

[10.1071/CP24259](https://doi.org/10.1071/CP24259)

Crop & Pasture Science

Supplementary Material

Studies on key seed physico-chemical factors and climatic variables regulating hardseededness in green gram (*Vigna radiata* L.) genotypes

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Supplementary Table S1. List of genotypes with reported hard seed (%) used in the study

S. No.	Hard seeded genotype	Reported hard seeds (%)#	S. No.	Non-hard seeded genotype	Reported hard seeds (%)#
1.	TM 96-25	52	10.	HUM 12	3
2.	LGG 460	22	11.	IPM 02-3	4
3.	PUSA 9072	37	12.	IPM 205-7	3
4.	MH 421	22	13.	SM 11-75	3
5.	V 61-73	28	14.	PUSA 0871	9
6.	PUSA 9531	31	15.	AKM 9904	5
7.	PUSA 105	25	16.	PS 16	4
8.	PUSA 1031	24	17.	PANT M-5	4
9.	PUSA RATNA	29	18.	IMP-02/15	6

#the hard seed (%) was reported by Paul *et al.* (2018).

Supplementary Table S2. Variation for lignin content in green gram genotypes produced during monsoon (2018 & 2019) and summer (2018 & 2019) seasons

Genotype	AIL (%) (M-18)	AIL (%) (M-19)	AIL (%) (S-18)	AIL (%) (S-19)	ASL (%) (M-18)	ASL (%) (M-19)	ASL (%) (S-18)	ASL (%) (S-19)
<i>Hard seeded</i>								
TM 96/25	21.10 ^{ab}	19.81 ^{ab}	8.65 ^a	8.12 ^{ab}	1.90 ^a	1.84 ^a	1.29 ^{ab}	1.25 ^a
LGG-460	21.12 ^a	20.77 ^a	8.55 ^a	8.39 ^a	1.80 ^a	1.83 ^a	1.21 ^a	1.24 ^a
PUSA 9072	17.70 ^{bc}	17.48 ^{abc}	7.66 ^{ab}	7.11 ^{abcd}	1.81 ^a	1.84 ^a	1.23 ^{abc}	1.15 ^{ab}
MH 421	17.15 ^{cd}	16.90 ^{abc}	7.74 ^{ab}	7.45 ^{abc}	1.63 ^b	1.69 ^{ab}	1.04 ^{de}	1.07 ^{abc}
V-61/73	15.08 ^d	16.66 ^{bc}	6.83 ^{abcd}	7.13 ^{abcd}	1.55 ^{bc}	1.57 ^{bc}	1.18 ^{abc}	1.17 ^{ab}
PUSA 9531	16.24 ^{cd}	18.27 ^{abc}	7.31 ^{abc}	7.03 ^{abcd}	1.50 ^{bcd}	1.50 ^{bc}	1.18 ^{abc}	1.16 ^{ab}
PUSA 105	15.84 ^{cd}	15.50 ^{cd}	6.34 ^{abcd}	6.69 ^{abcd}	1.42 ^{cde}	1.44 ^{cd}	1.16 ^{bcd}	1.17 ^{ab}
PUSA 1031	15.24 ^{cd}	15.28 ^{cd}	6.11 ^{bcd}	5.76 ^{bcd}	1.38 ^{de}	1.35 ^{cde}	1.10 ^{cde}	1.11 ^{abc}
PUSA RATNA	11.58 ^e	12.58 ^d	5.79 ^{bcd}	5.98 ^{abcd}	1.36 ^e	1.35 ^{cde}	1.03 ^{def}	1.04 ^{abc}
Mean	16.77	17.02	7.22	7.08	1.59	1.60	1.17	1.15
<i>Non-hard seeded</i>								
HUM 12	5.97 ^{fg}	6.28 ^e	5.13 ^{cd}	4.96 ^{cd}	1.19 ^f	1.22 ^{def}	0.98 ^{efg}	0.967 ^{bcd}
IPM 02-3	5.53 ^{fg}	6.26 ^e	5.08 ^{cd}	5.13 ^{cd}	1.13 ^{fg}	1.15 ^{ef}	0.96 ^{efg}	0.933 ^{bcde}
IPM 205/7	5.30 ^{fg}	5.52 ^e	4.49 ^d	4.63 ^d	1.08 ^{fgh}	1.08 ^f	0.97 ^{efg}	0.997 ^{abc}
SM 11/75	4.12 ^g	4.91 ^e	4.92 ^{cd}	5.03 ^{cd}	1.03 ^{gh}	1.06 ^f	1.03 ^{def}	1.05 ^{abc}
PUSA 0871	4.49 ^{fg}	4.91 ^e	5.19 ^{cd}	5.32 ^{cd}	1.12 ^{fg}	1.08 ^f	0.90 ^{fgh}	0.973 ^{bcd}
AKM 9904	4.73 ^{fg}	4.99 ^e	5.21 ^{cd}	5.27 ^{cd}	1.06 ^{fgh}	0.987 ^f	0.81 ^{hi}	0.860 ^{cde}
PS 16	5.72 ^{fg}	6.18 ^e	4.99 ^{cd}	5.18 ^{cd}	1.03 ^{gh}	0.997 ^f	0.85 ^{gh}	0.870 ^{cde}
PANT M 5	6.73 ^f	6.75 ^e	4.59 ^d	4.60 ^d	0.980 ^h	0.997 ^f	0.70 ^{ij}	0.737 ^{de}
IPM 02/15	4.72 ^{fg}	5.21 ^e	6.08 ^{bcd}	6.115 ^{abcd}	0.963 ^h	1.01 ^f	0.65 ^j	0.713
Mean	5.33	5.66	5.08	5.14	1.06	1.06	0.892	0.90

*Different letters within a column indicate significant difference ($p < 0.05$).

Supplementary Table S3. Variation for sugar content in green gram genotypes produced during monsoon (2018 & 2019) seasons

Genotype	Cellulose mg/mL (M-18)	Cellulose mg/mL (M-19)	Xylose mg/mL (M-18)	Xylose mg/mL (M-19)	Arabinose mg/ml (M-18)	Arabinose mg/mL (M-19)
<i>Hard seeded</i>						
TM 96/25	3.84 ^{efgh}	3.77 ^{def}	0.920 ^a	0.917 ^a	0.290 ^{abcd}	0.313 ^{ab}
LGG-460	3.93 ^{defgh}	3.87 ^{cdef}	0.923 ^a	0.920 ^a	0.337 ^a	0.340 ^a
PUSA 9072	3.63 ^{fgh}	3.61 ^{ef}	0.817 ^{ab}	0.857 ^{ab}	0.303 ^{abc}	0.313 ^{ab}
MH 421	3.69 ^{fgh}	3.62 ^{ef}	0.769 ^{bcd}	0.810 ^{ab}	0.317 ^{abc}	0.300 ^{ab}
V-61/73	3.40 ^{gh}	3.69 ^{def}	0.817 ^{ab}	0.813 ^{ab}	0.263 ^{bcd}	0.277 ^{ab}
PUSA 9531	3.69 ^{fgh}	3.77 ^{def}	0.793 ^{bc}	0.823 ^{ab}	0.273 ^{bcd}	0.287 ^{ab}
PUSA 105	3.13 ^h	3.25 ^f	0.760 ^{bcd}	0.743 ^{bc}	0.253 ^{cd}	0.263 ^{abcd}
PUSA 1031	3.59 ^{fgh}	3.68 ^{def}	0.657 ^d	0.653 ^c	0.260 ^{bcd}	0.257 ^{abcd}
PUSA RATNA	2.96 ^h	3.95 ^d	0.683 ^{cd}	0.650 ^c	0.233 ^{de}	0.220 ^{bcde}
Mean	3.54	3.58	0.79	0.80	0.28	0.29
<i>Non-hard seeded</i>						
HUM 12	5.83 ^a	5.89 ^a	0.343 ^e	0.330 ^d	0.180 ^{ef}	0.187 ^{cdef}
IPM 02-3	5.44 ^{abc}	5.39 ^{ab}	0.313 ^e	0.297 ^d	0.150 ^{fg}	0.180 ^{cdef}
IPM 205/7	5.02 ^{abcd}	5.16 ^{abc}	0.357 ^e	0.357 ^d	0.140 ^{fg}	0.177 ^{def}
SM 11/75	5.69 ^{ab}	6.09 ^a	0.317 ^e	0.350 ^d	0.117 ^g	0.210 ^{cd}
PUSA 0871	5.05 ^{abc}	5.19 ^{abc}	0.317 ^e	0.303 ^d	0.137 ^{fg}	0.130 ^{ef}
AKM 9904	4.37 ^{abc}	5.49 ^{ab}	0.260 ^e	0.263 ^d	0.123 ^{fg}	0.127 ^{ef}
PS 16	4.84 ^{abcde}	4.99 ^{abcd}	0.270 ^e	0.263 ^d	0.117 ^g	0.123 ^{ef}
PANT M 5	4.38 ^{cdefg}	4.27 ^{bcdef}	0.283 ^e	0.303 ^d	0.100 ^g	0.117 ^f
IPM 02/15	4.70 ^{bcdef}	4.85 ^{abcde}	0.277 ^e	0.280 ^d	0.100 ^g	0.130 ^{ef}
Mean	5.14	5.26	0.30	0.30	0.13	0.14

*Different letters within a column indicate significant difference ($p < 0.05$).

Supplementary Table S4. Variation for sugar content in green gram genotypes produced during summer (2018 & 2019) seasons

Genotype	Cellulose mg/mL (S-18)	Cellulose mg/mL (S-19)	Xylose mg/mL (S-18)	Xylose mg/mL (S-19)	Arabinose mg/mL (S-18)	Arabinose mg/mL (S-19)
<i>Hard seeded</i>						
TM 96/25	5.70 ^{ab}	5.72 ^{ab}	0.393 ^{ab}	0.383 ^a	0.140 ^{bcd}	0.150 ^{abc}
LGG-460	5.13 ^{cdef}	5.26 ^{bcd}	0.403 ^a	0.380 ^a	0.155 ^{ab}	0.163 ^{ab}
PUSA 9072	5.19 ^{bcde}	5.19 ^{bcde}	0.360 ^{abcd}	0.340 ^{abcd}	0.132 ^{bcde}	0.123 ^{abcdef}
MH 421	5.17 ^{bcdef}	5.30 ^{bcd}	0.377 ^{abc}	0.367 ^{ab}	0.145 ^{abc}	0.140 ^{abcd}
V-61/73	5.04 ^{cdefg}	5.17 ^{bcde}	0.377 ^{bcde}	0.353 ^{abc}	0.175 ^a	0.173 ^a
PUSA 9531	4.97 ^{defgh}	5.16 ^{bcde}	0.383 ^{ab}	0.350 ^{abcd}	0.138 ^{bcde}	0.127 ^{abcde}
PUSA 105	4.75 ^{efghi}	4.83 ^{defg}	0.360 ^{abcd}	0.313 ^{abcde}	0.146 ^{abc}	0.137 ^{abcd}
PUSA 1031	4.50 ^{ghi}	4.57 ^{efg}	0.340 ^{bcde}	0.310 ^{abcde}	0.120 ^{cde}	0.120 ^{abcdef}
PUSA RATNA	4.22 ⁱ	4.28 ^g	0.347 ^{bcde}	0.353 ^{abc}	0.121 ^{cde}	0.130 ^{abcde}
Mean	4.96	5.05	0.367	0.350	0.141	0.140
<i>Non-hard seeded</i>						
HUM 12	6.12 ^a	6.26 ^a	0.313 ^{def}	0.310 ^{abcde}	0.135 ^{bcde}	0.117 ^{bcdef}
IPM 02-3	5.56 ^{bc}	5.76 ^{ab}	0.320 ^{cdef}	0.327 ^{abcd}	0.129 ^{bcde}	0.130 ^{abcde}
IPM 205/7	5.43 ^{bcd}	5.25 ^{bcd}	0.297 ^{efg}	0.303 ^{abcde}	0.117 ^{cedf}	0.110 ^{bcdef}
SM 11/75	5.21 ^{bcde}	5.23 ^{bcde}	0.307 ^{def}	0.310 ^{abcde}	0.106 ^{def}	0.093 ^{def}
PUSA 0871	5.31 ^{bcd}	5.51 ^{bc}	0.317 ^{def}	0.317 ^{abcde}	0.105 ^{efg}	0.106 ^{cdef}
AKM 9904	4.99 ^{defgh}	5.05 ^{cdef}	0.267 ^{fg}	0.287 ^{bcde}	0.107 ^{def}	0.103 ^{cdef}
PS 16	4.64 ^{fghi}	4.66 ^{defg}	0.270 ^{fg}	0.280 ^{cde}	0.088 ^{fgh}	0.113 ^{bcdef}
PANT M 5	4.59 ^{ghi}	4.64 ^{defg}	0.243 ^g	0.243 ^e	0.065 ^g	0.070 ^f
IPM 02/15	4.46 ^{hi}	4.49 ^{fg}	0.240 ^g	0.270 ^{de}	0.065 ^h	0.080 ^f
Mean	5.14	5.20	0.286	0.294	0.102	0.130

*Different letters within a column indicate significant difference ($p < 0.05$).

Supplementary Table S5. Variation for phenol content (mg/g gallic acid equivalent) and calcium concentration (ppm) in green gram genotypes produced during monsoon (2018 & 2019) and summer (2018 & 2019) seasons

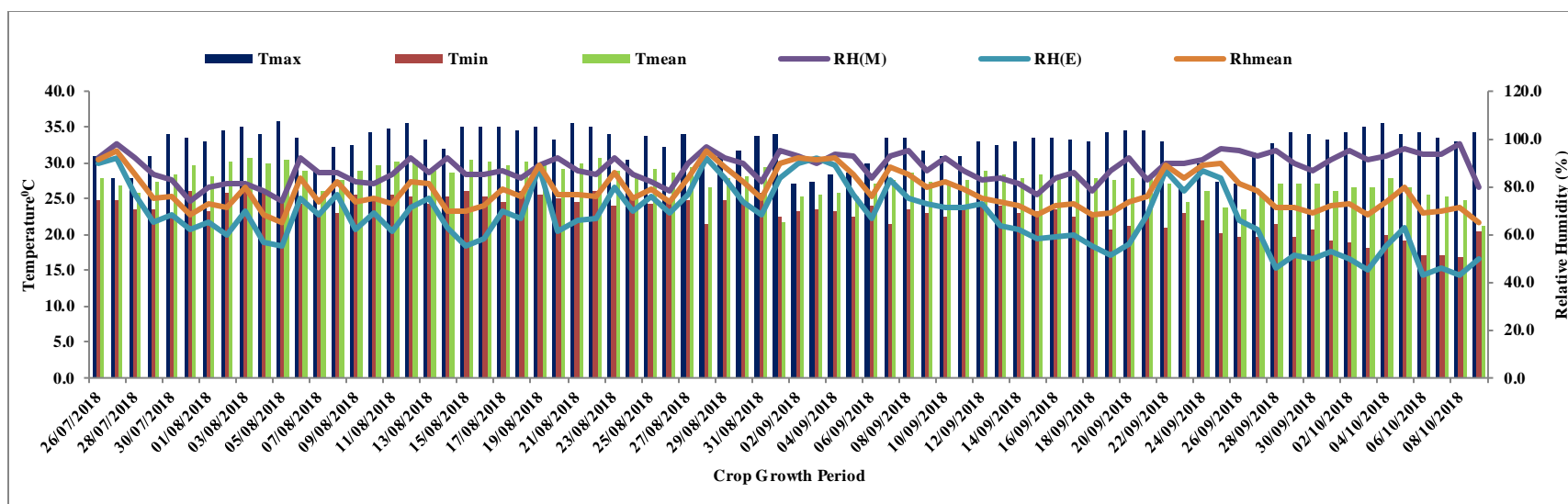
Genotype	Phenol content (M-18)	Phenol content (M-19)	Phenol content (S-18)	Phenol content (S-19)	Ca conc. (M-18)	Ca conc. (M-19)	Ca conc. (S-18)	Ca conc. (S-19)
<i>Hard seeded</i>								
TM 96/25	29.76 ^a	29.79 ^{ab}	18.67 ^{abc}	18.95 ^a	930 ^a	906.67 ^{ab}	745 ^{ab}	760 ^a
LGG-460	23.91 ^{abc}	26.69 ^{abc}	18.95 ^{ab}	18.52 ^a	811.50 ^c	811.67 ^{bc}	640 ^{ef}	633.33 ^{de}
PUSA 9072	29.82 ^a	31.48 ^a	18.77 ^{abc}	18.18 ^a	834.50 ^{bc}	838.33 ^{abc}	690 ^{cd}	692.33 ^{bcd}
MH 421	24.70 ^{ab}	26.00 ^{abc}	19.55 ^a	12.18 ^a	918 ^{ab}	916.67 ^a	625.50 ^{de}	658.67 ^{cde}
V-61/73	22.59 ^{bc}	27.00 ^{abc}	16.89 ^{abcd}	16.84 ^a	800.50 ^c	793.33 ^{ade}	587.50 ^{gh}	620 ^{efg}
PUSA 9531	25.04 ^{ab}	21.11 ^{abcde}	17.36 ^{abcd}	17.46 ^a	818.50 ^c	813.33 ^{bc}	745 ^{ab}	737 ^{ab}
PUSA 105	23.19 ^{bc}	22.56 ^{bcdef}	17.74 ^{abcd}	17.16 ^a	799 ^c	805 ^c	780 ^a	760 ^a
PUSA 1031	23.71 ^{abc}	25.17 ^{abcde}	16.05 ^{bcde}	16.70 ^a	931.50 ^a	921.67 ^a	710 ^{bc}	701.67 ^{abc}
PUSA RATNA	24.36 ^{ab}	25.42 ^{abcd}	15.88 ^{bcde}	14.85 ^a	822 ^c	826.67 ^{abc}	577.50 ^{hi}	566.67 ^{fgh}
Mean	25.23	26.58	17.76	16.98	851.72	848.15	681.04	681.07
<i>Non-hard seeded</i>								
HUM 12	18.05 ^{cd}	19.27 ^{cdefg}	14.64 ^{defg}	15.10 ^a	641.50 ^{efg}	642.67 ^{efg}	550 ^{ij}	560 ^{gh}
IPM 02-3	15.14 ^d	17.03 ^{defg}	15.73 ^{cdef}	16.51 ^a	665.5 ^{defg}	662.33 ^{efg}	605 ^{fgh}	613.33 ^{efg}
IPM 205/7	14.39 ^d	15.52 ^{fg}	13.72 ^{efgh}	14.13 ^a	678.50 ^{defg}	678.33	535 ^j	537 ^h
SM 11/75	15.98 ^d	18.65 ^{cdefg}	14.81 ^{defg}	15.40 ^a	588 ^g	590 ^g	605 ^{fgh}	623.33 ^{ef}
PUSA 0871	12.87 ^d	14.99 ^{fg}	16.02 ^{bcde}	17.05 ^a	690 ^{def}	685 ^{efg}	670 ^{de}	664.33 ^{cde}
AKM 9904	13.60 ^d	15.40 ^{fg}	11.96 ^{gh}	12.74 ^a	745.50 ^{cd}	743.33 ^{cde}	540 ^{ij}	552 ^h
PS 16	15.66 ^d	16.86 ^{efg}	12.59 ^{fgh}	11.97 ^a	639.50 ^{efg}	640 ^{fg}	656 ^{de}	656.67 ^{cde}
PANT M 5	13.61 ^d	16.75 ^{efg}	12.08 ^{gh}	13.84 ^a	702.50 ^{de}	693.33 ^{def}	635 ^{efg}	647 ^{cde}
IPM 02/15	12.50 ^d	13.07 ^g	10.81 ^{gh}	11.33 ^a	597.50 ^{fg}	595 ^{fg}	547.5 ^{ij}	537 ^h
Mean	14.65	16.39	13.59	14.23	660.94	658.89	593.72	598.96

*Different letters within a column indicate significant difference ($p < 0.05$).

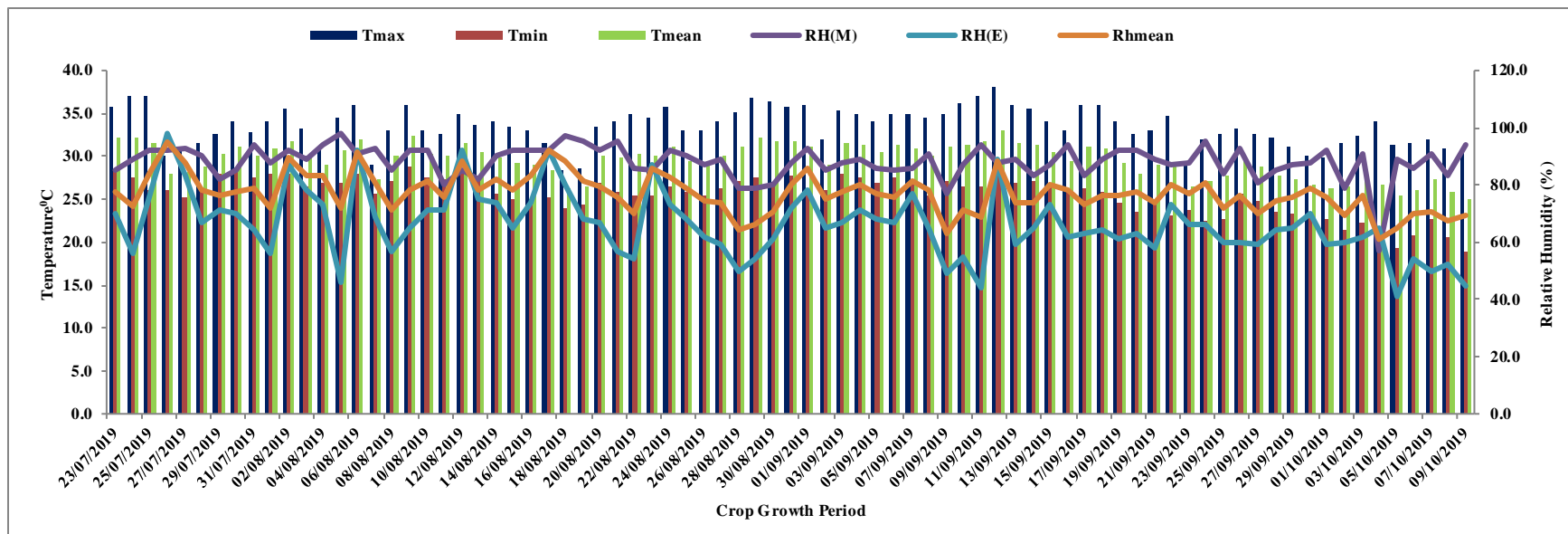
Supplementary Table S6. Comparison for hard seeds (%) and physico-chemical parameters in green gram genotypes produced during two contrasting seasons

Season and seed type	% hard seeds	AIL (%)	ASL (%)	Cellulose (mg/mL)	Xylose (mg/mL)	Arabinose (mg/mL)	TPC (mg/g)	Ca conc. (ppm)
Hard seeded (K-18)	34.19 ^a	16.61 ^a	1.59 ^a	3.54 ^b	0.792 ^a	0.283 ^a	25.23 ^a	851.72 ^a
Hard seeded (S-18)	5.74 ^b	7.22 ^b	1.16 ^b	4.96 ^a	0.367 ^b	0.141 ^b	17.76 ^b	681.94 ^b
Non-hard seeded (K-18)	4.22 ^{bc}	5.33 ^c	1.06 ^c	5.14 ^a	0.304 ^c	0.133 ^b	14.65 ^c	660.94 ^b
Non-hard seeded (S-18)	3.33 ^c	5.08 ^c	0.872 ^d	5.14 ^a	0.286 ^c	0.103 ^c	13.59 ^c	593.72 ^c
Hard seeded (K-19)	35.37 ^b	17.03 ^a	1.60 ^a	3.58 ^b	0.799 ^a	0.286 ^a	26.58 ^a	848.15 ^a
Hard seeded (S-19)	6.07 ^b	7.07 ^b	1.15 ^b	5.05 ^a	0.350 ^b	0.140 ^b	16.98 ^b	681.07 ^b
Non-hard seeded (K-19)	4.63 ^{bc}	5.67 ^c	1.06 ^c	5.26 ^a	0.307 ^c	0.143 ^b	16.39 ^b	658.89 ^b
Non-hard seeded (S-19)	3.07 ^c	5.14 ^c	0.900 ^d	5.21 ^a	0.294 ^c	0.130 ^b	14.23 ^c	598.96 ^c

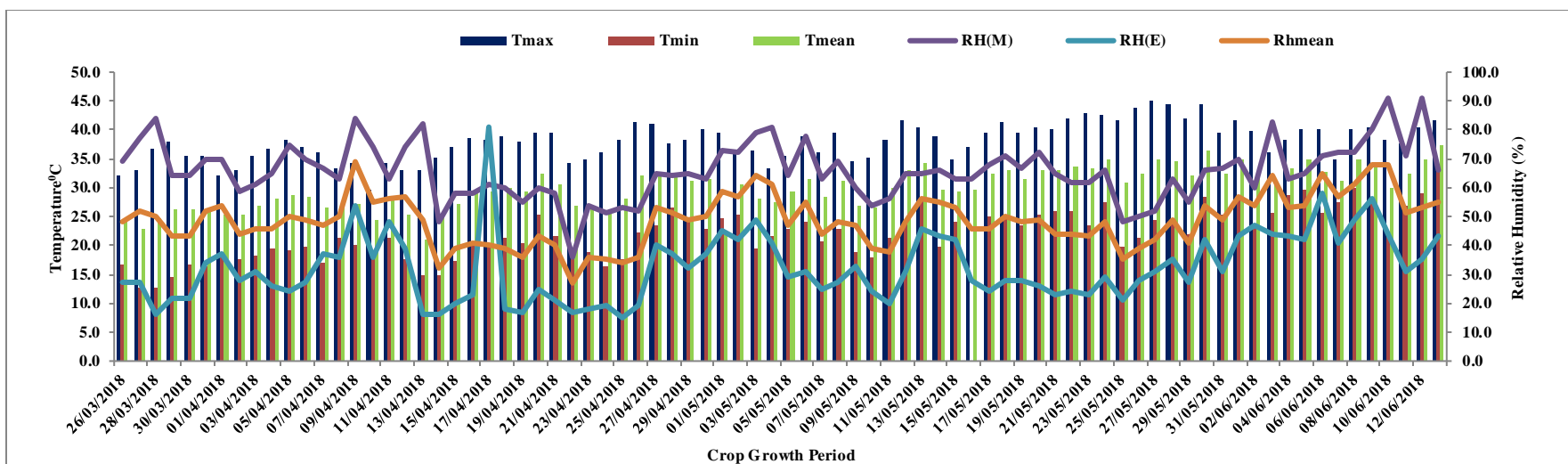
*Different letters within a column indicate significant difference ($p < 0.05$).



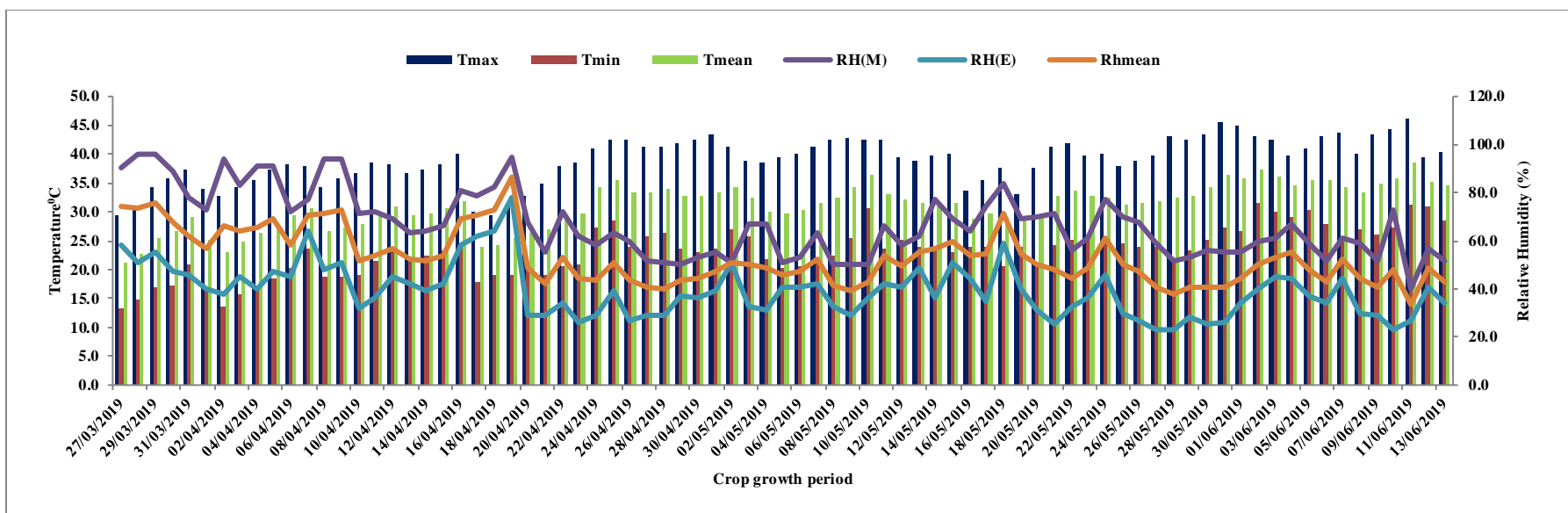
Supplementary Fig. S1. Climatic variables during crop growth period in Monsoon 2018.



Supplementary Fig. S2. Climatic variables during crop growth period in Monsoon 2019.



Supplementary Fig. S3. Climatic variables during crop growth period in summer 2018.



Supplementary Fig. S4. Climatic variables during crop growth period in summer 2019.