

Physiological investigations on heat stress tolerance in wheat

Multi-location Heat Tolerance trial (MLHT) was conducted to identify the temperature stress tolerant lines among AVT genotypes and checks planted/evaluated under timely sown (TS) and late sown (LS) conditions. Two trials MLHT1 (16 entries for NWPZ and NEPZ) and MLHT2(16 entries for CZ and PZ) were conducted during the crop season 2019-20. Both MLHT1 and MLHT2 trials were conducted at 8 locations each. Sowing was done under TS (November) and LS (December) conditions with at least 21 days difference between the sowing dates to expose the crop to optimum and high temperature environments, respectively. The two trials were sown in 4 x 4 lattice square design for 16 entries with two replications. Observations on weather, growth and yield parameters were recorded at all the locations in the prescribed format. Physiological parameters viz., NDVI (Normalized difference vegetation Index), canopy temperature (CT), chlorophyll content index (CCI) and chlorophyll fluorescence (CFL) were recorded at 15 and 21 days after anthesis (DAA) at Pune, Junagadh, Nipahad, Vijapur, Hisar, Ludhiana, Kanpur, Karnal and Sabour. The data from Dharwad was not included in the MLHT2 analysis due to trial rejection by zonal monitoring team whereas Udaipur data was not included in pooled analysis due to very low yield reduction under late sown conditions.

Magnitude of heat stress:

- Compared to previous crop season minimum temperature across centres were higher by 2.3°C and 2.2°C under TS and LS conditions, respectively during vegetative phase. During reproductive phase, minimum temperature was also higher by 0.7°C and 0.2°C under TS and LS conditions, respectively.
- Maximum temperature, compared to previous crop season was lower by 0.6°C and 1.0°C under TS and LS conditions, respectively during vegetative phase and during reproductive phase it was lower by 2.6°C & 3°C in TS and LS conditions respectively.
- During 2019-20, relatively cooler temperature across the centres during grain filling period might have influenced the yield under both TS and LS conditions.

Heat Sensitivity Index (HSI) was the main criteria for adjudging the genotypic performance and was calculated using the formula $HSI = (1 - YD/Yi) / (1 - XD/Xi)$ Where, YD and Yi are the grain yield for each genotype under heat stress and control conditions respectively. XD and Xi are the mean of all study genotypes grain yield under heat stress and control conditions respectively. For example, HSI < 0.5 is considered as highly heat tolerant, HSI 0.5-1 as moderately heat tolerant and HSI > 1.0 as heat susceptible genotypes.

Table 1: List of wheat genotypes identified as less heat sensitive(HSI<1.0) in MLHT1&2 trials during 2019-20

Trial	Zone	Genotypes
MLHT1	NWPZ&NEPZ	HD3293 (0.62), DBW187 (0.82), WH1270 (0.84), RWP2018-31 (0.93), RWP2018-32 (0.94), HD3298 (1), DBW303 (1)
MLHT2	CZ&PZ	HI1633 (0.57), HI1634 (0.68), NIAW3170(d) (0.81), NIDW1149(d) (0.86), DDW49 (1)

Values in the paranthesis indicates Heat Sensitivity Index(HSI)

Correlation of grain yield with different traits under late sown conditions

The pooled analysis of the data over locations indicated reduction in most of the measured traits under LS condition. The correlation of traits with grain yield under late sown conditions in both CZ & PZ and NWPZ & NEPZ trials indicated that, the grain yield is positively correlated with Biomass, Harvest index, Days to maturity, Grain filling duration, Grain weight per spike and Thousand grain weight whereas it is negatively correlated with canopy temperature and days to maturity across all locations

Table2: HSI of MLHT1 genotypes in NWPZ&NEPZ locations and pooled across locations during 2019-20

Genotype	Location wise HSI								Pooled			
	NWPZ				NEPZ				HSI	Grain yield		% Reduction over TS
	Durgapura	Hisar	Karnal	Ludhiana	Kanpur	Pusa	Ranchi	Sabour		TS	LS	
HD3293	0.71	0.87	0.81	1.13	-1.01	0.85	0.69	0.70	0.62	2001.8	1693.7	15.4
DBW187	0.28	0.62	0.95	1.43	1.26	0.87	4.28	0.69	0.82	2176.5	1735.6	20.3
WH1270	0.45	0.97	-0.04	1.65	1.02	0.96	0.36	0.94	0.84	2258.5	1788.1	20.8
RWP-2018-32	0.57	1.06	1.48	1.44	0.53	1.09	-8.19	0.99	0.94	2088.5	1602.3	23.3
RWP-2018-31	0.84	0.76	1.68	-1.54	1.27	1.10	3.20	1.02	0.93	1902.1	1462.1	23.1
HD3298	1.30	0.93	0.82	0.96	1.08	0.14	5.76	1.13	1.03	2126.8	1584.9	25.5
DBW303	1.72	1.12	0.32	0.70	0.80	1.64	-0.72	1.01	1.03	2256.7	1682.6	25.4
RWP-2018-28	1.33	1.29	0.98	1.41	0.87	0.30	-1.81	1.11	1.14	2137.0	1533.6	28.2
RWP-2018-26	1.02	1.13	1.02	1.84	1.69	1.37	-1.30	1.10	1.24	2137.8	1481.5	30.7
RWP-2018-27	1.70	0.99	2.00	1.95	1.52	1.50	0.90	1.00	1.34	1982.4	1322.7	33.3
RAJ3765(C)	0.60	0.93	0.26	-1.74	1.31	1.75	0.21	0.95	0.79	1891.8	1519.6	19.7
DBW150(C)	1.26	0.91	0.39	-0.72	0.98	0.54	4.45	0.98	0.82	2001.7	1595.9	20.3
WH730(C)	0.17	1.06	0.84	1.08	0.31	1.00	2.04	1.04	0.91	1870.1	1447.4	22.6
HD2967(C)	0.36	0.82	1.80	0.96	1.61	0.68	1.17	1.04	1.04	1929.8	1430.3	25.9
HD2932(C)	1.36	1.30	1.92	0.94	0.51	0.87	1.25	1.07	1.19	2115.9	1489.8	29.6
HD3086(C)	1.66	1.02	0.69	2.58	1.53	0.72	1.25	1.13	1.26	2258.1	1554.9	31.1

Table 3: HSI of MLHT2 genotypes in CZ&PZ locations and pooled across locations during 2019-20

Genotype	Location wise HSI							Pooled			
	CZ				PZ			HSI	Grain yield		% Reduction over TS
	Indore	Junagadh	Udaipur	Vijapur	Niphad	Parbhani	Pune		TS	LS	
HI1633	1.11	0.53	-0.23	0.71	1.45	-4.49	0.23	0.57	1405.0	1242.7	11.6
HI1634	1.03	0.31	-0.05	0.65	1.20	-3.50	2.27	0.68	1326.9	1143.5	13.8
CG1029	0.54	0.74	-0.62	0.85	0.23	3.35	3.75	1.05	1513.1	1190.4	21.3
RWP-2018-29	1.04	1.77	0.27	1.09	1.27	-0.31	-5.83	1.23	1231.3	924.2	24.9
NIAW3170(d)	1.17	0.36	-0.20	0.64	1.25	0.02	-1.37	0.81	1317.6	1101.7	16.4
NIDW1149(d)	1.24	1.10	0.04	0.74	1.34	-0.12	1.23	0.86	1350.9	1115.1	17.5
DDW49(d)	0.00	0.65	-0.08	1.51	0.08	1.08	3.10	1.02	1228.3	974.2	20.7
DDW48(d)	0.59	0.61	-0.25	0.99	1.63	6.29	3.80	1.37	1459.8	1055.6	27.7
RAJ3765(C)	0.62	1.03	0.02	0.81	0.39	-3.51	-1.60	0.47	1173.7	1062.3	9.5
HD2932(C)	1.27	1.16	0.08	1.26	0.09	3.15	2.61	1.19	1472.7	1119.1	24.0
DBW71(C)	1.61	0.76	0.14	1.05	-0.14	1.40	-0.20	1.26	1436.4	1070.2	25.5
WH730(C)	0.62	1.56	0.03	1.09	1.68	1.19	1.46	1.32	1264.2	927.5	26.6
HI1605(C)	1.19	1.61	0.05	1.01	1.10	4.16	-0.23	1.48	1411.4	987.6	30.0
AKDW2997-16(d)(C)	0.93	1.39	0.16	0.71	1.76	0.61	4.87	0.90	1410.1	1153.7	18.2
HI8713(d)(C)	1.32	1.09	0.19	1.53	1.25	1.50	0.34	1.02	1441.6	1144.9	20.6
HI8805(d)(C)	1.40	1.13	-0.03	1.25	0.87	0.93	-1.52	0.66	1343.3	1164.7	13.3