# Canopy Temperature Depression for Drought Resistance Selection in Wheat


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Canopy temperature depression (CTD) is an easily measured manifestation of crop metabolic and physiologic response to the environment. Among other things, CTD can be used to distinguish stress tolerant wheat genotypes from stress intolerant ones. Typically, breeding programs have too many entries to continuously monitor each one for CTD. Instead, they often use periodic sampling schemes with handheld infra-red thermometer (IRT) guns. Information is therefore needed on the optimum time of sampling to obtain the largest probability of detecting genotypic differences.

## Objective

Determine optimum timing of CTD sampling for determination of genotypic differences to stress tolerance in wheat.

## Methods

Three BC3-generation sister lines (TX86A5606, TX88A6880 and TX86A8072) have been identified as sensitive, medium and resistant, respectively, to drought (Table 1). Canopy and air temperatures were continuously measured using thermocouple infrared thermometers (model Irt/c, 2-T-80, Exergen Corp., Newton, MA) and recorded with a data logger (model 21X, Campbell Sci. Inc., Logan, UT) (see below photo). CTD was recorded from booting to fifteen days after flowering, approximately 30 days, in 2000 and from heading to forty days after flowering, approximately 60 days, in 2001. At maturity grain yield and total biomass were measured for each plot.

**Table 1**. Mean yields of three genotypes at Bushland, Tx

| Mean over 1992-2000 time period (bu/a) | | |
|---|---|---|
| Line | Rainfed | Irrigated |
| TX86A8072 | 36.7a | 88.9b |
| TX88A6880 | 33.1ab | 91.4ab |
| TX86A5606 | 29.5b | 95.0a |

## Results and Discussion

Significant and consistent differences among genotypes were observed for CTD in both years (Figure 1) despite high interactive effects for genotype x hour, genotype x day, and genotype x year. Similar to grain yield data (Table 1), CTD of TX 88A6880 was significantly different from TX86A8072 in 2000, but not in 2001.

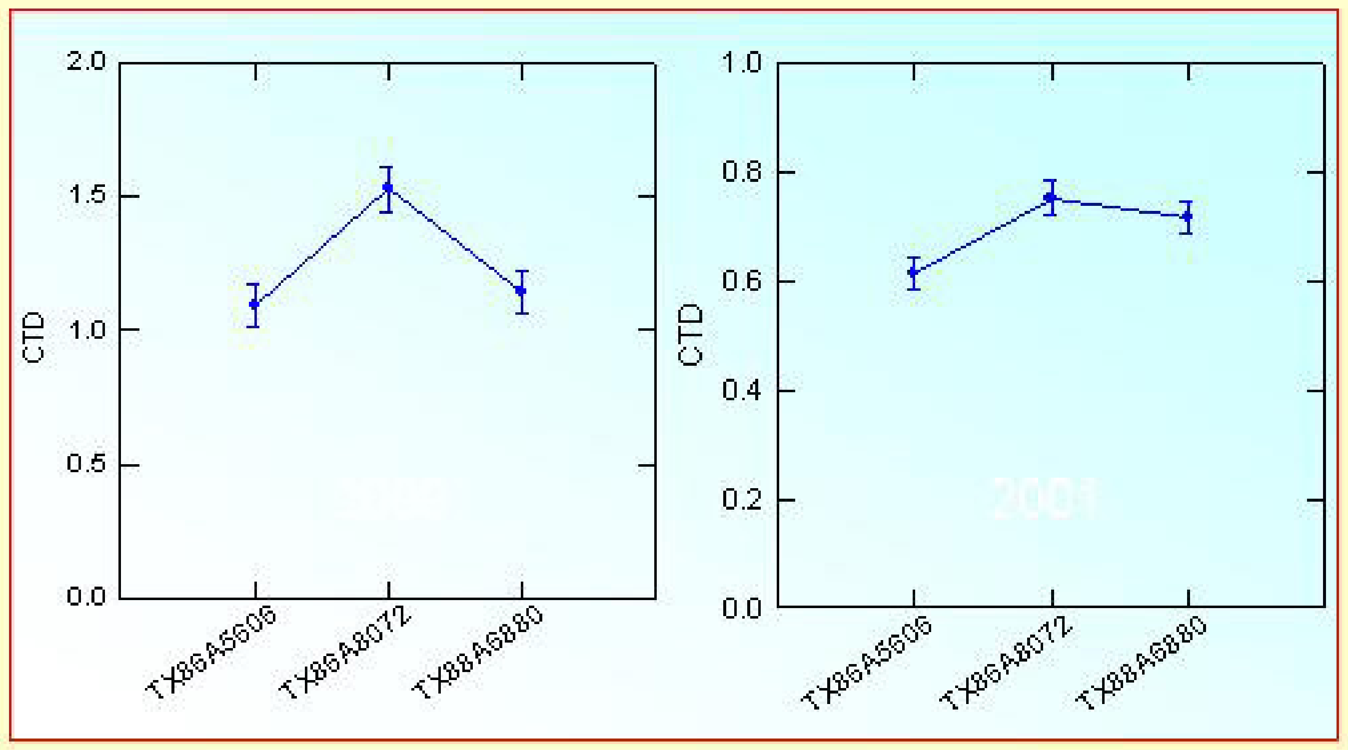


**Figure 1**. Mean values of CTD in three closely related lines of wheat under dryland.

TX86A5606 TX88A6880 TX86A8072

Photographs of the three wheat varieties taken on May 2nd (above) and May 31st (below) 2001.

Significant differences for biomass and grain yield were also obtained (data not shown). Both yield and biomass were correlated with CTD (Figure 2). The grain yield varied between 226 and 348 $g/m^2$ with a CTD range of approximately 2.5 °C in 2000 and between 485 and 621 $g/m^2$ with a range of 0.7 °C in 2001.

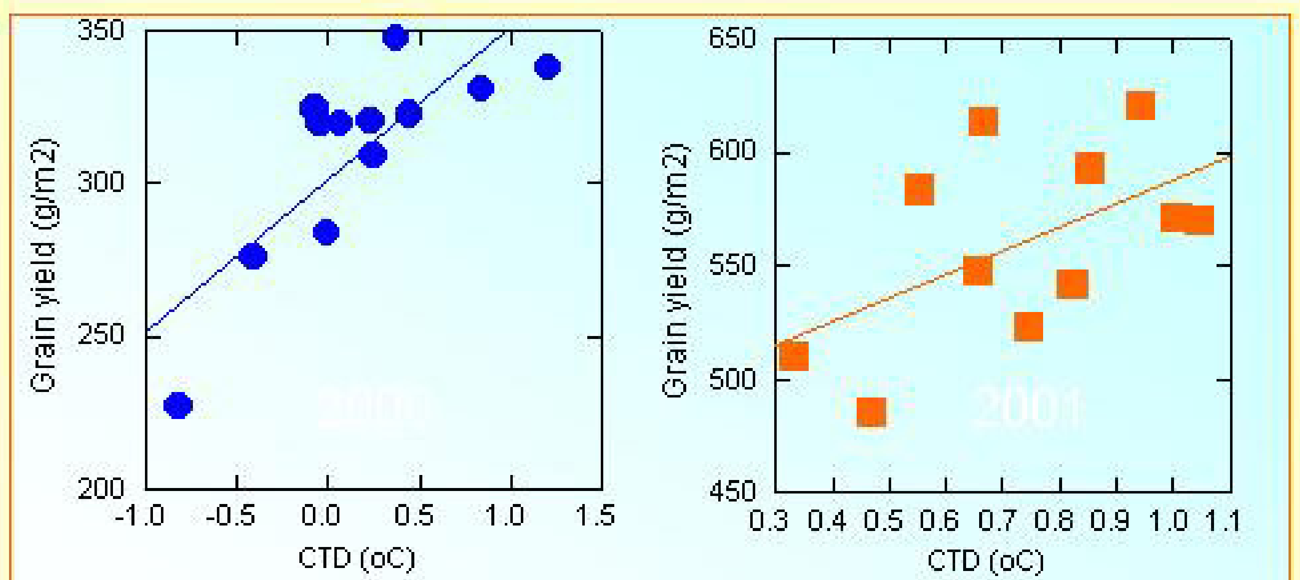


**Figure 2**. Correlation of grain yield with mean seasonally daily CTD measured in 2000 (left) and 2001 (right) ($p \leq 0.01$ and 0.10, respectively).

During the day, CTD varied from negative values (i.e., canopy temperature > air temperature) to positive values (Figure 3). Canopy temperature was as much as 10 °C lower than air temperature during evening hours. Daily cumulative differences among genotypes were consistently 7.6 and 6 °C in 2000 and 2001, respectively. When canopy temperatures of the three genotypes at noon were summed over the measurement period, TX88A6880 and TX86A5606 had accumulated 68 °C h and 218 °C h more heat units, respectively, than TX86A8072.

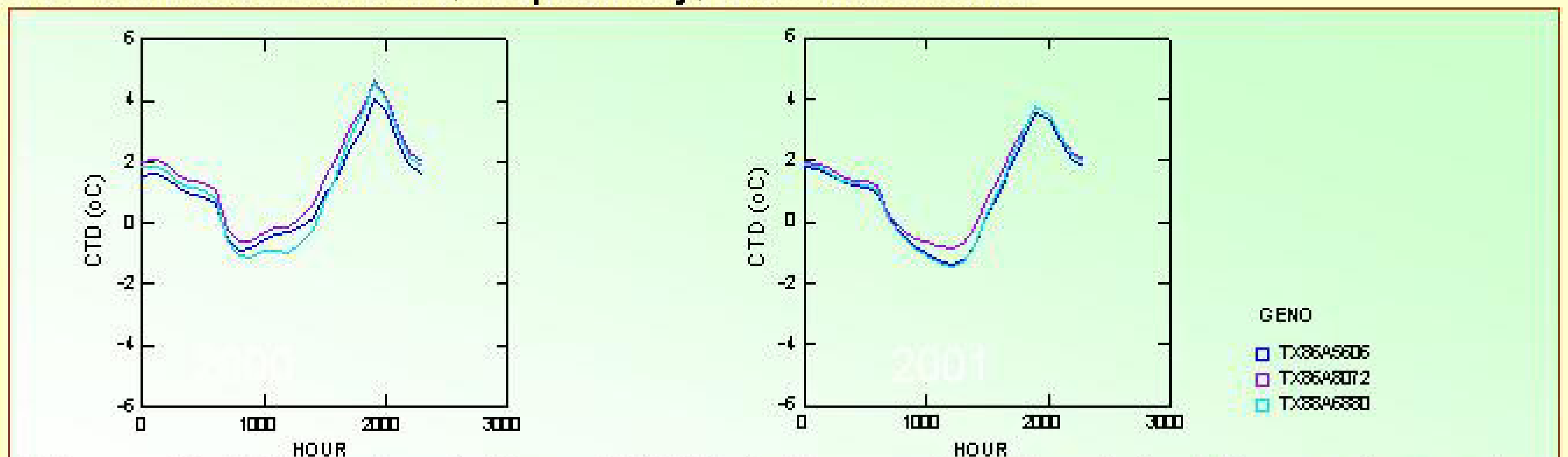


**Figure 3**. Diurnal variation of CTD in three closely related lines of wheat under dryland. CTD is presented as means over seasons.

In 2000, a more consistent ranking of the genotypes was observed when sampling pre-dawn. Unfortunately, in 2001 differences between genotypes were not statistically significant at this time of day. After-dawn, the resistant genotype, TX86A8072, showed consistently greater CTD than the other genotypes. However, for TX88A6880 and TX86A5606, it was not clear whether the decrease of CTD at noon or at 7 p.m. should be considered. The behavior of these two genotypes suggests that they may exhibit different mechanisms of adaptation to water deficit, observable using CTD.

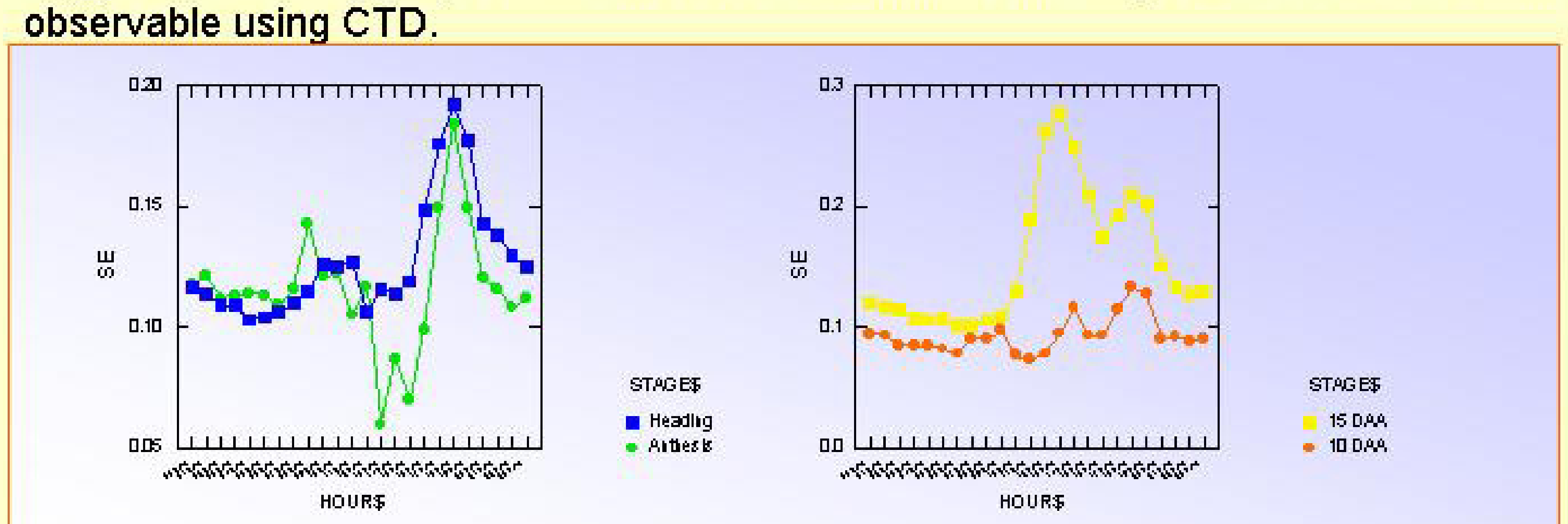


**Figure 4**. Diurnal variation of SE of CTD means at four physiological stages in 2000.

Diurnal variation of standard error (SE) of CTD (Figure 4) in the year 2000 suggested that the best time to sample in order to detect genotypic differences most uniform sampling time for canopy temperature may be pre-dawn for all physiological stages.

The period from noon to 4 p.m. has been proposed as the optimum time for observing canopy temperature response to heat stress. However, when comparing CTD measured at 2 p.m., 3 p.m., and 4 p.m. versus 3 a.m., 4 a.m., and 5 a.m., our data from 2000 year show that the only time when genotype x hour, genotype x day, and genotype x hour x day interactions are not significant is pre-dawn (Table 2).

**Table 2**. Anova for the effect of sampling time on CTD.

| | | Pre-dawn | | After-dawn | |
|---|---|---|---|---|---|
| Source of variation | df | Mean-Square | P | Mean-Square | P |
| Genotype | 2 | 2.204 | 0.001 | 6.292 | 0.001 |
| Hour | 2 | 0.825 | 0.001 | 30.023 | 0.001 |
| Day(Developmental stage) | 3 | 0.524 | 0.001 | 12.189 | 0.001 |
| Genotype*Hour | 4 | 0.000 | 0.999 | 0.325 | 0.004 |
| Genotype*Day | 6 | 0.011 | 0.959 | 0.149 | 0.093 |
| Hour*Day | 6 | 0.37 | 0.001 | 0.426 | 0.000 |
| Genotype*Hour*Day | 12 | 0.000 | .999 | 0.007 | 0.999 |
| Error | 108 | 0.042 | | 0.080 | |


**Summary**: Our data suggest that the optimal time to observe genotypic differences for CTD, and minimize G x E interaction, is pre-dawn. Further studies are required to confirm the generality of this observation. If confirmed, the ability of modern instrumentation to remotely and automatically measure CTD would make this a practical technique for use by breeding interested in screening for drought or heat stress tolerance.



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