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IDENTIFICATION OF HEAT STRESS TRAITS IN WHEAT (*TRITICUM AESTIVUM* L.) IN THE WAY OF TAGGING MAJOR GENE(S) FOR HEAT STRESS TOLERANT

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Abstract

A field experiment was conducted with four wheat varieties Raj4134, HD2733, NW 1014 and K9006 for characterization of heat stress tolerance traits under heat stress condition. Heat stress was induced by delayed sowing of 35 days from normal date of sowing so that grain filling stage of wheat could experience severe heat stress. Data related to plant height, chlorophyll content, starch content and protein profile were done at dough stage of grain filling in both control and heat stress condition. High yielding wheat varieties HD2733 and K9006 severely affected by drastic reduction in plant height, chlorophyll content, starch content and yield. Raj4134 and NW1014 remained long stay green at late reproductive stage and also showed peculiar novel protein band that not appeared under normal condition. Appearance new protein bands might be heat shock protein that protect heat sensitive enzymes like granule bound starch synthase, soluble starch synthase etc. under heat stress that play key role in grain starch synthesis consequently less percent reduction in yield. Therefore, appearance of novel protein bands during heat stress and less percent reduction in growth, chlorophyll content, starch content and ultimately yield might be taken as screening criteria in wheat breeding programme for developing heat stress tolerance varieties in wheat.

Key worlds : Heat stress, SPAD, protein profiling, starch, yield and wheat.

Introduction

Heat stress due to global warming is one of the major environmental yield constraints for the world wheat production. The wheat crop faces heat stress at grain filling stage in the northern part of India. The severity of heat stress depends upon its intensity, duration and stage of the crop (Wahid *et al*., 2007). The occurrence of heat stress at reproductive stage is more harmful than vegetative stage as it causes direct effects on grain number, size of grain, dry weight and finally yield of the crops (Wollen *et al*., 2003).

Heat stress reduces the stay green duration by increasing senescence process (Al Khatib and Paulson, 1984). Early leaf senescence reduces the photosynthesis process at vegetative stage and limits reseved photosynthates for future growth. The early senescence is more critical at reproductive stage, photosynthesis greatly reduce due to loss of chlorophyll and activity of heat sensitive enzymes. Thus, plants cope up heat stress with limited reserves resources at reproductive development.

Starch synthesis and deposition are affected by inefficiency of heat sensitive enzymes under heat stress (Jenner *et al*., 2003). Thus, heat stress at reproductive stage reduces the grain yield and quality of wheat (Gooding *et al*., 2003).

There is genetic variability in wheat varieties for heat stress tolerance. The heat sensitive varieties show more reduction in yield and yield attributing traits as compared to heat tolerance. The selection of heat tolerance wheat varieties by physio-molecular approaches for developing high yielding heat tolerance wheat varieties through wheat breeding programme is major concerned of this paper.

Materials and Methods

A field experiment was conducted with four wheat varieties for characterization of its physio bio molecular traits for heat stress tolerance in wheat. Wheat varieties were exposed to severe heat stress by 40 days delayed from normal sowing (15 November) so that grain filling

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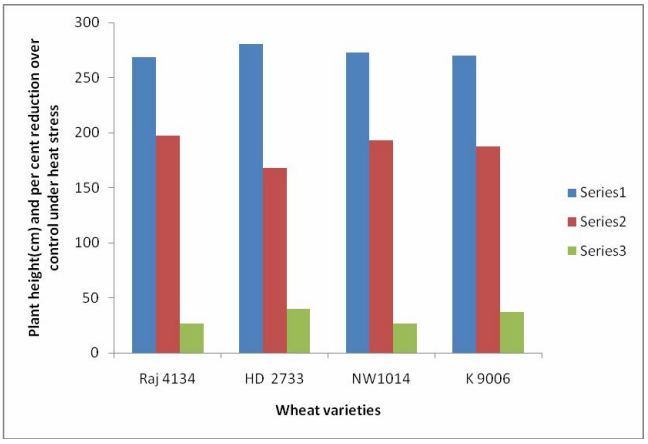
stage of wheat varieties could experience severe heat stress condition. General agronomic practices were done as per needs of the crop. Heat stress at dough stage of grain filling ranged between 37-39^{0}C. Plant height was recorded from ground surface of stem to the tip of stem at grain filling stage. Leaf chlorophyll content was estimated by the chlorophyll meter (SPAD). Starch content (Yemm and Welles, 1954), protein content (Lowry *et al*.,), protein profiling (Laemili *et al*., 1970) and grain yield were estimated at dough stage of developing wheat grain under control and heat stress condition.

Results and Discussion

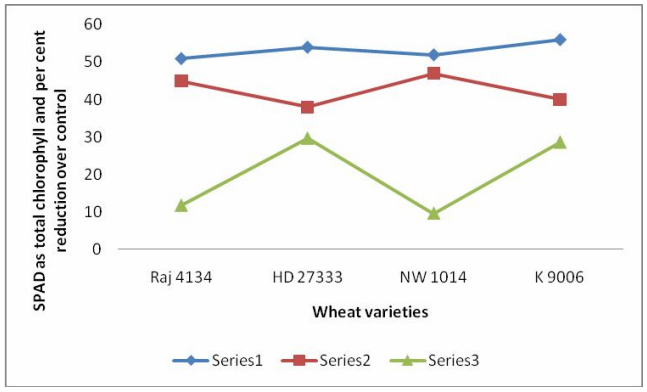
Wheat varieties showed the genetic diversity in plant height (fig. 1). The maximum plant height was recorded in K9006 (91.20 cm) while minimum in HD 2733 (64.72) under control condition. Heat stress significantly reduced the plant height. The high reduction in plant height was recorded in HD 2733 (33.25%) and K9006 (25.43%) while low in Raj 4134 (15.94%) and NW1014 (21.85%) under the heat stress condition. The reduction in plant height is due to fast phasic change and due to this, vegetative phase become short and reproductive come early (VollenWeider and Gunthardt Goerg, 2005).



Series 1=Control; Series 2=Heat stress and Series 3= Percent reduction over control

Fig. 1 : Effect of heat stress on plant height (cm) of wheat varieties.

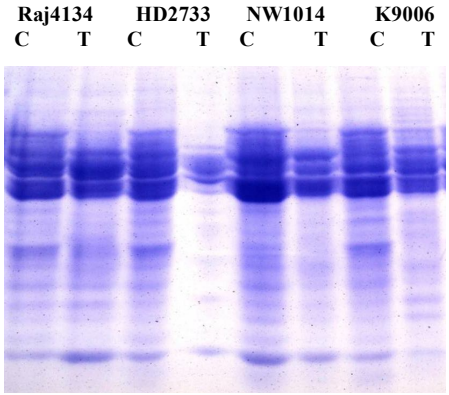
The chlorophyll content varied from variety to variety under control and stress condition (fig. 2). The high SPAD values were recorded in K9006 (56) and HD2733 (54) under control condition. The heat stress reduced stay green duration of wheat varieties. The maximum reduction in chlorophyll content was recorded in HD 2733 (29.63%) while minimum in NW 1014 (9.62%). Tolerant wheat varieties like NW 1014 and Raj 4134 remained stay green for long duration at reproductive stage in comparison to heat sensitive HD2733 and K9006 wheat varieties. Chlorophyll synthetic enzymes are heat sensitive and less functional during severe heat stress. It needs optimum temperature for proper function. When temperature increases the heat sensitive enzymes denatured and chlorophyll synthesis process decreases. The formations of chlorophyll less affected in heat tolerance varieties as it specific proteins protect the integrity of heat sensitive enzymes and remain functional even under heat stress condition (Vierling, 1991 and Zaharieva *et al*., 2001).



Series 1=Control; Series 2=Heat stress and Series 3= Percent reduction over control

Fig. 2 : Effect of heat stress on total chlorophyll content (SPAD) in leaves of wheat varieties under heat stress at reproductive stage.

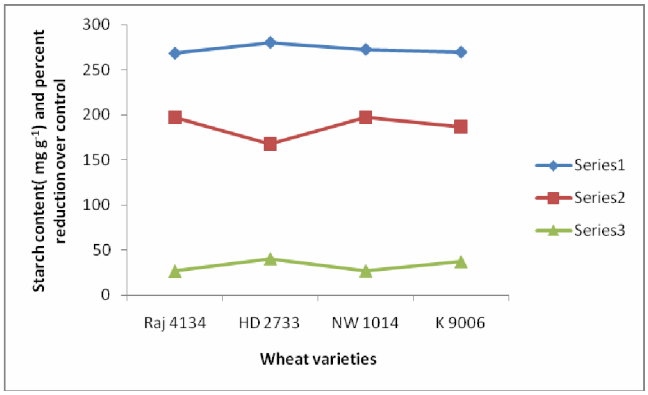
The banding pattern of dough stage of wheat varieties significantly differed in normal and heat stress condition (fig. 3). Many expressed protein bands of HD 2733 and K9006 disappeared in heat stress condition whereas loss of bands in Raj 4134 and NW 1014 were very less and it also showed some new protein bands that were not showed in HD 2733 and K9006. The grain shape and size of Raj 4134 and NW 1014 were less affected due to heat stress in comparison to HD 2733 and K9006. The appearance of new band under heat stress might be an indication of heat stress proteins that protect the configuration of rate limiting enzymes for starch synthesis (Rampino *et el*., 2009).



C = Control, T= Heat treatment

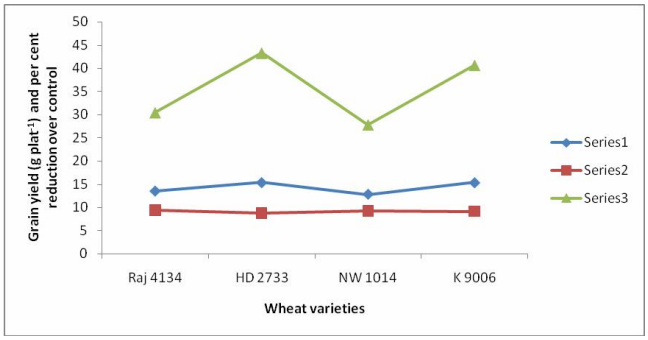
Fig. 3 : Variation in expression of wheat protein at dough stage of wheat varieties under heat stress condition.

The heat stress significantly reduced the starch content in wheat varieties (fig. 3). The high starch content was noted in HD2733 (280.34 mgg^{-1}) and K9006 (269.67 mgg^{-1}) under control condition. But under heat stress, the HD2733 also showed maximum percent reduction (40.20%) in comparison to Raj 4134 (26.43%) and NW1014 (26.88%). The reduction in starch content in heat susceptible varieties might be due to less efficiency of granule bound starch synthase activity under heat stress (Jenner, 1994 and Morell *et al*., 2001), while heat tolerance heat varieties forms heat shock protein and keep pace of rate limiting enzymes for starch synthesis and showed comparatively less reduction in starch content under heat stress condition (Rampino *et al*., 2009).



Series 1=Control; Series 2=Heat stress and Series 3= Percent reduction over control

Fig. 4 : Effect of heat stress on starch content (mg g^{-1}dry wt.) in dough stage seeds of wheat varieties.



Series 1=Control; Series 2=Heat stress and Series 3= Percent reduction over control

Fig. 5 : Effect of heat stress on grain yield (g $plant^{-1}$) of wheat varieties.

The grain yield varied among wheat varieties in normal and heat stress condition (fig. 4). HD2733 showed maximum grain yield (15.35 g $plant^{-1}$) in control, but it per cent reduction (43.29%) was also high in heat stress environment. NW1014 and Raj 4134 showed less reduction of 27.73% and 30.37% respectively due to its generic level of heat tolerance. Grain yield is decided by mutagenic factors. It depends upon genetic potential and tolerance again stress in plants. Heat stress decreases the yield due to affecting growth and development processes, lowering the yield component potential and affecting the activity of key enzymes that contribute a lot during grain filling and development (Wahid *et al*., 2007).

Conclusion

Heat stress significantly reduced growth, chlorophyll, starch content and yield of wheat varieties. But the percent reduction was very high in HD 2733 and K9006 in comparesion to Raj 4134 and NW 1014. Heat tolerant varieties Raj 4134 and NW 1014 also showed some new protein bands in dough stage of seeds under heat stress condition while such banding pattern were not observed in heat sensitive varieties HD 2733 and K9006. The new bands might be heat shock proteins that protect enzymes and protein configuration under heat stress and resulting less loss in yield and yield supporting component. Therefore, stay green duration, stability in starch content, less reduction in growth and appearance of novel protein bands might be taken as screening criteria for selection of heat tolerance wheat varieties in wheat breeding programme.

Acknowledgment

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References

Al Khatib, K. and Paulson (1984). Mode high temperature injury to wheat during grain development. *Plant Physiol*., **61** : 363-368.

Gooding, M. J., R. H. Ellis, P. R. Shewry and J. D. Schorield (2003). Effect of restricted water availability and increased temperature on the grain filling, drying and quality of winter wheat. *J. Cereal Sci*., **37** : 295-309.

James, M. G., K. Denyer and A. M. Myers (2003). Starch synthesis in the cereal endosperm. *Curr. Opin. Plant Boil*., **6** : 215-222.

Jenner, C. F. (1994). Starch synthesis in the kernel of wheat under high temperature condition. *Funct. Plant boil*., **21** : 791-806.

Laemmli (1970). Method of protein profiling. Purification and characterization of an enzyme with novel regulating properties. *Planta*, **114** : 418-424.

Laemmli, U. K. (August 1970). Cleavage of structural proteins during the assembly of the head of bacteriophage T4. *Nature*, **227** : 680-685.

Morell, M. K., S. Rahman, A. Regina, R. Aeppels and J. Li (2001). Wheat starch biosynthesis. *Euphytica*, **119** : 55-58.

Rampino, P., G. Mita, S. Pataleo, N. D. Fanzo and C. Perrotta

(2009). Acquisition of thermotolerancre and HSP genes expression in durum wheat (*Triticum durum* Desf.) cultivars. *Exper. Botany*, **66** : 257-264.

Vierling, E. (1991). The role of heat shock proteins in plants. *Ann. Rev. Plant Physiol. and Plant Mol. Biol.*, **42** : 579-620.

Vollen Weider, P. and M. S. Gunthardt-Goerg (2005). Diagnosis of abiotic and biotic stress factors using the visible symptoms in foliage. *Environ.Pollut.*, **137** : 455-465.

Wahid, A., S. Gelani, M. Asharf and M. R. Foolad (2007). Heat tolerance in plants : An overview. *Environ.and Experi. Botany*, **61** : 199-223.

Wollen Weber, P., J. R. Porter and J. Schelberg (2003). Lack of interaction between high temperature at vegetative and reproductive growth stage in wheat. *J. Argon. Crop Sci.*, **189** : 142-150.

Yemm, E. W. and E. J. Willis (1954). The estimation of carbohydrate in plant extract by anthrone. *J. Biochem.*, **57** : 508-514.

Zaharieva, M., E. Gaulin, M. Havraux, E. Eacevedo and P. Monneveux (2001). Drought and heat response in the wild wheat relative Aegilopes Roth : Potential interest wheat improvement. *Crop Sci.*, **41** : 1321-1329.