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SCREENING FOR HIGH TEMPERATURE TOLERANCE IN WHEAT SPECIES THROUGH SEEDLING VIGOUR INDEX AND COLEOPTILE LENGTH

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ABSTRACT

Laboratory experiments to screen wheat genotypes for high temperature tolerance at germination and seedling vigour index indicated a large variation among genotypes in respect of germination, root and shoot development. The germination progressively and significantly decreased with increase in temperature from 25 to 35°C. Shoot length gave a differential response to higher temperature, seedling vigour index obtained by multiplication of root length with germination per cent gives vigour index of seedling under high temperature.

Key words: High temperature, vigour index, coleoptile length, *Triticum* spp.

Wheat is one of the most important food grain crops of the world. Its growth, development and yield is influenced by environmental conditions, such as, temperature, radiation and photoperiod [1]. A proper understanding of the effect of temperature on the growth and development of the wheat plant is essential [2]. The optimum temperature range for germination in wheat was found to be 20–25°C and germination considerably decreased at high temperatures [3].

Rao [4] warned that there is a great need to evolve wheat genotypes having heat tolerance in the five-state peninsular region and central India. With this in view, a study was conducted to screen high temperature tolerance of wheat varieties and to suggest a suitable method for calculation of seedling vigour index for high temperature tolerance.

MATERIALS AND METHODS

A laboratory experiment with three replications was conducted to screen for temperature tolerance of 25 wheat varieties in an incubator using the towel paper method. One hundred seeds were sown in each towel paper.

The 25 genotypes selected for this study included four different species, viz., *T. aestivum*, *T. durum*, *T. dicoccum* and triticale: Ajantha, NI 5439, Kailash (PBN-142), HD 2189, HD 2278, Sonalika, Kalyan Sona, Hindi 62, HI 977, HI 8284, N 8923, PBN 135, N 59, MACS 9, MACS 1967, PBN 525, PBN 633, HD 4502, AKW 38-5, MACS 2317, MACS 2218, DWR 105, DWR 117, Khapli and triticale.

Germination tests were conducted in accordance with the rules of the seed testing (ISTA-1976). Seeds of these genotypes were germinated in towel papers at five temperatures, viz., 15, 20, 25, 30 and 35°C $\pm$ 1°C.

The observations on germination and root and shoot length was recorded on 11th day after sowing. The seedling vigour index was calculated by the method of Abdul Baki and Anderson [5], in which root length is multiplied by germination per cent.

RESULTS AND DISCUSSION

The germination of wheat seed progressively and significantly decreased with increase or decrease in the temperature from 25°C (Table 1). Thus, the germination of wheat seed was significantly lower at higher or lower temperatures than at 25° C and further increase or decrease in temperature progressively and significantly reduced germination percentage.

The germination vigour was expressed in terms of root length (Table 2) and seedling vigour index (Table 3). The varieties differed significantly in respect of mean germination per cent. It was observed that the mean germination was significantly higher in the cultivars Ajantha, Hindi 62 and N 8923, followed by NI 5439, Kailash (PBN 142), N 59, HD 4502, PBN 135, Sonalika, AKW 38-5 and HD 2189, which were at par and significantly superior to the remaining cultivars. The cultivar Khapli (*T. dicoccum*) and DWR 115 were significantly inferior. Further, the cultivars showed differential response to temperature treatments, which was evident from significant interaction effects. Thus, with increase in temperature, the reduction in germination was less marked in the cultivars Ajantha, Hindi 62, NI 5439, Kailash (PBN 142), N 59, MACS 2218, MACS 2317, HI 977 and AKW-38-5. Thus, the genotypic differences exist in respect of temperature tolerance in the rate of emergence among the wheat varieties, as reported earlier [3]. It was, therefore, suggested that the selection for temperature tolerance is possible. In the present case, among the genotypes studied, the cultivars Ajantha, Hindi 62, NI 5439, Kailash (PBN 142), N 59, MACS 2218, MACS 2317, HI 977 and AKW-38-5 are the most temperature tolerant genotypes at germination.

The root length measured on the 11th day of sowing showed significant differences both genotypically and treatmentwise. The cultivar Ajantha showed less root length due to increase in temperature and, consequently, the vigour index is very low. The results further indicated that N 8923, N 59, MACS 9, MACS 2317, Sonalika, HI 977, Hindi 62, HD 2189, NI

Table 1. Germination (%) of wheat genotypes at different temperatures

Variety	15°C	20°C	25°C	30°C	35°C	Mean
Ajantha	98.6	99.8	99.8	95.7	91.0	97.0
NI 5439	96.5	98.0	98.0	87.4	86.8	93.4
Kailash(PBN-142)	98.4	98.9	99.2	93.5	87.7	95.6
HD 2189	93.1	97.3	99.2	94.3	90.4	94.9
HD 2278	96.0	97.0	98.3	94.7	84.4	94.1
Sonalika	95.7	97.4	97.7	97.0	89.3	95.4
Kalyan Sona	95.1	94.0	95.0	92.8	86.0	92.6
Hindi 62	97.3	98.0	99.7	94.2	91.7	96.2
HI 977	90.0	92.0	95.4	92.0	88.7	91.6
HI 8284	84.7	96.4	98.7	97.0	91.0	91.6
N 8923	97.7	98.9	98.7	97.7	95.0	97.6
PBN 135	97.9	98.7	98.7	93.5	87.7	95.3
N 59	98.1	98.3	98.3	96.7	86.3	95.5
MACS 9	95.9	96.7	98.4	90.4	90.1	94.3
MACS 1967	97.0	98.1	98.1	97.2	72.4	92.6
PBN 525	95.1	98.1	98.4	95.3	70.0	91.4
PBN 633	95.2	95.2	96.4	95.0	72.1	91.2
HD 4502	97.7	98.0	998.7	95.0	88.4	96.2
AKW-38-5	94.0	96.0	98.4	96.7	93.5	95.7
MACS 2218	89.3	90.1	90.7	93.4	88.7	90.4
MACS 2317	92.8	93.9	94.9	93.3	92.3	93.5
DWR 105	87.7	90.4	94.7	93.4	82.0	89.6
DWR 115	85.0	87.8	91.1	87.1	79.5	86.1
Khapli	84.0	86.0	88.7	77.7	76.7	82.6
Triticale	92.8	96.5	97.4	85.8	72.0	88.9
Mean	94.6	95.6	97.3	93.5	86.0	
	Variety (V)		Temperature (T)		V x T	
SE (±)	0.7		0.3		1.5	
CD at 5%	1.8		0.8		4.2	

5439 and Ajantha had good vigour index even at higher temperatures. Therefore, it could be concluded that among the genotypes tested, N 8923, N 59, MACS 9, MACS 2317, Sonalika, HI 977, Hindi 62, HD 2189, NI 5439 and Ajantha are the most tolerant to higher temperatures.

Coleoptile length in wheat is reported to be closely related with the field emergence [7]. The genotypes with longer coleoptile gave better emergence and this forms a criterion for selection on the basis of field emergence. In the present study, maximum coleoptile length

Table 2. Mean root length (cm) of wheat genotypes as influenced by temperature

Variety	15°C	20°C	25°C	30°C	35°C	Mean
Ajantha	9.8	15.4	19.0	16.5	12.7	14.7
NI 5439	14.8	16.8	19.5	13.7	10.8	16.1
Kailash (PBN-142)	9.7	15.8	20.9	13.3	9.6	13.9
HD 2189	14.1	16.9	21.4	14.7	10.1	15.4
HD 2278	14.5	16.9	19.3	13.9	10.1	14.8
Sonalika	16.7	18.1	20.2	14.9	9.7	15.9
Kalyan Sona	13.9	16.1	20.5	12.3	9.8	14.5
Hindi 62	10.7	14.5	19.3	13.9	9.9	13.6
HI 977	16.2	17.1	18.9	14.4	12.3	15.8
HI 8284	15.7	15.8	15.9	15.8	7.7	14.2
N 8923	20.0	20.3	20.8	17.2	10.3	17.7
PBN 135	9.8	16.6	20.8	13.3	9.7	14.0
N 59	17.1	18.4	19.0	14.6	8.9	15.6
MACS 9	15.7	18.1	21.1	16.2	8.5	15.9
MACS 1967	13.8	16.7	20.3	14.9	8.1	14.8
PBN 525	10.6	13.3	19.5	13.3	8.2	13.0
PBN 633	17.1	18.7	20.4	16.1	7.9	16.0
HD 4502	14.2	14.6	20.5	15.8	9.6	14.9
AKW-38-5	16.1	17.7	19.6	16.5	10.1	16.0
MACS 2317	17.6	18.3	19.3	17.6	10.8	16.7
MACS 2218	16.7	17.1	18.3	13.5	17.8	14.7
DWR 105	14.7	17.2	19.1	15.2	8.1	14.7
DWR 115	14.1	16.4	16.6	13.9	8.2	14.0
Khapli	12.9	14.1	15.9	11.1	7.2	12.3
Triticale	10.7	15.5	21.4	13.4	8.8	13.9
Mean	14.3	16.7	19.5	14.7	9.4	
	Variety (V)		Temperature (T)		V x T	
SE (±)	0.1		0.1		0.6	
CD at 5%	0.3		0.3		1.8	

was recorded in the seedlings grown at constant temperature of 25°C–30°C. The coleoptile length considerably decreased at higher temperatures.

In the present study, MACS 2218, AKW 38-5, DWR 105, DWR 115 showed greater coleoptile length as compared with the check cv. Hindi 62. Genotypes Ajantha, NI 5439, Kailash (PBN 142), HI 977, N 8923, PBN 135, Khapli, triticale, and HD 4502 had longer coleoptiles than the check HD 2189. Kalyan Sona and PBN 633 developed shorter coleoptiles than all other genotypes. Among the different wheat species, it was observed that *T. durum*

Table 3. Mean seedling vigour index (germination per cent x root length) in wheat genotypes at different temperatures

Variety	Seedling vigour index at different temperatures					
	15°C	20°C	25°C	30°C	35°C	Mean
Ajantha	970.4	1539.5	1901.3	1581.3	1152.7	1429.0
NI 5439	1434.5	1648.3	1910.9	1200.0	941.5	1427.1
Kailash (PBN-142)	951.4	1563.8	2067.7	1245.8	847.2	1335.1
HD 2189	1316.4	1646.3	2123.8	1384.9	911.9	1476.7
HD 2278	1301.4	1642.7	1891.9	1320.5	856.2	1402.6
Sonalika	1500.73	1763.7	1974.1	1449.6	867.4	1529.1
Kalyan Sona	1307.4	1518.0	1943.5	1136.7	844.4	1349.9
Hindi 62	1040.1	1418.7	1906.4	1307.8	911.8	1316.9
HI 977	1461.2	1577.8	1802.1	1332.4	1090.3	1452.7
HI 8284	1322.8	1368.5	1564.5	1532.2	700.6	1297.7
N 8923	1954.7	2011.2	2056.5	1673.7	985.1	1738.2
PBN 135	965.3	1633.4	2058.6	1246.2	849.0	1350.5
N 59	1680.8	1810.1	1877.9	1462.9	762.6	1511.8
MACS 1967	1352.2	1642.5	1991.0	1448.4	589.3	1404.7
PBN 525	1008.8	1303.7	1924.8	1266.6	576.6	1216.1
PBN 633	1629.9	1798.4	1965.8	1528.8	577.5	1500.1
HD 4502	1392.2	1433.0	2026.8	1506.0	848.0	1441.2
AKW-38-5	1507.6	1699.2	1924.5	1598.4	948.7	1535.7
MACS 2317	1637.4	1710.4	1828.7	1637.3	998.1	1562.4
MACS 2218	1497.2	1541.1	1657.2	1268.9	694.6	1331.8
MACS 9	1495.6	1779.9	2057.9	1462.8	762.6	1511.8
DWR 105	1285.4	1553.4	1808.2	1426.3	666.2	1348.0
DWR 115	1282.9	1441.3	1510.1	1207.3	648.7	1218.1
Khapli	1081.1	1256.9	1413.2	861.7	553.5	1033.3
Triticale	996.6	1491.8	2082.1	1149.6	638.2	1271.6
Mean	1338.5	1591.8	1890.8	1367.8	809.1	
	Variety (V)		Temperature (T)		V x T	
SE (±)	27.5		12.3		61.6	
CD at 5%	76.3		34.1		170.7	

and *T. dicoccum* had longer coleoptiles as compared to the *T. aestivum*.

The maximum coleoptile length of 8.5 cm was recorded at 30° C, which was significantly superior over the remaining temperature treatments. The minimum coleoptile length (4.3 cm) was observed at 15°C, which was at par with the 20°C treatment. Genotypic differences for coleoptile length in response to temperature were reported earlier also [7–9].

Table 4. Mean coleoptile length (cm) in wheat as influenced by temperature

Variety	15°C	20°C	25°C	30°C	35°C	Mean
Ajantha	4.7	5.4	5.6	5.6	5.5	5.4
NI 5439	4.7	4.7	4.9	5.7	5.7	5.1
Kailash (PBN-142)	3.2	3.8	3.9	4.6	4.7	4.1
HD 2189	3.5	3.5	3.6	4.5	4.3	3.9
HD 2278	3.6	3.9	4.1	4.5	4.4	4.1
Sonalika	4.0	4.1	4.1	5.0	4.8	4.4
Kalyan Sona	4.3	3.3	4.7	3.8	4.3	3.7
Hindi 62	5.4	5.7	6.1	6.8	7.0	6.2
HI 977	5.3	3.8	3.9	4.4	4.2	4.3
HI 8284	5.4	5.5	5.6	5.6	5.5	5.5
N 8923	4.9	4.9	4.8	4.5	4.3	4.7
PBN 135	3.4	3.8	3.9	4.6	4.8	4.1
N 59	4.9	5.2	5.6	6.8	6.4	5.8
MACS 9	5.1	5.4	5.8	5.8	6.1	5.6
MACS 1967	4.8	5.2	5.9	6.3	6.1	5.7
PBN 525	5.1	5.9	6.1	6.7	6.2	6.0
PBN 633	3.4	3.6	3.7	3.8	4.9	3.9
HD 4502	3.7	3.7	3.8	4.1	4.8	4.0
AKW-38-5	6.8	7.3	7.0	6.7	6.2	6.8
MACS 2317	5.6	5.9	6.2	6.1	5.6	5.9
MACS 2218	8.3	8.4	8.9	8.5	7.4	8.3
DWR 105	6.9	6.6	6.4	6.3	5.4	6.3
DWR 115	7.8	6.9	6.6	6.1	5.5	6.6
Khapli	5.0	5.1	5.6	6.1	6.5	5.7
Triticale	4.5	5.2	5.3	5.1	6.6	5.9
Mean	4.9	5.1	5.2	5.5	5.4	
SE ± (G x T)	0.27					
CD at 5%	0.76					

The treatment of MACS 2218 at 25°C, recorded the highest coleoptile length (8.9 cm) and was at par with MACS 2218 exposed to 30°C, 20°C and 15°C, and was significantly superior to the remaining treatments.

In the present investigation, the coleoptile growth was not influenced by temperature. Therefore, seedling vigour index would be a proper criterion for heat tolerance studies in wheat, and the new formula, i.e. germination per cent multiplied by shoot length, would give a better assessment of seedling vigour index under high temperature.

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