

## SHORT COMMUNICATION

**CANOPY TEMPERATURE DEPRESSION AS AN INDICATION OF CORRELATIVE MEASURE OF SPOT BLOTCH RESISTANCE AND HEAT STRESS TOLERANCE IN SPRING WHEAT**U.R. Rosyara<sup>1,4</sup>, D. Vromman<sup>2</sup> and E. Duveiller<sup>3</sup><sup>1</sup> Institute of Agriculture and Animal Science, GPO Box 1571, Rampur, Chitwan, Nepal<sup>2</sup> Unité de Phytopathologie, Université Catholique de Louvain, Croix du Sud, Louvain-la-Neuve, Belgium<sup>3</sup> CIMMYT International, D.F., Mexico<sup>4</sup> South Dakota State University, Plant Science Department, Box 2140C, Brookings, SD 57007, USA**SUMMARY**

Heat stress and spot blotch disease are most important stresses in non-traditional tropical wheat-growing areas causing significant yield losses and covering more than twenty five million hectares of land worldwide. These two stresses are supposed to be associated complicating development of tolerant genotypes. The current study was done with the objective of assessing potential application of canopy temperature depression (CTD) as an integrative trait for screening spot blotch resistance and heat stress tolerance. Ten genetically diverse genotypes with different level of resistance to spot blotch were grown both heat stressed (late sowing) and non-stressed (timely sowing) field conditions during 2002-2003 at Rampur and Bhairahawa, Nepal. Canopy temperature was measured during the different growth stages in fungicide protected and non protected plots using a hand held infrared thermometer and was used to calculate CTD and Area Under CTD Progress Curve (AUCTDPC). A strong negative correlation was observed between AUDPC per day and AUCTDPC ( $r = -0.72^{**}$ ) indicating that foliar blight susceptibility has important role in decreasing AUCTDPC. Genetic differences were observed for both spot blotch resistance and heat stress tolerance, so that genotypes could be categorized into tolerant to either one or both stresses based on AUCTDPC and AUDPC per day readings. AUCTDPC proved to be an integrative trait for both types of stresses and has promise for further application in selection of stress tolerant genotypes in tropical environments.

*Key words:* *Bipolaris sorokiniana*, wheat, canopy temperature, heat stress tolerance, spot blotch, selection criteria.

For wheat, heat stress and spot blotch disease caused by *Bipolaris sorokiniana* Sacc. are the two most important stresses in non traditional, tropical wheat-growing

areas of the world, causing significant yield losses. These two factors affect at least twenty five million hectares of land worldwide (Duveiller and Gilchrist, 1994; van Ginkel and Rajaram, 1998), resulting in premature senescence of the leaves and reduced grain filling duration (Al-Khatib and Paulsen, 1990; Duveiller and Gilchrist, 1994; Joshi *et al.*, 2007; Mercado *et al.*, 2003). Under field conditions, late planting (resulting in heat stress) was found to increase spot blotch severity (Sharma and Duveiller, 2004).

Spot blotch resistance and heat stress tolerance are two important breeding objectives of most of wheat improvement programs of South Asia, however progresses have been very limited due to lack of suitable selection criteria. In the case of spot blotch, breeding programs have identified promising resistance sources although none confers immunity (Ortiz-Ferrara *et al.*, 2003). Interestingly, the best grain yield performance is not necessarily obtained by entries scoring a low AUDPC for spot blotch, which underscores the importance of general adaptation to heat stressed environments.

Deviation of temperature of plant canopies in comparison to ambient temperature, also known as CTD, has been a good criterion for screening heat stress tolerance (Reynolds *et al.*, 1998). CTD was also found to be negatively correlated with disease severity (Eyal and Blum, 1989; Nutter and Aderman, 1987). CTD has caught breeders' attention because it is easy to calculate and can be used to screen large amounts of material in a single day (Brennan *et al.*, 2007). Studies using CTD for the assessment of heat stress tolerance and spot blotch resistance are few. Thus the present investigation aims at identifying potential applications of CTD measurements using infrared thermometry, to assess variation in foliar blight resistance along with heat tolerance as an integrative selection criterion.

Spring wheat genotypes used in the study, i.e. Sonalika (=RR21), Kanchan, BL1473, Nepal297, BL2217, Milan/Sangahi 7, SW89-5422, NL750, PBW343, and Croc, were planted at Rampur and Bhairahawa during 2002-2003 wheat growing season. Date of sowing was normal (27<sup>th</sup> November 2002) and late (29<sup>th</sup> December 2002) at both locations. The plot size was 2 m<sup>2</sup> consisting of four rows 2 m in length. Fertilizers were applied

at the rates of 120, 60, and 40-kg/ha of N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O, respectively. Spreader rows of Sonalika (a highly susceptible cultivar) were planted around each plot for generating inoculum. An Epoxiconazol-based fungicide was sprayed on disease protected plots at the rate of 0.05% a.i. and was applied six times at seven-day intervals starting around 35 days after sowing. The percent of diseased leaf area (DLA) was scored visually on the flag leaf and penultimate leaf (flag leaf minus one). Five scores of spot blotch were recorded at 4 to 7 days interval to calculate the area under disease progress curve (AUDPC). AUDPC and AUDPC per day were calculated according to Duveiller *et al.* (2005).

Canopy temperature measurements were made using a hand-held infrared thermometer (Spectrum Technologies, Plainfield, IL, USA). Five measurements were taken per plot at approximately 0.5 m from the edge of the plot and approximately 0.5 m above the canopy with an approximately 30-60° from the horizontal. Measurements were made within 0-4 days of the date of disease assessment. Canopy temperature readings were not made two days after irrigation and rainfall. Measurements were done between 12:00 to 16:00 hours on cloudless, bright days. Ambient temperatures were measured using the handheld thermometer instantly after five readings in each plot.

CTD and AUCTDPC was calculated using the following formula-  
CTD = Ambient Temperature (AT) – Canopy temperature (CT).

$$\text{AUCTDPC} = \sum_{i=1}^{n-1} \left[ \left( \frac{C_{(i+1)} + C_i}{2} \right) \right] (T_{(i+1)} - T_i)$$

where,

C<sub>i</sub> = CTD reading at date i

T<sub>i</sub> = date on which the CTD was scored

n = number of dates on which CTD was recorded

Standard weather parameters were measured using installed Watchdog Model 425 weather station (Spectrum Technologies, Plainfield, IL, USA). Cumulative growing degree-days (CGDD) was calculated using 0°C as the base temperature from germination of seedlings to physiological maturity, as previously reported by Cao and Moss (1989).

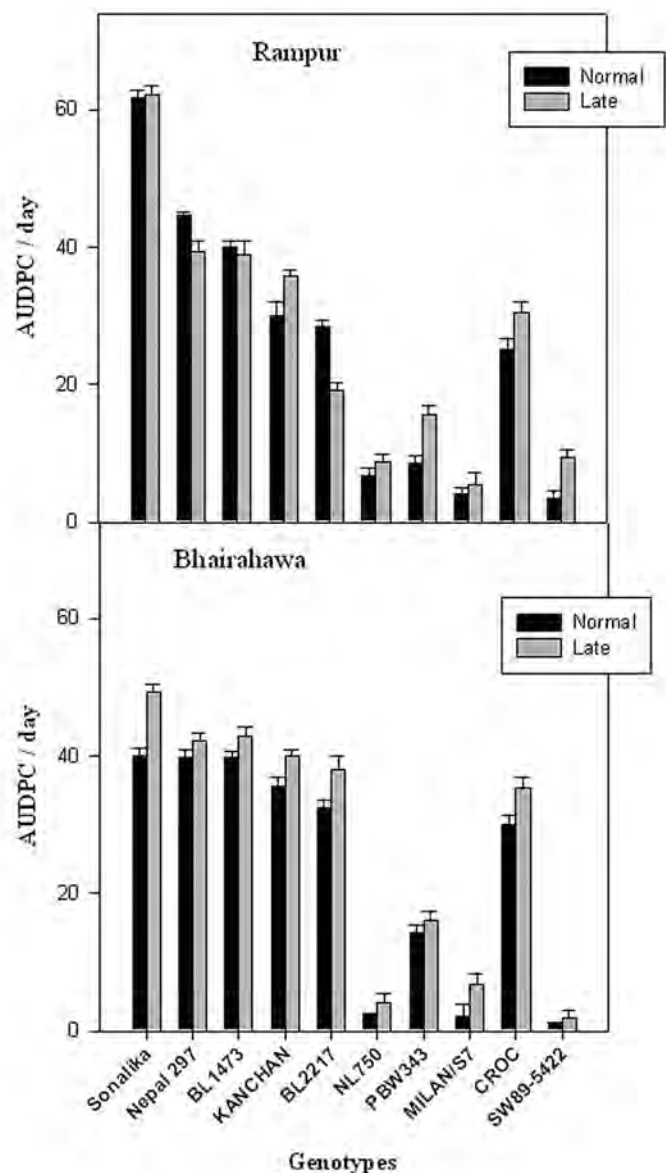
**Table 1.** Pearson's linear correlation between AUDPC per day and AUCTDPC averaged over genotypes in wheat grown during 2002-2003 at Rampur and Bhairahawa, Nepal.

Sowing time	Rampur	Bhairahawa	Overall
Normal sown	-0.82**	-0.72**	-0.79**
Late sown	-0.78**	-0.62**	-0.70**
Overall	-0.80**	-0.65**	-0.72**

\*\* Significant 0.01 probability level

Spot blotch pressure at both locations was high and no other diseases were observed. As expected, late planting induced higher post-anthesis heat stress. The average cumulative growing degree day (from germination to physiological maturity) per plot was higher for late planted wheat (3380 CGDD for Rampur and 3512 CGDD for Bhairahawa) than for normal planting (2780 CGDD for Rampur and 2810 CGDD for Bhairahawa).

Analyses of variance for AUDPC per day and AUCTDPC, showed that the main effects for both environment and genotype were significant (p < 0.05), whereas the genotype x environment effect was not significant (data not presented). The effect of fungicide treatments to protect from disease was significant for both variables. Genotypes NL750, Milan/Shanghai 7, and SW89-



**Fig. 1.** Area under disease progress curve per day among genotypes grown under normal sowing and late sowing conditions under natural epiphytotic of foliar blight grown at Rampur and Bhairahawa in 2002-2003.

5422 proved fairly resistant with low AUDPC per day value, whereas PBW 343 was moderately resistant (Fig. 1).

Foliar blight resistant genotypes had consistently higher AUCTDPC values than susceptible genotypes in both environments and in all conditions (Fig. 2, 3). Differences among genotypes were minimal when they were planted timely and protected with a fungicide to control foliar blight, thus evidencing the impact of foliar blight on AUCTDPC (Fig. 3). Temperature is one of the factors associated with increased infection and disease development caused by *B. sorokiniana* (Duveiller *et al.*, 2005). The maintenance of healthy tissues by plants enables them to maintain a lower canopy temperature which, in turn, helps against the pathogen which requires relatively high temperatures for faster growth and development.

Strong negative correlation was found between foliar

blight scores with AUCTDPC in both locations and sowing conditions (Table 1). A strong negative correlation was observed between AUDPC per day and AUCTDPC ( $r = -0.72^{**}$ ) suggesting that foliar blight susceptibility has an important role in decreasing AUCTDPC, although it cannot be excluded that other components are also involved. Heat stress alone is also expected to reduce AUCTDPC values in late-sown wheat, thereby reducing the correlation between the two parameters. Obviously, heat stress may have a confounding effect with the symptoms of foliar blight (Duveiller and Gilchrist, 1994) or by increasing the temperature of plants without symptoms of senescence. Both components are expected to have adverse effect on photosynthesis.

The results of reduced CTD due to disease are consistent with previous studies for different host-pathogen systems (Eyal and Blum, 1989; Pederson, 1986). Geno-

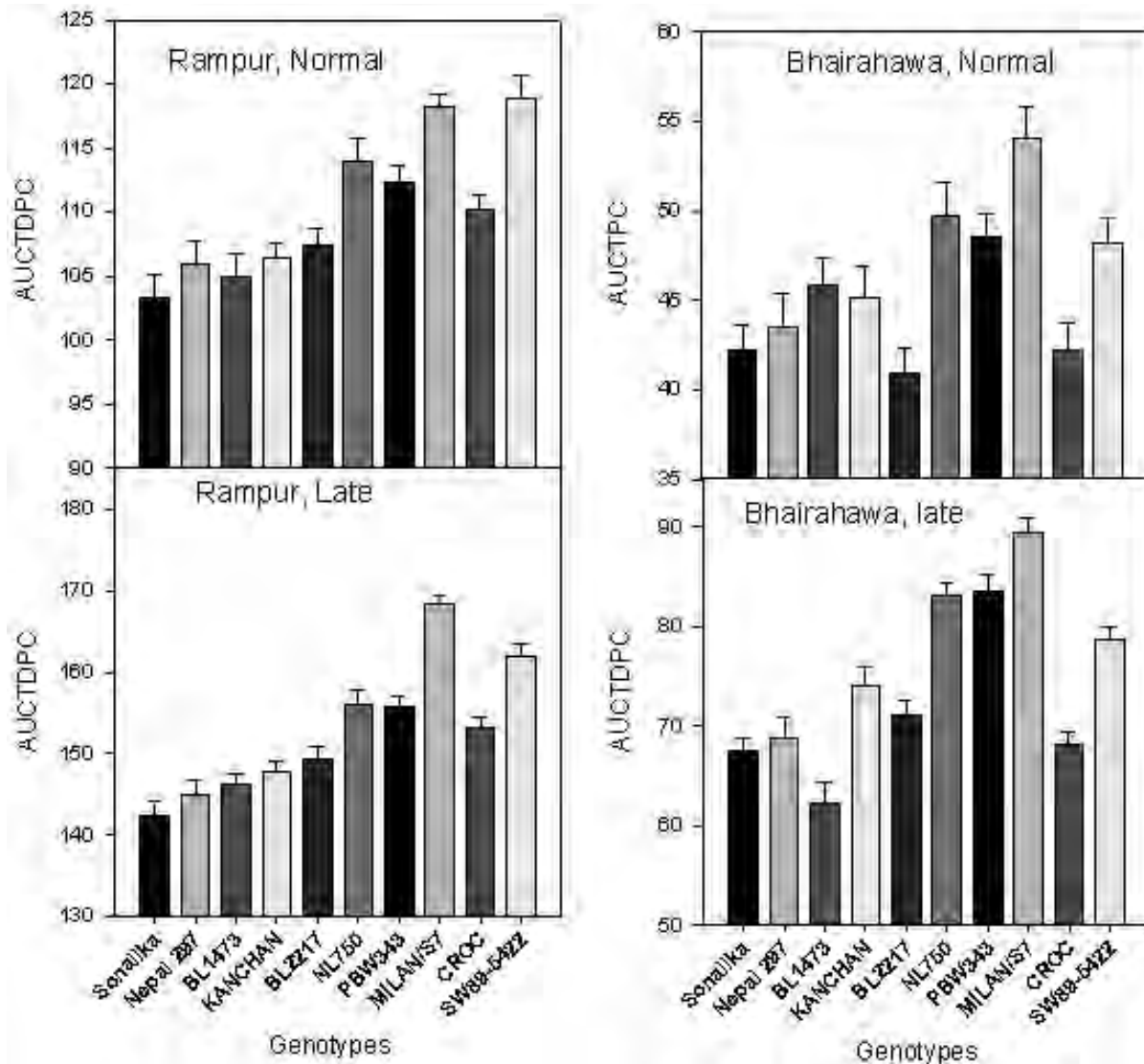


Fig. 2. Area under canopy temperature depression progress curve among genotypes grown under foliar blight-stressed condition planted in normal planting date and late planting date at Rampur and Bhairahawa in 2002-2003.

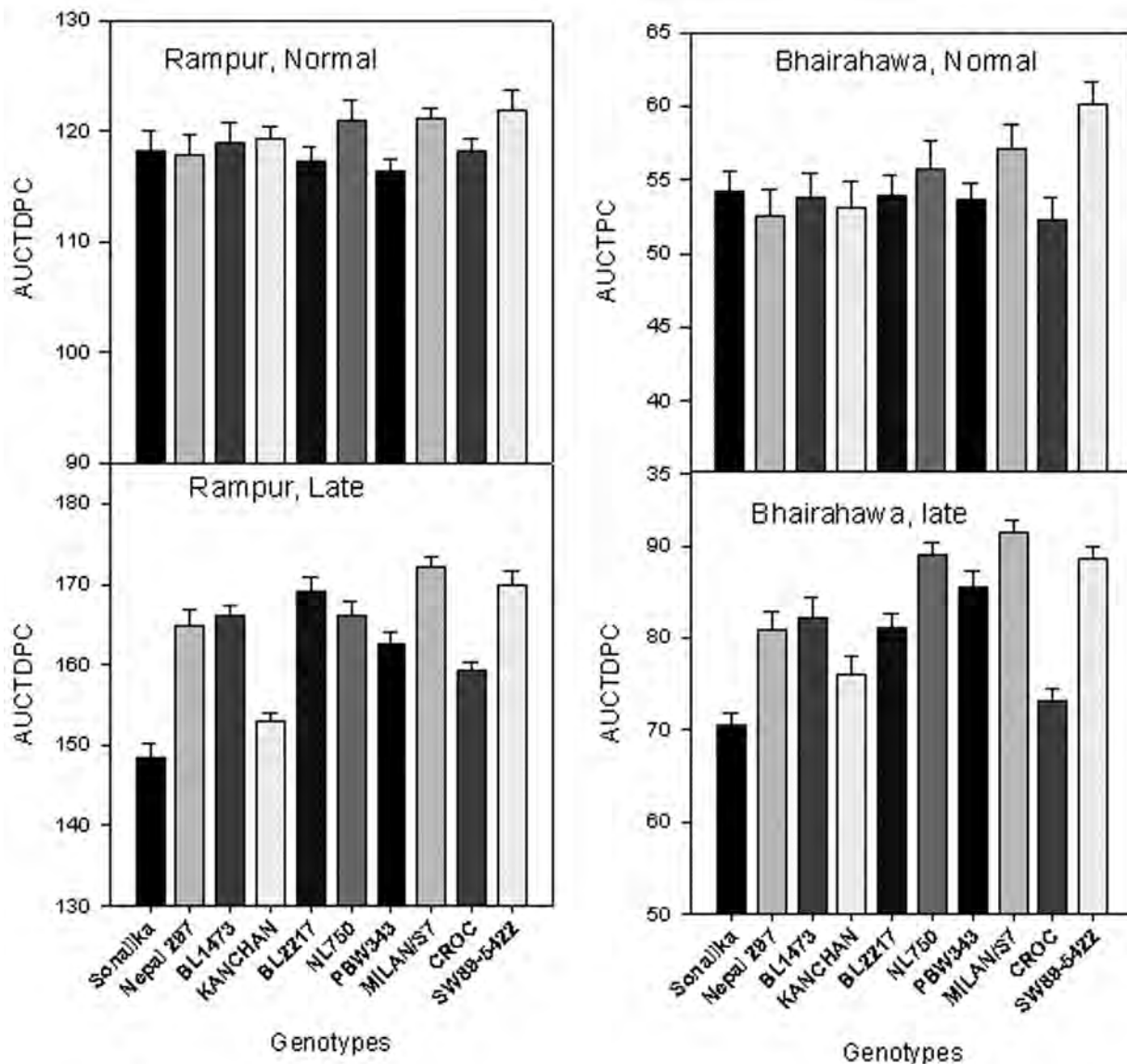


Fig. 3. Area under canopy temperature depression progress curve among genotypes grown under foliar blight non stressed condition planted in normal planting date and late planting date at Rampur and Bhairahawa in 2002-2003.

typic differences were more prominent at later growth stages when the disease progress attained a higher level, and at these times ambient temperature was high and atmospheric relative humidity was relatively low. Under foliar blight protected and heat stressed situation, all four resistant genotypes were able to maintain their high AUCTDPC values (Fig. 3). In addition, three foliar blight-susceptible genotypes, BL 1473, Nepal 297 and BL 2217, had lower AUCTDPC values compared to four resistant genotypes, showing that reduced AUCTDPC in the genotypes was primarily due to foliar blight and that they could maintain the CTD under foliar blight-free conditions (Fig. 3). This shows that these genotypes have some degree of tolerance to heat stress.

Genotypes Sonalika, Kanchan and Croc proved to be sensitive to heat stress as they had low AUCTDPC values even under disease-protected conditions. Interestingly,

no genotypes in our study were resistant to spot blotch and sensitive to heat stress. A possible explanation for this could be that similar mechanisms may underlie tolerance to both stresses. BL 1473 is a recommended cultivar in Nepal for late planting conditions due to its heat tolerance (M.R. Bhatta, personal communication). Also BL 1473 appeared to be tolerant to foliar blight based on grain yield and thousand kernel weight (Rosyara *et al.*, 2007).

Previous studies differ in finding CTD useful to assess genetic differences in wheat performance under different conditions (Araus *et al.*, 1998; Royo *et al.*, 2002). Nevertheless, CTD is easier to measure, inexpensive, requires less labour than other methods of stress tolerance assessment. Its use requires selection of suitable reading time. The results of this study suggest that infrared thermometry of heat-stressed as well as spot blotch-infected

wheat canopies can serve as an useful measure for predicting residual green leaf area. Caution should be exerted for identifying a suitable day and time within the day to measure canopy temperature. In addition, measuring CTD over the growth cycle from flowering to maturity and calculating AUCTDPC can prove more useful than a single score. AUCTDPC holds a promise as integrated selection criteria for screening foliar blight and heat stress tolerance in irrigated spring wheat grown in tropical environments.

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