Bangladesh J. Bot. **39**(1): 51-55, 2010 (June)

# EFFECTS OF POST-ANTHESIS HEAT STRESS ON STEM RESERVES MOBILIZATION, CANOPY TEMPERATURE DEPRESSION AND FLORET STERILITY OF WHEAT CULTIVARS

**S. Sikder*** **and N.K. Paul**[1]

*Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh*

*Key words:* Post-anthesis, Heat stress, Floret sterility, Canopy temperature, Mobilization

## Abstract

Testing of four heat tolerant (Gourab, Sourav, Kanchan and Shatabdi) and two heat sensitive (Sonora and Kalyansona) wheat cultivars under normal and late growing post-anthesis heat stress conditions revealed higher pre-anthesis stem reserves mobilization to the final grain weight and floret sterility in heat sensitive cultivars compared to heat tolerant cultivars. The heat tolerant cultivars showed higher canopy temperature depression than the heat sensitive cultivars in both the growing conditions indicating the higher ability of heat tolerant cultivars to maintain cooler canopy environment than the heat sensitive ones.

## Introduction

Wheat (*Triticum aestivum* L.) is primarily a thermosensitive winter crop. But its area and production have been extended to temperate to tropical and later subtropical regions. The optimum temperature of wheat ranged from 15 - 18º C (Choudhury and Wardlaw 1978) but also grows in regions exposed to chronic heat stress. Globally, about seven million hectares of wheat is affected by heat stress throughout the life cycle and 40% crop face terminal heat stress (Ruwali and Bhawsar 1998).

In Bangladesh wheat is the second most important cereal crop and grown under hot and humid climate and in a short winter. Currently, the national average of wheat yield is about 2.0 t/ha in Bangladesh (BBS 2007) which is more than 50% lower than the potential of some released varieties. The yield gap between the potential and national average is associated with many limiting factors of which high temperature stress is the vital factor (Ahmed and Meisner 1996). About 80 - 85% of wheat in Bangladesh is grown after trasplanted aman rice of which 60% of area is planted lately due to delay in harvesting of rice (Badaruddin *et al*. 1994) and thus the crop frequently encounters high temperature stress during the reproductive stage of growth causing significant yield reduction.

Different physio-morphological traits such as membrane thermostability (Saadalla *et al*. 1990, Shanahan *et al.* 1990, Renolds *et al.* 1994), stem reserves mobilization (Blum *et al.* 1994), canopy temperature depression (Renolds *et al.* 1994, Amani *et al.* 1996) and stomatal conductance (Renolds *et al.* 1994), grain number per spike, grains per spikelet, biomass at harvest (Shpilar and Blum 1986, Hu and Rajaram 1994) have been associated with performance of irrigated wheat under high temperature level. However, the present investigation was undertaken to study the pre-anthesis stem reserves traslocation to final grain weight, canopy temperature depression ability and floret streility of wheat cultivars under late growing post-anthesis heat stress condition.

*Corresponding author. E-mail: srisikder@gmail.com

[1]Department of Botany, University of Rajshahi, Rajshahi-6205, Bangladesh.

## Materials and Methods

The experiment was conducted on six wheat cultivars at the research farm of Crop Physiology and Ecology Department of Hajee Mohammad Danesh Science & Technology University, Dinajpur during 2006 - 07. On the basis of membrane thermostability out of six cultivars four (Gourab, Sourav, Kanchan and Shatabdi) were heat tolerant and two (Sonora and Kalyansona) were heat sensitive. The seeds were sown on November 30, as normal growing condition, and December 30 of 2006 as late growing post-anthesis heat stress condition (Fig. 1). The experiment was replicated thrice in a split plot design where two growing conditions (sowing times) were placed in main plots and six wheat cultivars were in sub-plots. Seeds were sown in rows 20 cm apart at the rate of 120 kg/ha in a unit plot size of 3 m × 2 m.

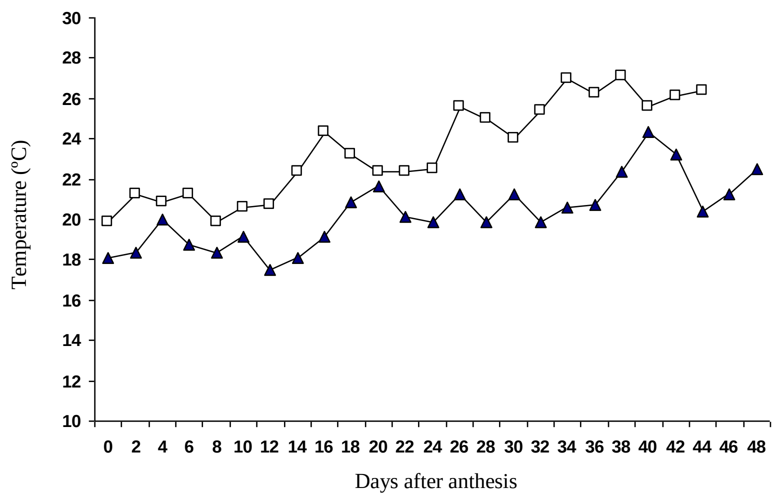


Fig. 1. Mean air temperature (° C) from anthesis to maturity of different wheat cultivars. --▲-- Normal, --□-- Late.

The pre-anthesis stem reserves (PSR) contribution towards the final grain weight was determined according to Gallaghar *et al.* (1975). This is based on the net loss in weight of above ground vegetative organs between anthesis and maturity with the difference in yield and net assimilation.

A hand held infra-red thermometer (Model: Crop TRAK, Item No. 2955L - Spectrum Technologies, Inc.) was used to measure canopy temperature. Canopy temperature depression (CTD) is the difference between ambient air temperature and canopy temperature in degree centigrade. The CTD was recorded at 5 days after anthesis during noon period. Finally, the floret sterility (%) was calculated at maturity period according to Hasan (2002).

## Results and Discussion

*PSR mobilization:* It is revealed that growing condition greatly influenced the PSR mobilization to final grain weight of wheat cultivars (Table 1). The interaction effect of growing conditions and cultivars significantly influenced the contribution of PSR to final grain weight. Under normal growing condition the per cent contribution of pre-anthesis stem reserves to the final grain weight varied from 11.90 to 15.10% in heat tolerant cultivars, while this range was 18.75 to 21.28% in heat sensitive cultivars. In this growing condition the highest pre-anthesis stem reserves mobilized from stem to grain in heat sensitive cultivar Kalyansona (21.28%) which was followed by other heat sensitive cultivar Sonora (18.75%). The lowest PSR mobilization towards the final grain weight was found in heat tolerant cultivar Gourab (11.90%) which was closely followed by cultivar Sourav (12.45%). Shatabdi and Kanchan showed 12.20 and 15.10% PSR mobilization to the final grain weight.

**Table 1. Pre-anthesis stem reserves mobilization (%), canopy temperature depression (mean ± SE) and floret sterility(%) of wheat cultivars as affected by two sowing times.**

| Cultivar | Pre- anthesis stem reserves mobilization (%) to final grain wt. | | Canopy temperature depression (º C) | | Floret sterility (%) | |
|---|---|---|---|---|---|---|
| | Normal sowing | Late sowing | Normal sowing | Late sowing | Normal sowing | Late sowing |
| Gourab | 11.90d | 21.42c | $5.00 \pm 0.57$ | $5.33 \pm 0.33$ | 33.60c | 40.16bc |
| Sourav | 12.45d | 26.36b | $4.60 \pm 0.33$ | $5.66 \pm 0.33$ | 37.91bc | 45.12ab |
| Kanchan | 15.10c | 25.36b | $4.66 \pm 0.33$ | $5.66 \pm 0.33$ | 38.40bc | 43.54ab |
| Shatabdi | 12.20c | 20.50c | $5.00 \pm 0.57$ | $6.00 \pm 0.57$ | 37.84bc | 40.99bc |
| Sonora | 18.75c | 35.32a | $2.66 \pm 0.33$ | $3.33 \pm 0.33$ | 40.13bc | 50.49a |
| Kalyansona | 21.28c | 37.25a | $4.00 \pm 0.57$ | $4.66 \pm 0.33$ | 41.40bc | 49.75a |
| CV (%) | 8.82 | | - | | 10.22 | |

Means followed by same letter(s) did not differ significantly at 5% level of significance and for SE, n = 3.

Under late growing post-anthesis heat stress conditions again two heat sensitive cultivars attained the highest pre-anthesis stem reserves contribution to the final grain weight 35.32 to 37.25% as against 20.50 to 26.36% in heat tolerant cultivar. The heat tolerant cultivar Shatabdi showed the lowest PSR mobilization (20.50%) to the final grain weight. Thus it appears that irrespective of sowing time, the heat sensitive cultivars showed higher PSR mobilization to the final grain weight compared to the heat tolerant cultivars. But sowing time had marked influence on PSR mobilization to the final grain weight. Both the heat tolerant and heat sensitive cultivars showed a common tendency of higher PSR mobilization to grain under post-anthesis heat stress condition. But this increment was much lower in heat tolerant cultivars. This indicates that heat tolerant cultivars showed a less dependence on stem reserves for developing grain. Similar results were found by Blum *et al.* (1994), Al-Khatib and Paulsen (1990) and Harding *et al.* (1990), in wheat. Sikder *et al.* (1999) reported that higher PSR mobilization of the heat sensitive varieties compared to heat tolerant cultivars.

*Canopy temperature depression:* Under normal growing condition heat tolerant cutivars Shatabdi and Gourab maintained the highest CTD, while heat sensitive cultivar Sonora had the lowest CTD (Table 1).

Under late growing heat stress condition, all the cultivars increased their CTD compared to normal growing condition. At this post-anthesis heat stress condition heat tolerant cultivar Shatabdi showed the highest canopy tenperature depression, which was followed by Gourab, Sourav and Kanchan. Heat sensitive cultivar Sonora had the lowest CTD which was followed by Kalyansona.

The variation in canopy temperature depression among the six wheat cultivars in both the growing conditions was due to varietal differences of the cultivars. Renolds *et al.* (1994) reported that varietal differences existed for canopy temperature depression among the wheat germplasms under heat stress condition. In the present study, it was also observed that the heat tolerant cultivars showed higher CTD in both the growing conditions than those of the heat sensitive cultivars. So, heat tolerant cultivars had greater ability to maintain canopy cooler than the heat sensitive cultivars. Renolds *et al.* (1998) also reported that potential to keep canopy cool is one of the important traits of high temperature tolerant wheat genotypes.

*Floret sterility:* Floret sterility was significantly influenced by the interaction effect of sowing time and cultivars (Table 1). Irrespective of heat susceptibility all the cultivars showed statistically similar floret sterility though there were widely variations among the cultivars under normal growing conditions. In this growing condition the heat sensitive cultivars had comparatively higher floret sterility than the heat tolerant cultivars.

Therefore, the late growing post-anthesis heat stress condition increased the sterility in all the cultivars. But the degrees of increment among different cultivars varied. These increments were significant for Sonora and Kalyansona.

In the present study, there were wide variations in floret sterility among the six cultivars. Varietal variations in floret sterility was also found by Rawson (1986) in wheat. Late growing post-anthesis heat stress condition increased the sterility in all the cultivars. But the degree of increment was higher in heat sensitive cultivars compared to heat tolerant cultivars . Results from other studies indicated that high temperature resulted in higher floret sterility (Rawson 1986). Higher temperature prevailed at delayed sowing was responsible for higher grain mortality (Saini *et al.* 1983).

## References

Ahmed S.M. and C.A. Meisner. 1996. Wheat research and development in Bangladesh. Bangladesh Australian Wheat Improvement Project and CIMMYT, Mexico. 162 pp.

Al-Khatib K. and G.M. Paulsen. 1990. Photosynthesis and productivity during high temperature stress of wheat genotypes from major world regions. Crop Sci. **30**: 1127-1132.

Amani I., R.A. Fischer and M.P. Renolds. 1996. Evaluation of canopy temperature as a screening tool for heat tolerance in spring wheat. J. Agron. Crop Sci. **176**: 119-129.

Badaruddin M., D.A. Saunders, A.B. Siddique, M.A. Hossain, M.O. Ahmed, M.M. Rahman and S. Parveen. 1994. Determining yield constraints for wheat production in Bangladesh. *In*: Wheat in heat stress environments; irrigated, dry areas and rice-wheat farming system, D.A. Saunders and G.P. Hattel (Eds). pp. 265-271. CIMMYT, Mexico.

BBS (Bangladesh Bureau of Statistics). 2007. Statistical Year Book of Bangladesh. Statistics Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh, Dhaka.

Blum A., B. Sinmena, J. Mayer, G. Golan and L. Shpilar. 1994. Stem reserve mobilization supports wheat grain filling under heat stress. Aust. J. Plant Physiol. **13**: 771-781.

Chowdhury S.I. and I.F. Wardlaw. 1978. The effect of temperature on kernel development in cereals. Aust. J. Agric. Res. **29**: 205-223.

Gallagher J.N., P.V. Biscoe and R.K. Scott. 1975. Barley and its environment. V. Stability of grain weight. J. Appl. Ecol. **21**: 319-336.

Harding S.A., J.A. Guikema and G.M. Paulsen. 1990. Photosynthetic decline from high temperature stress during maturation of wheat. I. Interaction with senescence processes. Plant Physiol. **92**: 648-653.

Hasan M.A. 2002. Physiological changes in wheat under late planting heat stress. MS thesis. BSMRAU, Gazipur. 37 pp.

Hu Z.H. and S. Rajaram. 1994. Differential responses of bread wheat characters to high temperature. Euphytica **72**: 197-203.

Rawson H.M. 1986. High temperature tolerant wheat: a description of variation and a search for some limitation of productivity: Field Crops Res. **14**: 197-212.

Renolds M.P., M. Balota, M.I.B. Delgado, I. Amani and R.I. Fischer. 1994. Physiological and morphological traits associated with spring wheat yield under hot, irrigated conditions. Aust. J. Plant Physiol. **21**: 717 -730.

Renolds M.P., R.P. Singh, A. Ibrahim, O.A.A. Ageeb, A. Larque-Saavedra and J.S. Quick. 1998. Eveluating physiological traits to complement empirical selection for wheat in warm environments. Euphytica **100**: 84-95.

Ruwali H.M. and R.C. Bhawsar. 1998. Effect of high temperature on grain development of wheat under late sown irrigated conditions. *In*: Wheat Research Needs Beyond 2000 A.D., V.S. Rao and S.C. Misra Eds, pp. 68-69. Proc. Int. Conf. Karnal.

Saadalla M.M., J.S. Quick and J.F. Shanahan. 1990. Heat tolerance in winter wheat. II. Membrane thermostability and field performance. Crop Sci. **30**(6): 1248-1251.

Saini H.S., M. Sedgley and D. Aspiral. 1983. Effect of heat stress during floral development on pollen tube development and overy anatomy in wheat (*Triticum aestivum* L.). Aust. J. Plant Physiol. **10**: 137-144.

Shanahan J.F., J.B. Edwards, J.S. Quick and J.R. Fenwick. 1990. Membrane thermostability and heat tolerance of spring wheat. Crop Sci. **30**: 247-251.

Shpilar L. and A. Blum.1986. Differential relation of wheat cultivars to hot environments. Euphytica **35**: 483-492.

Sikder S, J.U. Ahmed, T. Hossain, M.A.K. Mian and M.M. Hossain.1999. Membrane thermostability, grain growth and contribution of pre-anthesis stem reserves to grain weight of wheat under late seeded conditions. Thai J. Agric. Sci. **32**(4): 465-473.

*(Manuscript received on 7 July 2009; revised on 9 May 2010)*