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# High Temperature Stress: Effects on Seed Germination, Seedling Growth in Wheat

Shubhra Barwa

Department of Botany and Plant Physiology, CCS HAU Hisar-125001.

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**ABSTRACT**

The present investigation was aimed at screening twenty diverse wheat genotypes for their thermo tolerance potential at the seedling stage. The seedlings were raised in the germination boxes kept at 25°C in an incubator. One week old seedlings were subjected to gradual heat pre-treatment (with rise of 5°C/ hr) to achieve 35°C ±1°C. The acclimatized seedlings were exposed to 40°C for different durations to find lethal temperature ($LT_{50}$ ), on the basis of wilting of the primary leaf. Wheat seedlings reacted differently to high temperatures in terms of the coleoptile length and seedling emergence. On an average coleoptile length (C.L) decreased by 29% and total shoot length (T.S.L) by 12% due to high temperature pulse in wheat. Highest decline in C.L was noted in NIAW34 (54%) and minimum 6% in WH711. In terms of the T.S.L maximum decrease was noted in P1626 (34%) and minimum in WH712 (0.70%). The detrimental effect of high temperature on the seedling emergence also got reflective in terms of the growth parameters resulting in reduction of fresh and dry weight of the seedlings. On an average seedling fresh weight reduced by 64%, dry weight by 74% and RWC by 20% due to high temperature pulse in wheat.



## Introduction

Wheat is an important cereal crop grown in diverse agro-ecological conditions ranging from temperate to sub-tropical climate. On the global scale it provides nourishment to more number of people than any other food crops and is an excellent food even though its grain is deficient in essential amino acid such as lysine. Different wheat genotypes respond to abiotic stresses differently. Moisture and temperature are the two most important inputs for the germination of seed. High temperature affects crop productivity by adversely affecting seed germination, seedling growth, grain formation and grain development. The influence of high temperature on the growth and development of crops is well documented (wheeler et al 2000).The maximum to minimum temperatures can effect from seed germination to maturation (Lobell and Ortiz-Monasterio, 2007).Wheat selections react differently to heat stress in terms of coleoptile length and seedling emergence (Burleigh et al, 1964). Wheat has a lethal low temperature of Grain-filling Tmin −17.2±1.2°C, and a lethal high temperature of 47.5°C (Mehmooda buriro et al ,2011). Allan et al, 1962 reported that temperature above 32°C reduce wheat coleoptile length by inhibiting the cell elongation. Wheat seedling growth and vigor is especially temperature sensitive. The final mass of wheat seedlings declined at temperatures above 22°C while phasic development accelerated (Maestri et al,2002).Long term effects of high temperature stress in developing seed were lower seed germination quality ,delayed germination and loss of seed vigor (Abrol and Ingram,1996).

## Material and Method:

The present study was carried out to assess thermo-tolerance potential of the seedlings of the twenty diverse wheat genotypes. Grains of the above twenty wheat genotypes were grown at 22.5±1°C in an incubator. Seven days old seedling were subjected to gradual temperature pretreatment (with rise of 5°C/hr) to achieve 35±1°C. These acclimatized seedlings were exposed to 40°C for different durations to find Lethal temperature ($LT_{50}$) on the basis of wilting of the primary leaf. Coleoptile length was determined as the distance from scutellum to where leaf one had broken through the tip of coleoptile. Total shoot length was recorded as distance from bottom to tip of the shoot excluding the root portion. Both coleoptile and total shoot length were expressed in centimeter. For each genotype, fresh weights of wheat seedlings were determined separately. For dry weights, the plant samples were dried at 60±1°C in oven for 72 hrs to obtain constant weight. The samples were weighed and data express as mean of three replicates for each genotype and for each date of sowing. The data was statistically analyzed using factorial randomized block design.

## Results:

Overall, coleoptile length of the seedling 29% due to high temperature stress (40°C for 4 hrs) in wheat (Figure 1).

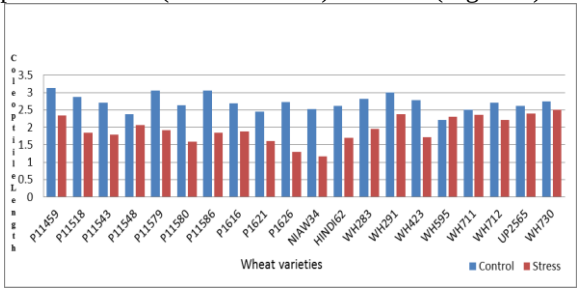


**Figure1.Varietal performance for Coleoptile length (cm) after high temperature pulse (40°C, 4 hrs) in wheat.**

**Tele:**

**E-mail address: shubhraiari@gmail.com**

**C.D. at 5% T 0.22, V 0.69 TXV NS T = High temperature treatment; V = Varieties; TxV = Interaction between T and V**

Under control conditions highest seedling coleoptile length was noted in P11459 (3.13 cm) and lowest in WH595 (2.21 cm). After stress treatment, seedling coleoptile length was highest in WH730 (2.50 cm) and lowest in NIAW34 (1.17 cm). Maximum decrease in seedling coleoptile length due high temperature pulse was found in NIAW34 (54%) and minimum (6%) in WH 711.

Decline in total shoot length (approximately 12%) was noted after high temperature pulse (Figure 2). In control plants, total shoot length was highest in WH730 (16.67cm) and lowest in P11548 (11.12 cm). After high temperature pulse (40°C for 4 hrs), TSL was highest in WH730 (15.10 cm) and lowest (8.34 cm) in P1626. Maximum decline in total shoot length due to high temperature pulse was noted in P1626 (34%) and minimum (0.70%) in WH712 variety of wheat.

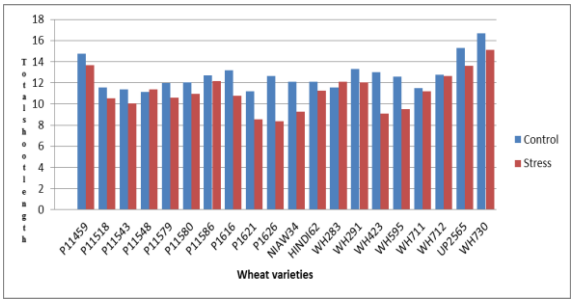


**Figure2. Varietal performance for Total shoot length (cm) after high temperature pulse (40°C, 4 hrs) in wheat.**

**C.D. at 5% T 0.65 V 2.05 TXV 2.90**

**Seedling Fresh and Dry weights**

Approximately 64% decline in seedling fresh weight was observed after stress in wheat (Figure 3). Under control conditions, fresh weight of seedling was highest (1.56 g) in WH 423 and lowest (0.93 g) in WH595. After high temperature pulse (40°C for 4 hr), maximum seedling fresh weight was noted in WH730 (0.91 g) and minimum (0.09 g) in P11548. Due to stress seedling fresh weight declined upto maximum extent (92%) in P11548 and to minimum extent (28%) in WH711.

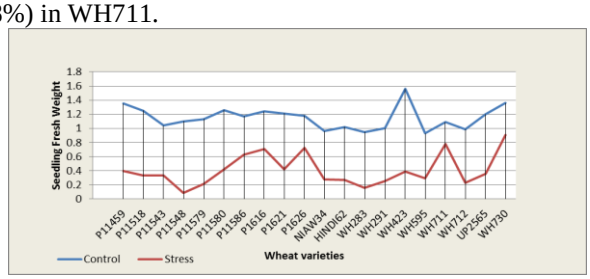


**Figure3. Varietal performance for Seedling Fresh weight (g) after high temperature pulse (40°C, 4 hrs) in wheat.**

**C.D at 5 % T 0.12 V 0.31 TXV NS**

Overall, reduction upto 74% in seedling dry weight was noted (Figure 4).

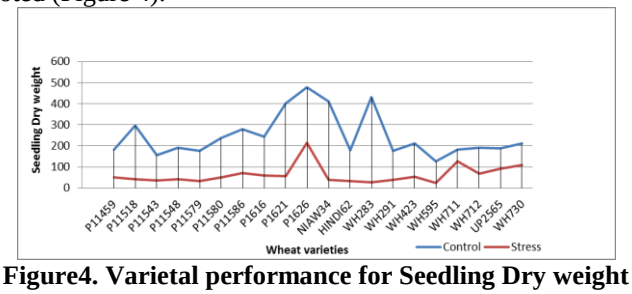


**Figure4. Varietal performance for Seedling Dry weight (g) after high temperature pulse(40°C, 4 hrs) in wheat.**

**C.D at 5 % T 0.05 V 0.17 TXV 0.25**

In control plants, seedling dry weight was highest (477 mg) in P1626 and lowest (127 mg) in WH595. Under stress conditions, maximum seedling dry weight was noted in P1626 (213 mg) and minimum (23 mg) in WH 595. Due to heat shock, decrease in seedling dry weight was highest in WH283 (94%) and lowest (30%) in WH711.

**Seedling Relative Water Content, RWC (%):**

Seedling RWC declined approximately 20% under stress relative to control (Figure 5). In control conditions, highest RWC was noted in WH 730 (87.80%) and lowest (75.88%) in NIAW 34. In stressed plants, again maximum RWC was observed in WH730 (73.04%) and minimum in NIAW 34 (53.01). Highest decrease in RWC due to high temperature pulse was noted in P1621 (32%) and lowest in WH711 (8%). RWC improved 13% after overnight revival of stressed plants. After revival, RWC was found to be highest in WH730 (89.86%) and lowest (57.28%) in WH423. On revival, maximum improvement in RWC relative to stress was found in WH283 (24.65%) and minimum in WH423 (4.44%).

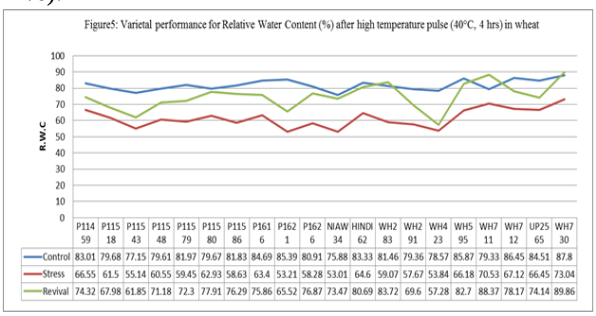


**Figure 5. Varietal performance for Relative Water Content(%) after high temperature pulse(40°C, 4 hrs) in wheat.**

**C.D. at 5% T 3.19 V 10.08 TXV 14.30**

**Discussion**

Wheat selections react differently to high temperature stress in terms of coleoptile length and seedling emergence (Burleigh *et al.*, 1964). In wheat high temperature beyond 30°C decreases germination (Avecedo *et al.*, 1991; Behl, 1996) leading to poor crop stand. Among the growth parameters coleoptile length decreased due to high temperature stress (Figure 1) The inhibitory effect of high temperature on plumule and radicle growth (Gupta *et al.*, 1987) might lead to reduced coleoptile length (Behl *et al.*, 1993) and consequently overall effect is reflected in poor emergence. The final mass of wheat seedlings declined with temperature above 22°C while phasic development accelerated (Maestri *et al.*, 2002). Due to high temperature at seedling emergence total shoot length, fresh weight and dry weight of the seedling also decreased in the wheat cultivars (Figure 2 – 4). High temperature stress adversely affects the plant water status (Kobza and Edwards, 1987). The effects of high temperatures stress are confounded with those of water stress which usually accompanies it and further results in decreased water potential of the plant (Ahmed *et al*, 1989; Shubhra et al, 2004).This indicates that detrimental effect of high temperature stress at early growth stage further reproduces itself in terms of other growth parameters as well and have a detrimental effect on the overall development and yield of the plant (Shubhra et al, 2006).

**Conclusion**

These results presented here suggest decrease in coleoptile length (6 – 54%), total shoot length (0.70 – 34%),

seedling fresh weight (28 – 90%) and seedling dry weight (30 – 94%) after three hours of high temperature stress (40°C) in wheat.The results presented in the present study were then assessed under field conditions with same wheat genotypes where HT conditions were induced by delaying the sowing of the wheat by over a month, but they did not correlate with those of field studies. The effect of HT stress was more acute under laboratory conditions when high temperature was applied gradually (with rise of 5°C/hr) followed by high temperature pulse of 40°C for 3-4 hours, than given by manipulation of sowing date in field studies. Moreover, variability for thermo tolerance was seen in wheat varieties under both field and laboratory studies. Thus more research needs to be carried out to quantify the interactions between HT stress, growth parameters an and soil water availability along wheat germ plasm and among different species of wheat to set the potential adaptation strategies adopted by plant to overcome the negative effects of high temperatures during germination and initial stages of growth.

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