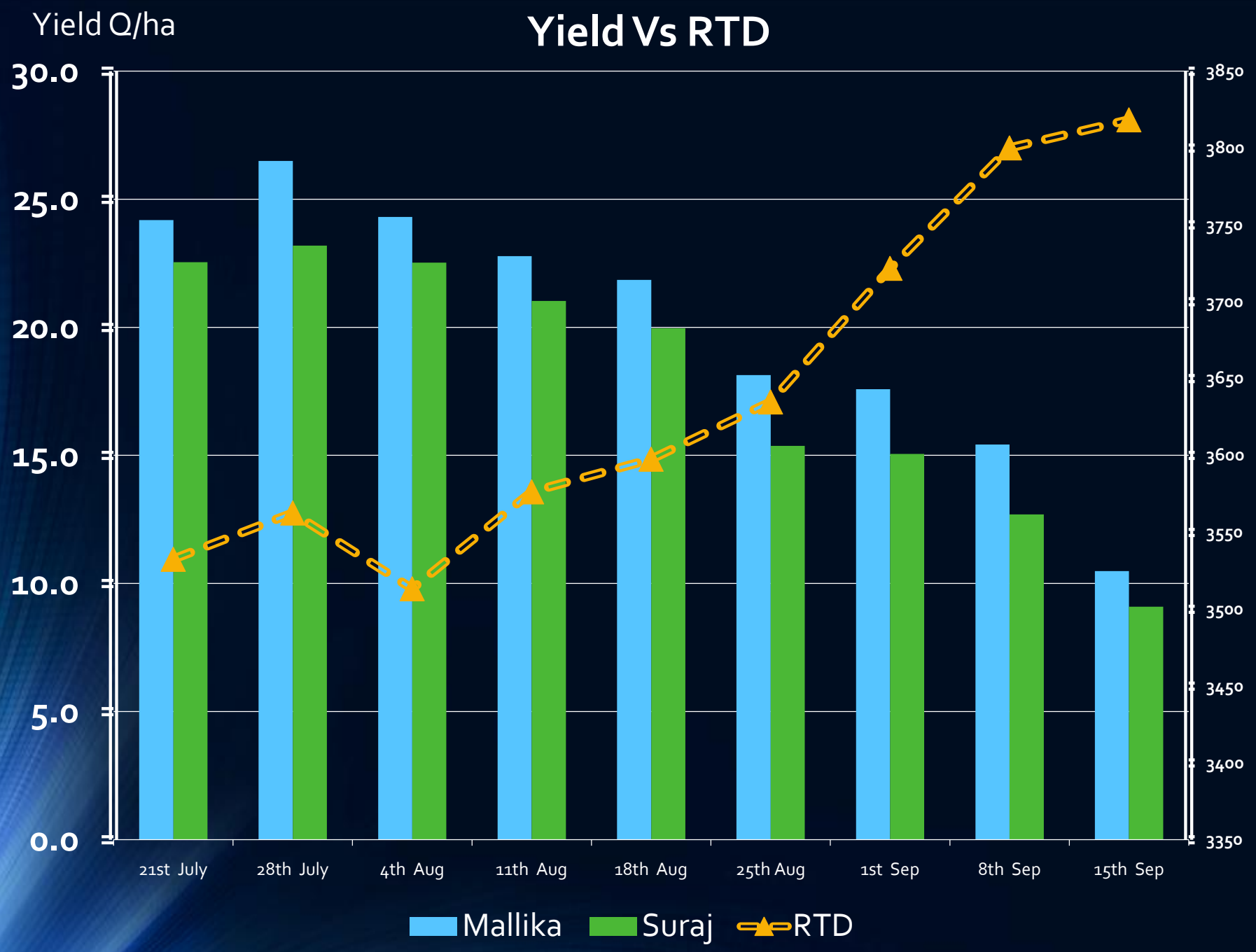
Date of sowing	Mallika	Suraj	Mean
D1 – 21st July	**24.2**	**22.5**	**23.4**
D2 – 28th July	**26.5**	**23.2**	**24.8**
D3 – 4th August	**24.3**	**22.5**	**23.4**
D4 – 11th August	**22.8**	**21.0**	**21.9**
D5 – 18th August	**21.8**	**20.0**	**20.9**
D6 – 25th August	18.1	15.4	16.7
D7 – 1st September	17.6	15.1	16.3
D8 – 8th September	15.4	12.7	14.1
D9 – 15th September	10.5	9.1	9.8
Mean	20.1	17.9	10.8

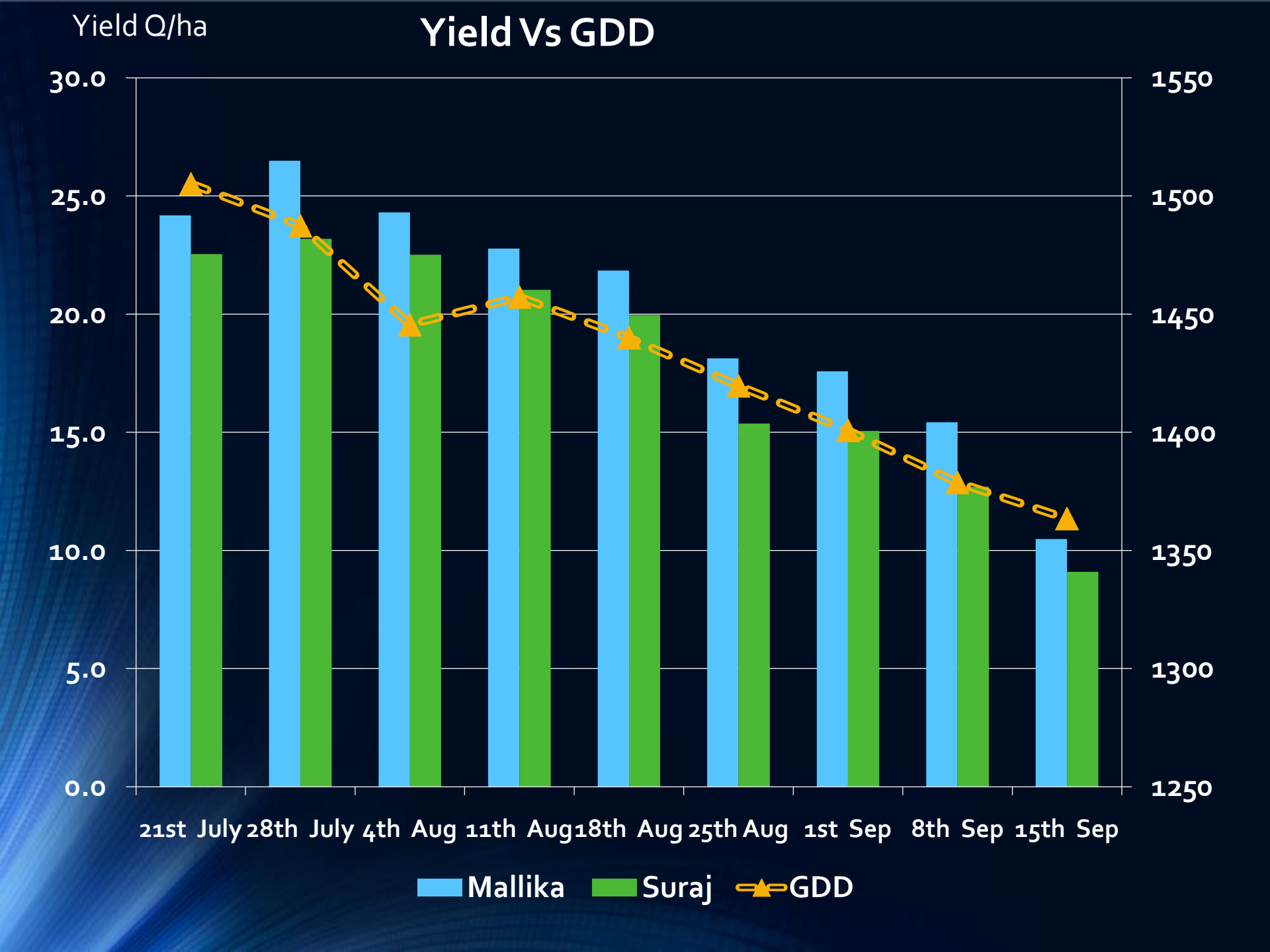
Anova	DOS x Geno	Genotypes	DOS
S. Ed	3.5	1.2	2.5
CD (0.05)	7.1	2.4	5.2
NS/S	NS	NS	S

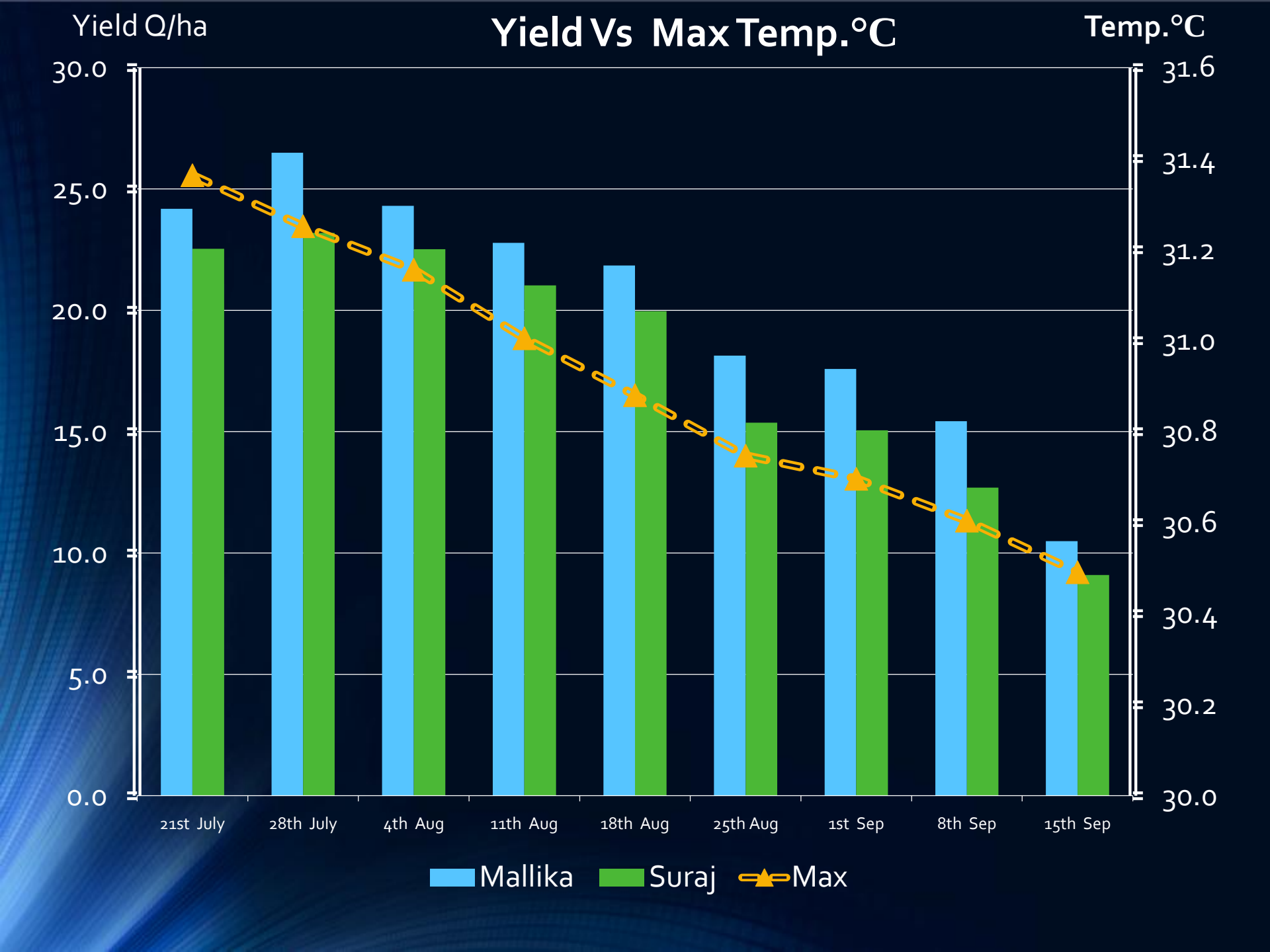
Mean seed cotton yield (q/ha) at different dates of sowing

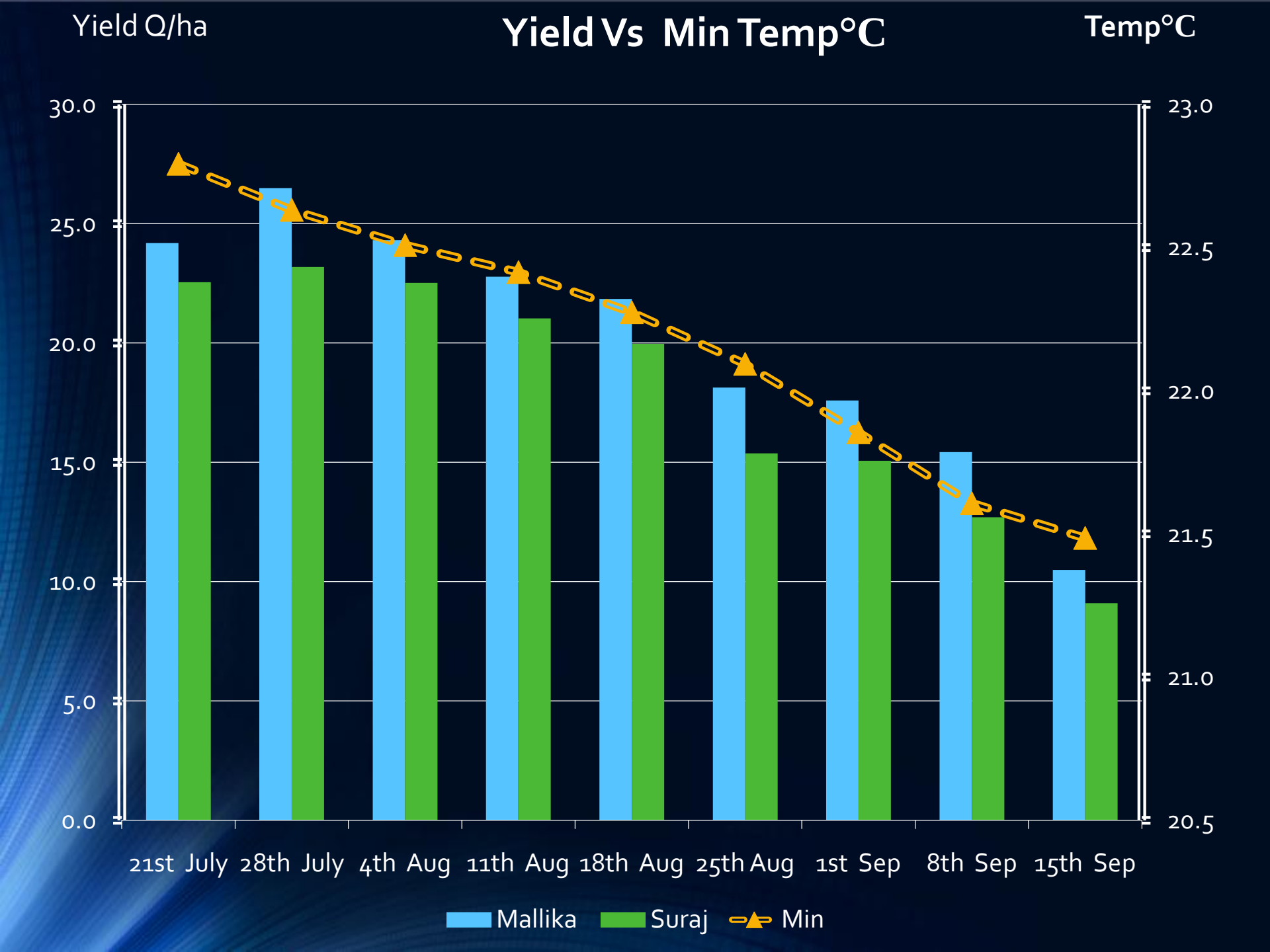


Yield Vs RTD

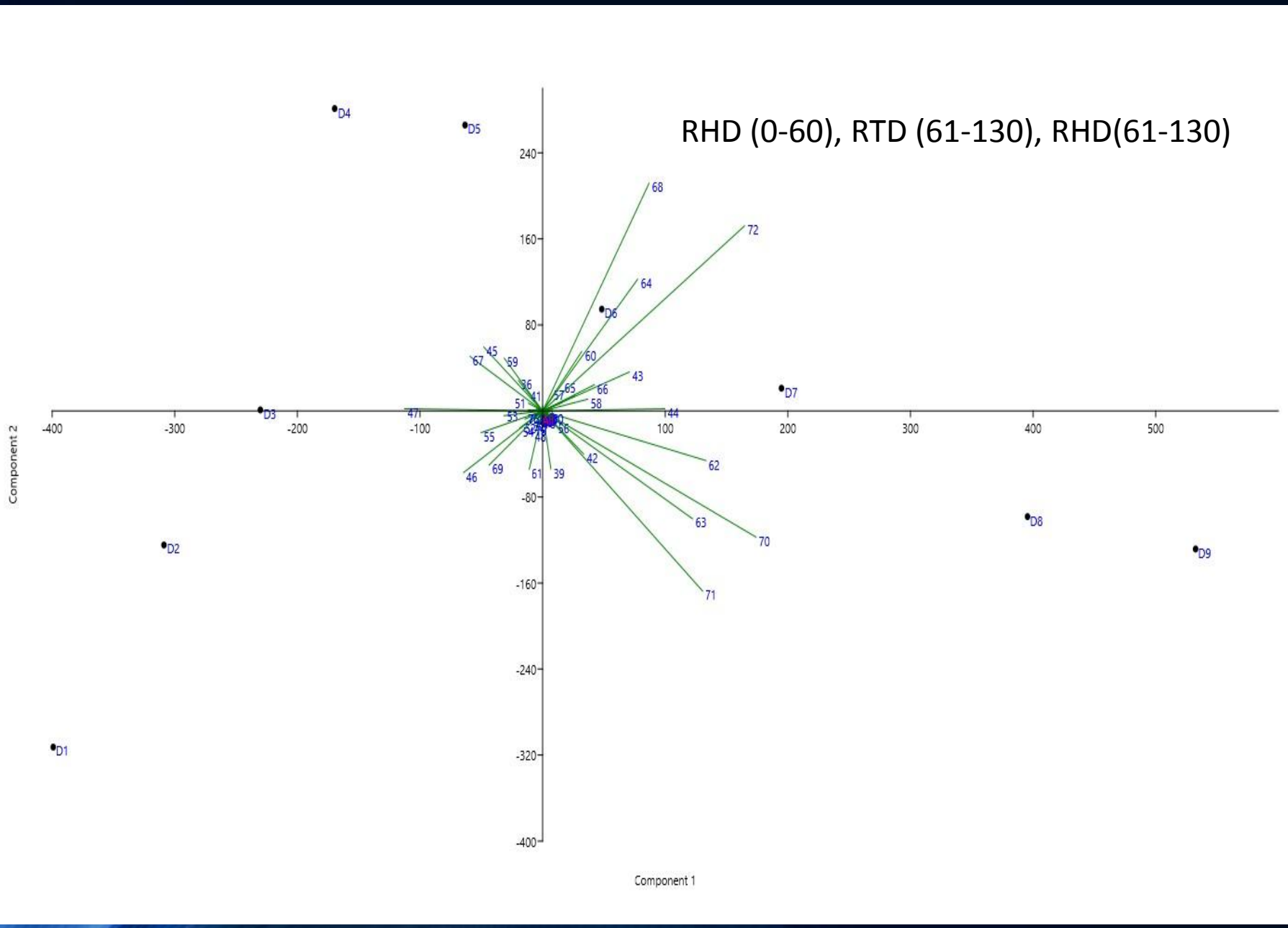

Yield Q/ha
30.0
25.0
20.0
15.0
10.0
5.0
0.0
3850
3800
3750
3700
3650
3600
3550
3500
3450
3400
3350
21st July
28th July
4th Aug
11th Aug
18th Aug
25th Aug
1st Sep
8th Sep
15th Sep
Mallika
Suraj
RTD


Yield Q/ha
Yield Vs GDD
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1550
1500
1450
1400
1350
1300
1250
21st July
28th July
4th Aug
11th Aug
18th Aug
25th Aug
1st Sep
8th Sep
15th Sep
Mallika
Suraj
GDD


Yield Vs Max Temp.°C
Yield Q/ha
Temp.°C
30.0
25.0
20.0
15.0
10.0
5.0
0.0
31.6
31.4
31.2
31.0
30.8
30.6
30.4
30.2
30.0
21st July
28th July
4th Aug
11th Aug
18th Aug
25th Aug
1st Sep
8th Sep
15th Sep
Mallika
Suraj
Max

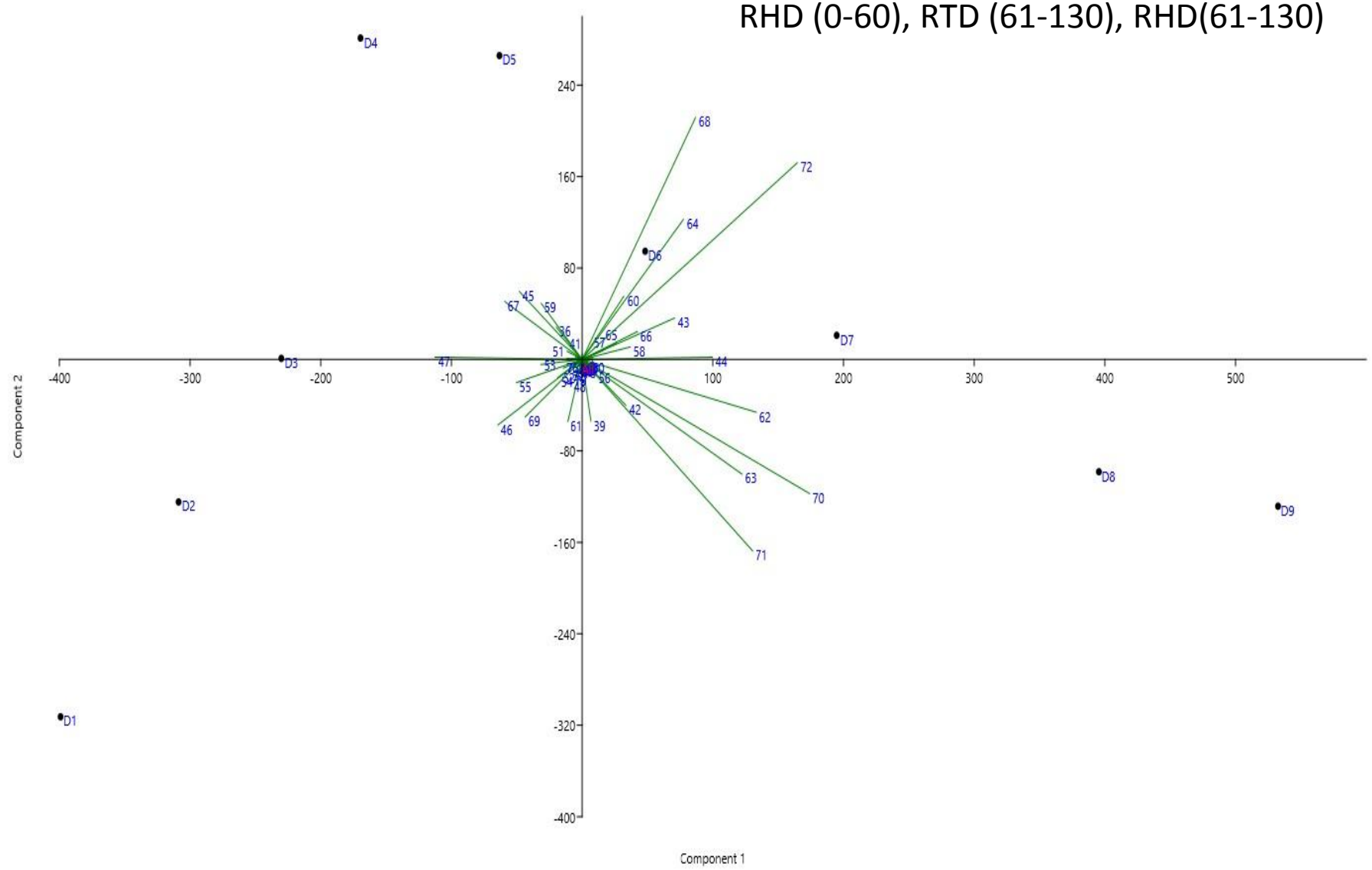

Yield Q/ha
Yield Vs Min Temp°C
Temp°C
30.0
25.0
20.0
15.0
10.0
5.0
0.0
23.0
22.5
22.0
21.5
21.0
20.5
21st July
28th July
4th Aug
11th Aug
18th Aug
25th Aug
1st Sep
8th Sep
15th Sep
Mallika
Suraj
Min

Bi plot Analysis of Yield Mallika Vs weather parameters



Bi plot Analysis of Yield Suraj Vs weather parameters

RHD (0-60), RTD (61-130), RHD(61-130)



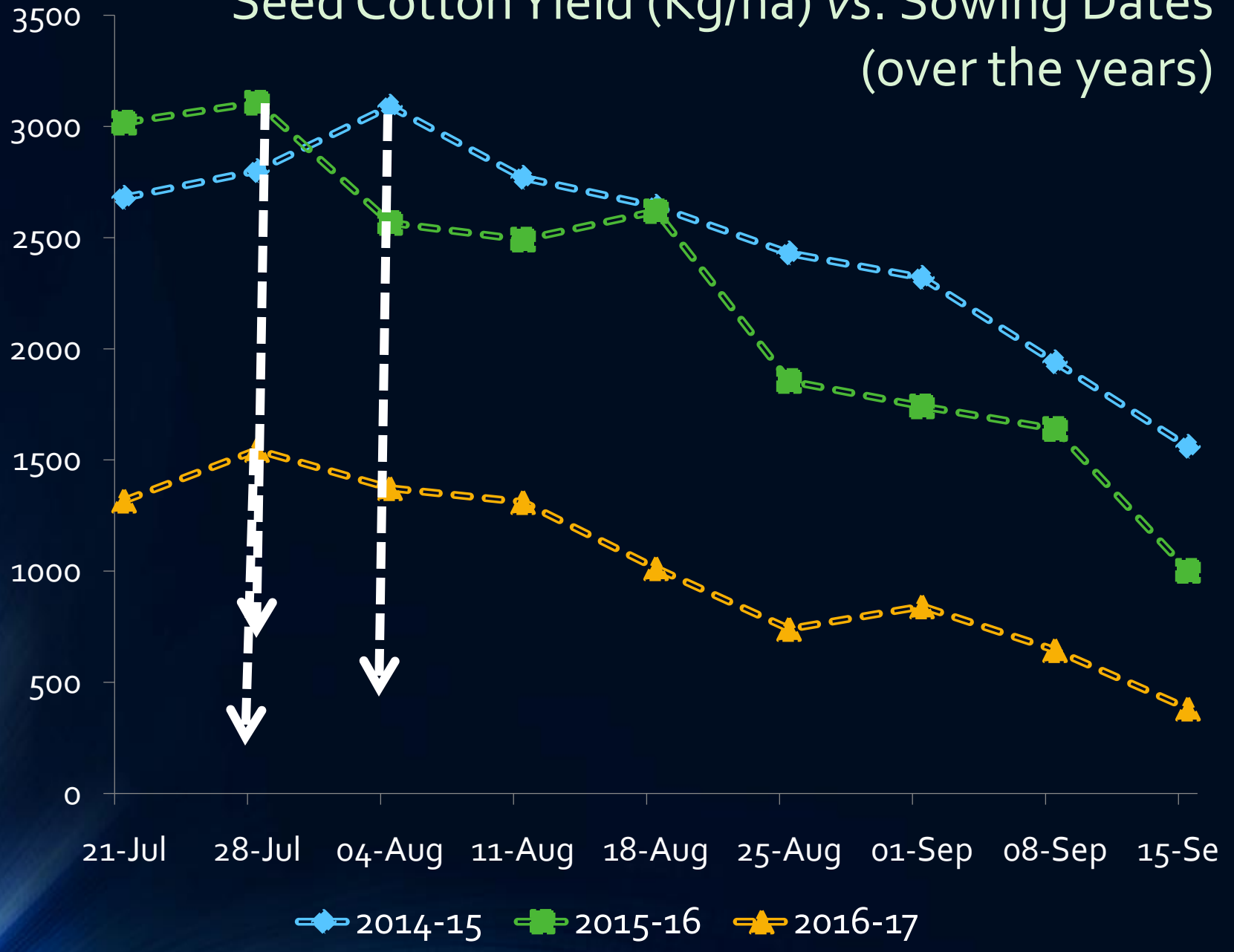
- Reproductive development in late sown crop was affected by cooler temperature and low light (Gormus and Yucel, 2002; Liu et al., 2015; Zhang et al., 2014)

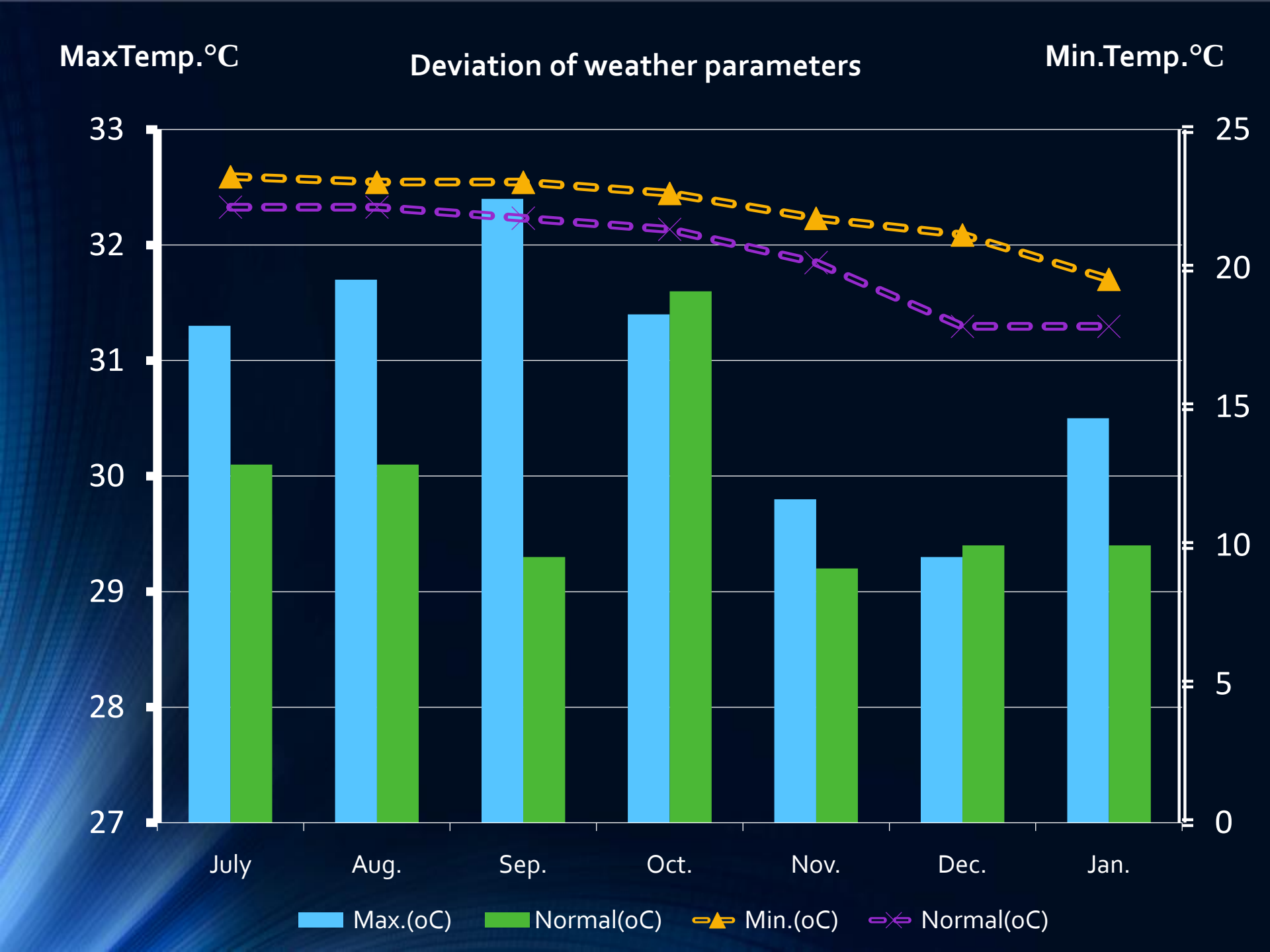
- Bt hybrids trials conducted during *rabi* season under AICCIP also revealed that timely planting of Bt cotton recorded 1.69 t/ha when compared with delayed one (1.39 t/ha) at Surat (AICCIP, 2009)

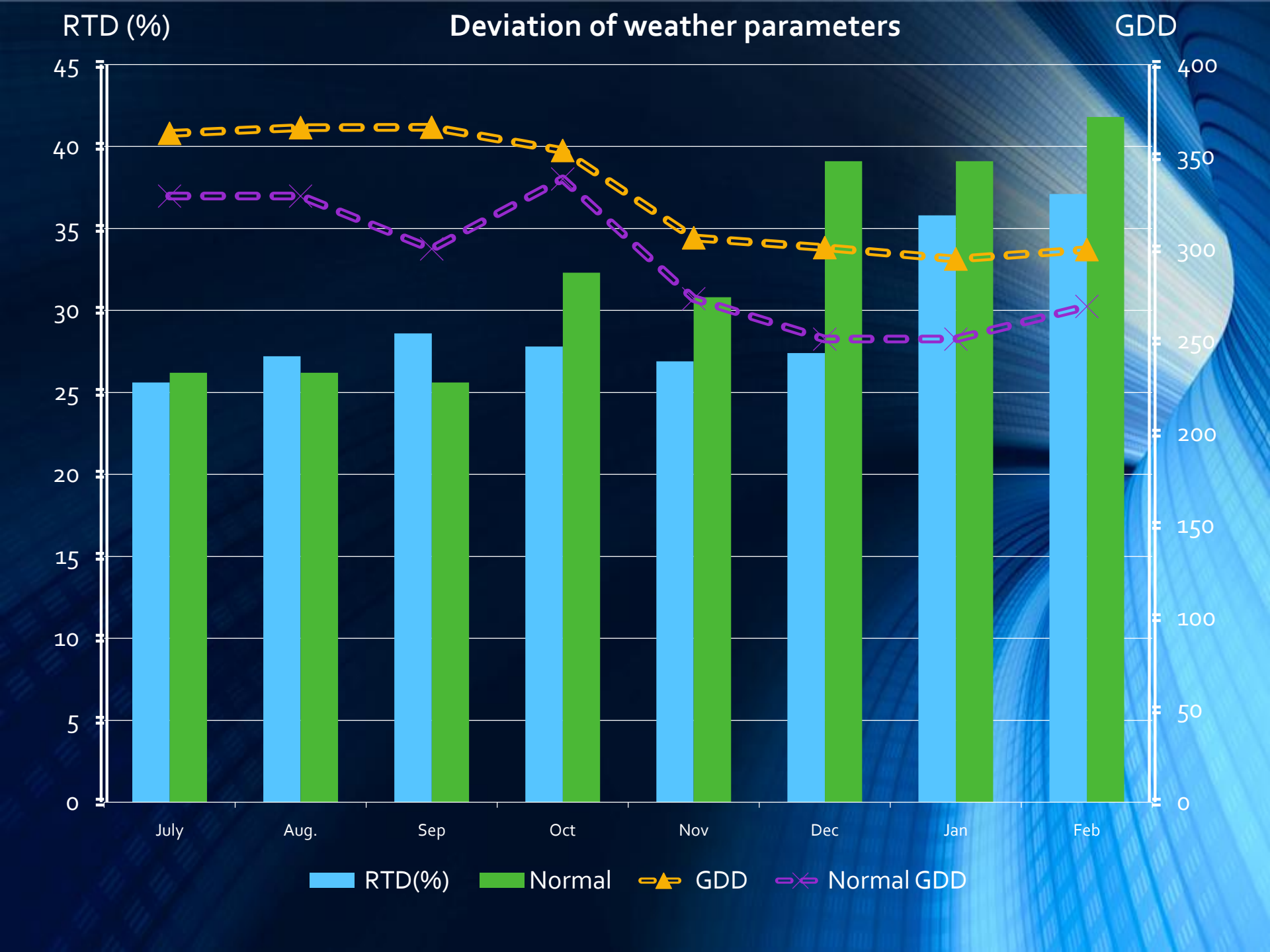
- Pettigrew (2002) also observed that the early planted cotton yielded 10% more lint than that produced by the late planted cotton

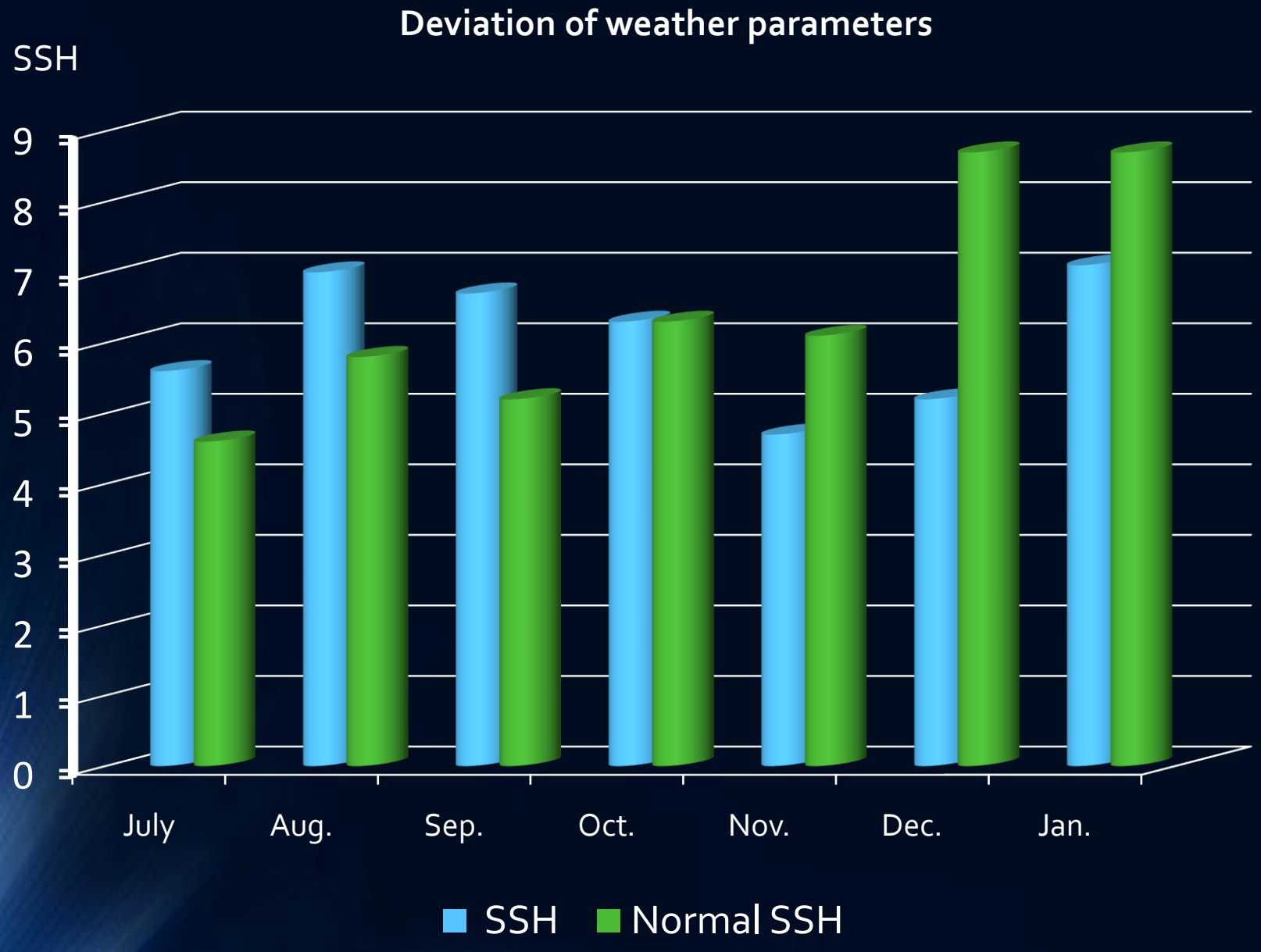
- Less yield was due to suboptimal weather conditions in late sowing date (Gormus and Yucel, 2002).

Seed Cotton Yield (Kg/ha) *vs*. Sowing Dates (over the years)

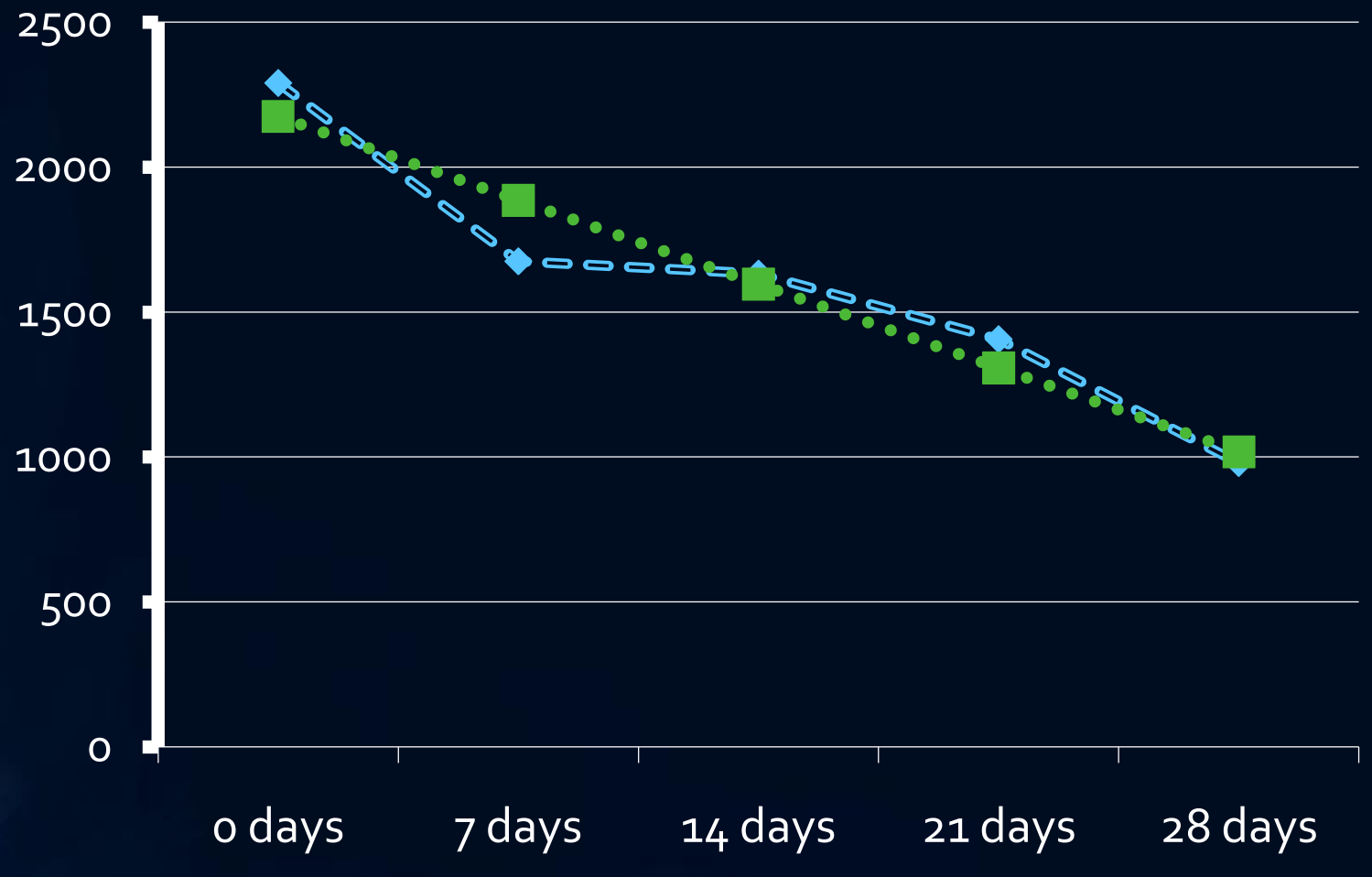



MaxTemp.°C
Deviation of weather parameters
Min.Temp.°C
33
32
31
30
29
28
27
25
20
15
10
5
0
July
Aug.
Sep.
Oct.
Nov.
Dec.
Jan.
Max.(oC)
Normal(oC)
Min.(oC)
Normal(oC)


Deviation of weather parameters
RTD (%)
GDD
45
40
35
30
25
20
15
10
5
0
400
350
300
250
200
150
100
50
0
July
Aug.
Sep
Oct
Nov
Dec
Jan
Feb
RTD(%)
Normal
GDD
Normal GDD


Deviation of weather parameters
SSH
9
8
7
6
5
4
3
2
1
0
July
Aug.
Sep.
Oct.
Nov.
Dec.
Jan.
SSH
Normal SSH

Rate of declining of yield (kg/ha)

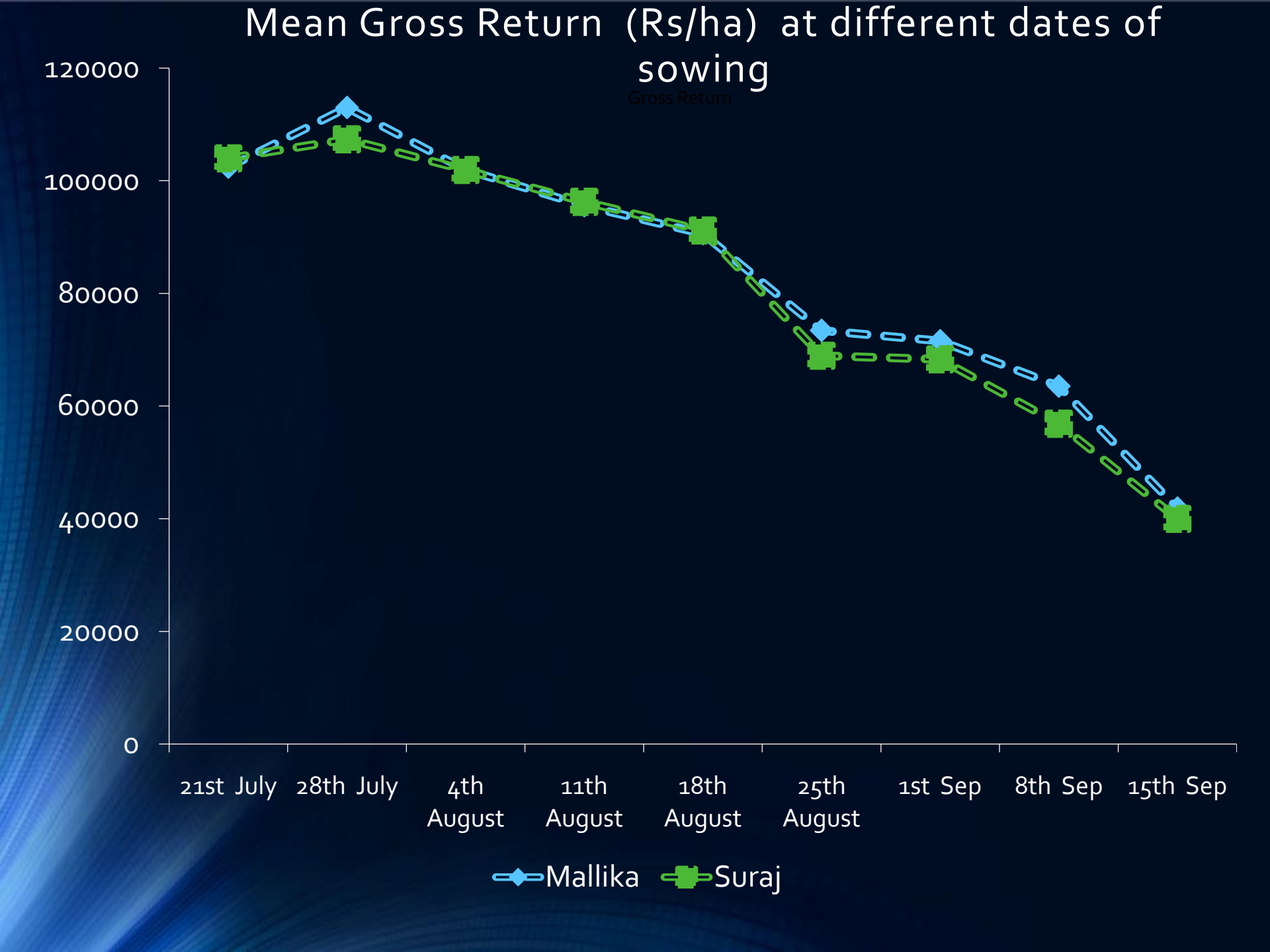


	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	2174.6	118.5	18.3	0.0004
Days	-41.3	6.9	-6.0	0.0094

Mean Gross return (Rs/ha) influenced by Genotypes and Sowing Dates

Date of sowing	Mallika	Suraj	Mean
D1 – 21st July	102409	103983	**104476**
D2 – 28th July	112994	107357	**111561**
D3 – 4th August	101954	101904	**103454**
D4 – 11th August	95566	96265	**97320**
D5 – 18th August	90598	91163	**92260**
D6 – 25th August	73418	68924	72496
D7 – 1st September	71566	68285	71186
D8 – 8th September	63511	56849	61190
D9 – 15th September	41851	39963	41732
Mean	83763	81633	83964

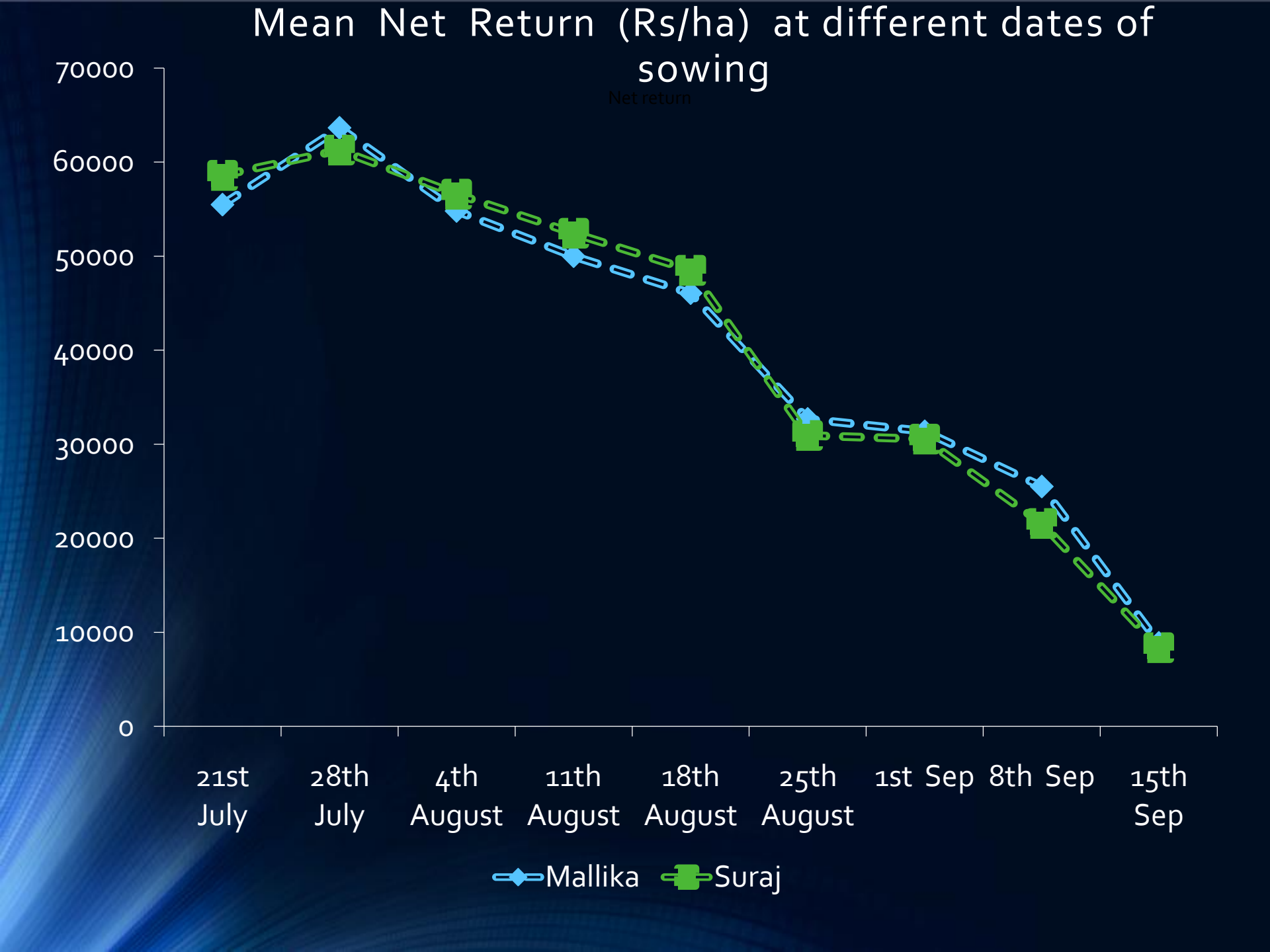
Anova	DOS x Geno	Genotypes	DOS
S. Ed	15469	5090	11139
CD (0.05)	31555	11195	22363
NS/S	NS	NS	S


Mean Gross Return (Rs/ha) at different dates of sowing
Gross Return
120000
100000
80000
60000
40000
20000
0
21st July
28th July
4th August
11th August
18th August
25th August
1st Sep
8th Sep
15th Sep
Mallika
Suraj

Mean Net return (Rs/ha) influenced by Genotypes & Sowing Dates

Date of sowing	Mallika	Suraj	Mean
D1 – 21st July	55472	58585	**58309**
D2 – 28th July	63636	61272	**63839**
D3 – 4th August	54794	56586	**57215**
D4 – 11th August	49984	52432	**52613**
D5 – 18th August	46056	48487	**48651**
D6 – 25th August	32690	30927	33133
D7 – 1st September	31372	30540	32216
D8 – 8th September	25505	21567	24546
D9 – 15th September	8883	8362	9448
Mean	40933	40973	42219

Anova	DOS x Geno	Genotypes	DOS
S. Ed	13219	4361	9512
CD (0.05)	26992	9058	19152
NS/S	NS	NS	S

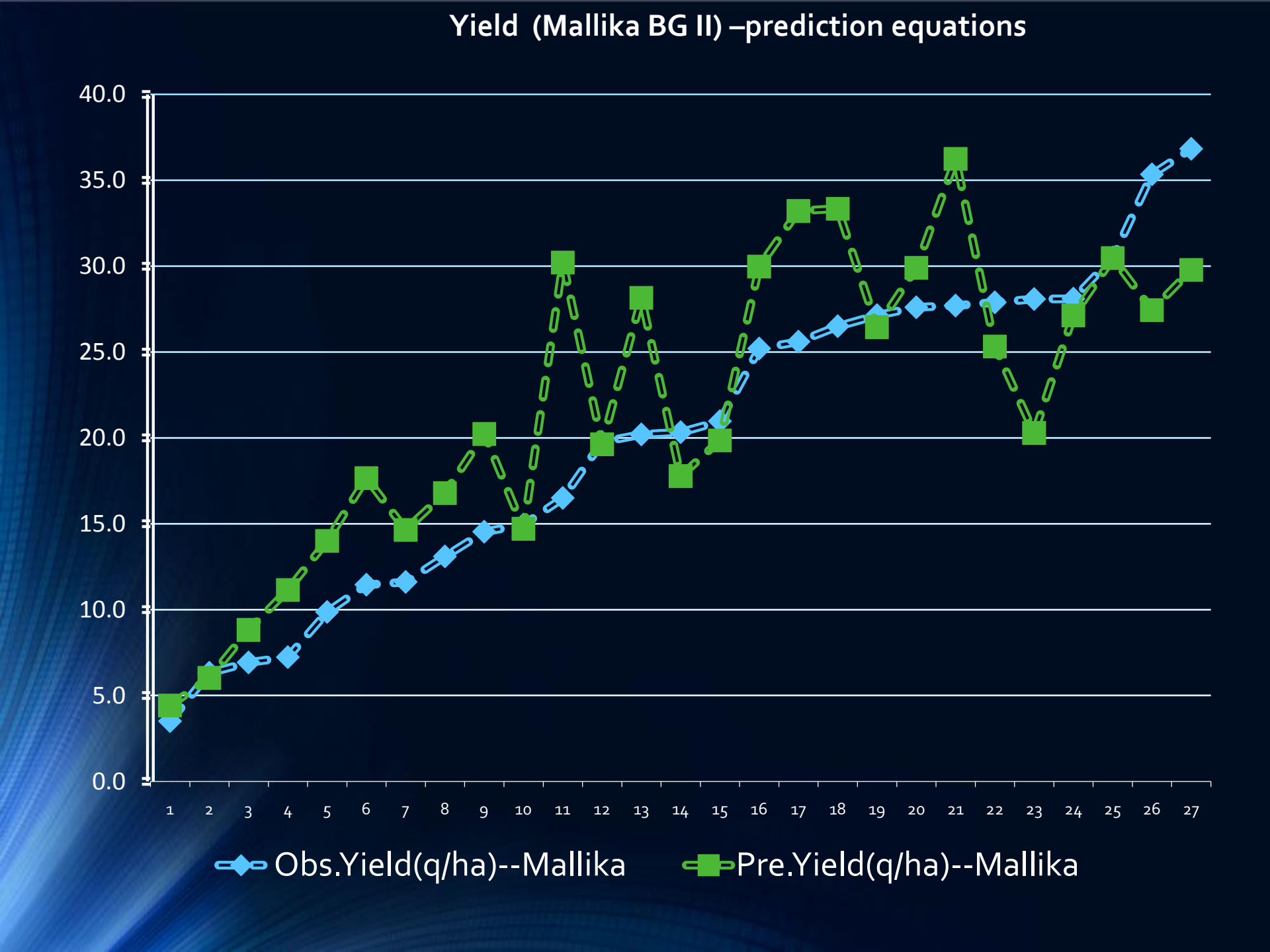

Mean Net Return (Rs/ha) at different dates of sowing
Net return
70000
60000
50000
40000
30000
20000
10000
0
21st July
28th July
4th August
11th August
18th August
25th August
1st Sep
8th Sep
15th Sep
Mallika
Suraj

Yield Vs weather parameters

Parameters	*Y-Mallika*	*Y-Suraj*
Max(0-60)	0.735	0.732
Mjax(61-130)	0.745	0.761
Min(0-60)	0.924	0.932
Min(61-130)	0.956	0.971
RH(0-60)	-0.917	-0.911
RH I (61-130)	0.824	0.815
RH II (0-60)	-0.955	-0.943
RH II (61-130)	0.844	0.850
SSH(0-60)	0.782	0.781
SSH(61-130)	NS	NS
RF(0-60)	0.951	0.963
RF(61-130)	0.954	0.964
ETC(0-60)	0.979	0.974
ETC(61-130)	NS	NS

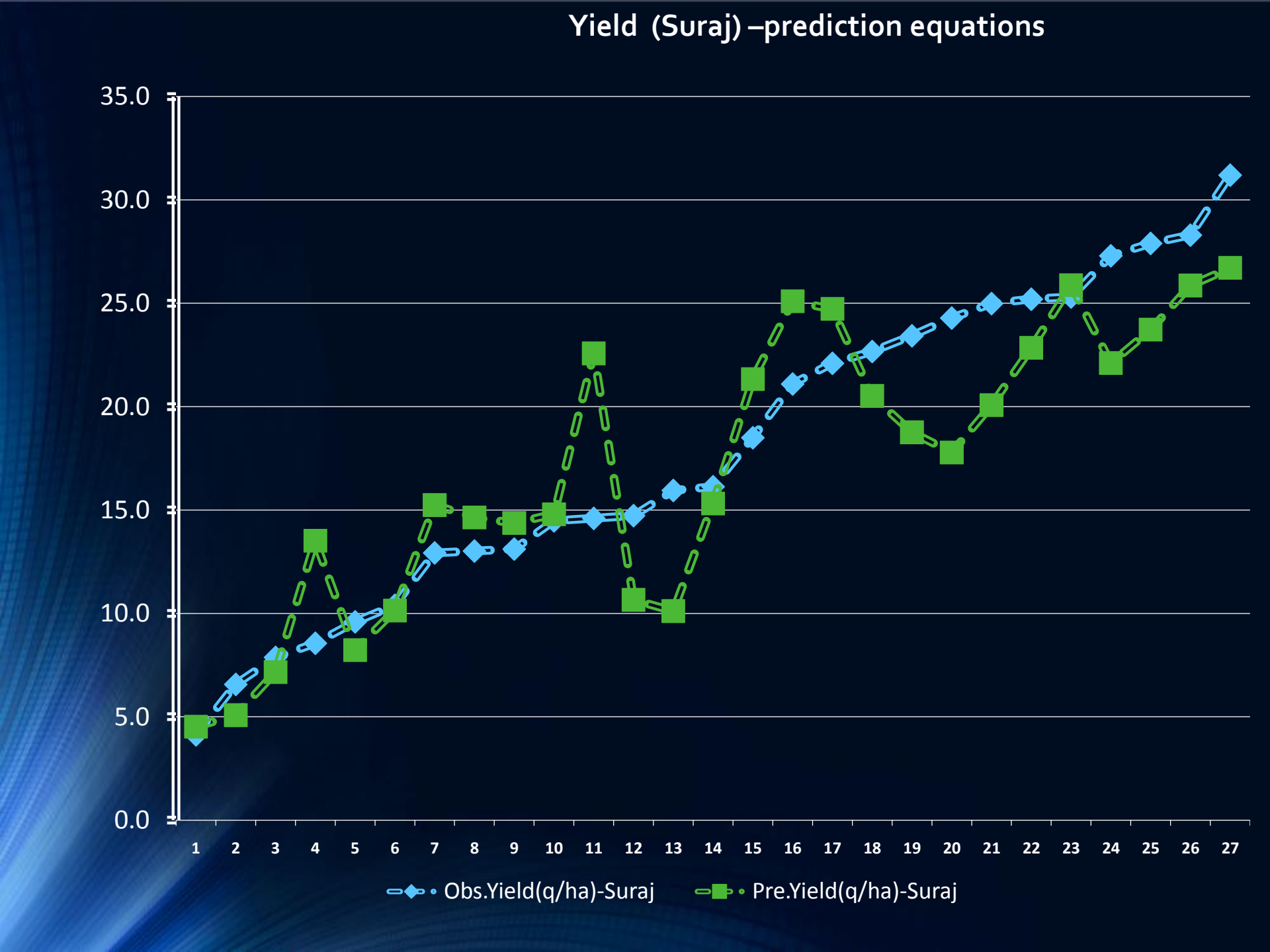
Yield (Mallika BG II) –prediction equations

Parameters	Coefficients	Standard Error	t Stat	P-value
Intercept	116.125	12.943	8.972	1.25E-08
RTD(0-60)	-0.020	0.007	-2.911	0.008
RTD(61-130)	-0.078	0.011	-6.959	7.13E-07
RHD(61-130)	0.042	0.009	4.724	0.000
RF (61-130)	0.018	0.007	2.501	0.021
SSH (61-130)	-0.021	0.022	-0.984	0.336


Yield (Mallika BG II) –prediction equations
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Obs.Yield(q/ha)--Mallika
Pre.Yield(q/ha)--Mallika

Yield (Suraj) –prediction equations

Parameters	Coefficients	Standard Error	t Stat	P-value
Intercept	94.691	17.483	5.416	2.26E-05
RTD(0-60)	-0.024	0.009	-2.553	0.0185
RTD(61-130)	-0.039	0.015	-2.574	0.0177
RHD(61-130)	0.021	0.012	1.791	0.0877
RF (61-130)	0.018	0.009	1.861	0.0767
SSH (61-130)	-0.023	0.029	-0.777	0.4460


Yield (Suraj) –prediction equations
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Obs.Yield(q/ha)-Suraj
Pre.Yield(q/ha)-Suraj

Field View of Dates of sowing Experiment 2014-15

Field View of Dates of sowing Experiment (2015-16)

Conclusion

- Sowing window of cotton was restandardized as 21st July to 18th August from 1st Aug to 30th Aug
- Relative temperature disparity is significant weather indices
- Genotypes (Mallika BGII hybrid and Suraj non Bt straight variety) recorded on par yield

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Thank you....