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Study of Yield and Yield Components of Wheat (*Triticum aestivum* L.) Genotypes at Grain Filling Stage under Heat Regimes

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ABSTRACT

A field experiment was conducted with wheat genotypes Halna, PBW 343, NW 1014, DBW 16, K 911 and AAI 11 during rabi 2015-16 at the student instructional farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P). Heat treatment was given by delayed sowing of 65 days (25 January) than normal date of sowing (23 November 2015). So, that wheat genotypes could experience severe heat stress at grain filling stage. The screening of wheat genotypes was done on the basis of plant height, tiller number per plant, days to 100% flowering, days to 100% maturity, stay green duration, number of spikes per plant, spike length, number of grain per spike, test weight and yield plant^{-1} at grain filling stage. The wheat genotypes Halna, NW 1014, DBW 16, K 911, and AAI 11 had high membrane stability index (MSI) and stay green duration also showed less percent reduction in yield and yield components comparatively PBW 343 and DBW 16. Therefore, MSI and stay green duration can be used as physiological screening indices for heat tolerance genotypes at grain filling stage.

Key world: *MSI, Stay green duration, Wheat, Heat stress, Yield components.*

INTRODUCTION

Wheat (*Triticum aestivum* L) is an important winter season cereal crop in India as well as in the many parts of the world. India has second position in both area and production after China. Wheat crop faces a number of abiotic stresses among which heat stress at grain filling is importance one. Heat stress may be defined as an increase in temperature above threshold level (> 30°C) and cause considerable damage to growth, development and finally yield of plant[1]. High temperature (> 30°C) at the time of grain filling is one of the major constraints in increasing productivity of wheat in tropical and sub-tropical countries[12].

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Heat stress reduces the stay green duration by accelerating senescence process. The early leaf senescence reduces the photosynthesis process at vegetative stage and limit reserved photosynthates for future growth. There is genetic variability in wheat varieties for heat stress tolerance.

Heat sensitive varieties show more reduction in yield and yield attributing traits as compared to heat tolerance[10]. Late planted wheat suffers drastic yield losses which may exceed to 40-50%. In response to higher temperatures flowering and ripening are accelerated with a significant reduction in the number of days to the boot stage, heading, flowering and maturity. Stress may also be critical when it occurs during grain filling, as it may result not only in a reduction in the extent of grain filling[17], but also in more rapid cell death and in the earlier occurrence of harvest ripeness[1]. Wheat is highly sensitive to heat stress and even slight variation in temperature during critical stages like pollination and milky ripe reduces the quality and quantity of wheat grains. Increase in temperature of 1ºC reduce the yield of wheat by 4% [8]. High temperature shortens the grain filling period significantly in all the bread and durum wheat genotype because of significant interaction of each genotype with temperature[9].

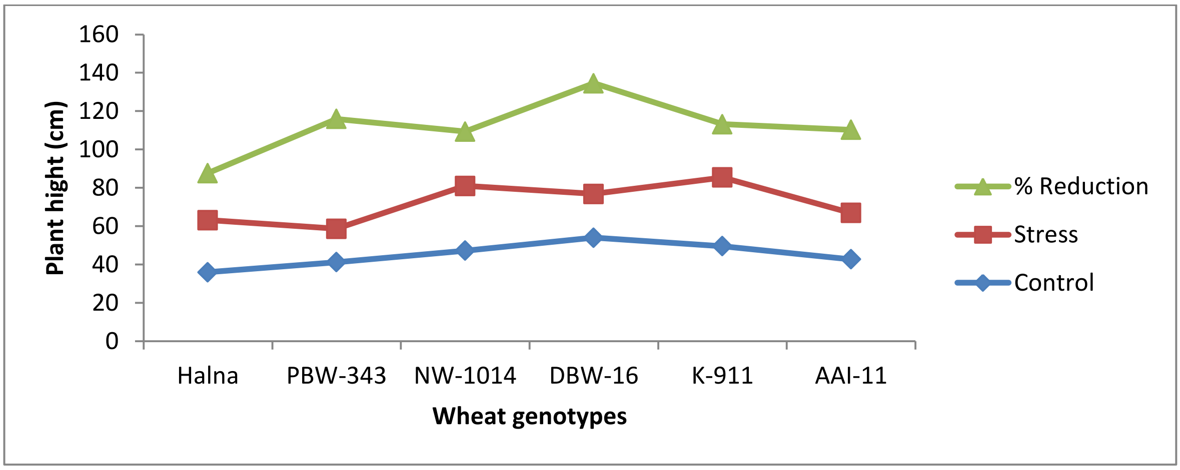
Stay green is a trait that has been used to indicate heat tolerance in hot environment. Wheat genotypes that had high Membrane stability index and stay green duration at grain filling stage are considered for heat tolerance and it uses as physiological indices for screening tolerant wheat varieties. The selection of heat tolerance wheat varieties by Membrane stability and stay green duration approaches for developing high yielding heat tolerance wheat varieties through wheat breeding programme is major concerned of this paper.

MATERIAL AND METHODS

Six wheat genotypes Halna, PBW 343, NW1014, DBW16, K-911 and AAI11 were sown at student instructional farm of Narendra Deva University of Agriculture and Technology Kumarganj, Faizabad in rabi season 2015-16. The treatment of heat stress was given by very late sowing of 60 days (25 January) than normal date of sowing (15 November, 2015). So that wheat genotypes could experience severe heat stress at grain filling stage. The temperature at the time of grain filling stage varied from 35 to 38^{0}C in very late sown wheat crop. Days to 100% flowering was recorded from date of sowing to 50% flowering. Days to 100% maturity was recorded by continuing days from sowing to 100% physiological maturity of five plants and average out to one as considered 100% maturity. Days to stay green duration was recorded from 100% greenness to reduction of greenness start. Plant height were recorded from base of plant to base of spike of five plants and average out to one. Tiller number of five plants were recorded separately and average out to one. Number of spikes of five plants were recorded and average out to one as spike plant^{-1}. Main Spike length of five plant were recorded and average out to one as spike length. Membrane stability index(MSI) were recorded in control verses treatment at the grain filling stage by the method of Sadalla *et al*[19]. Number of grain spike[1] were recorded by selecting main spike of five plants and average out to one as considered grains spike^{-1}. Grain yield of five plants randomly selected were taken at maturity and average out to one as grain yield in gram per plant. Test weight was recorded by randomly counting 1000 seeds and weighted in gram as test weight per plant.

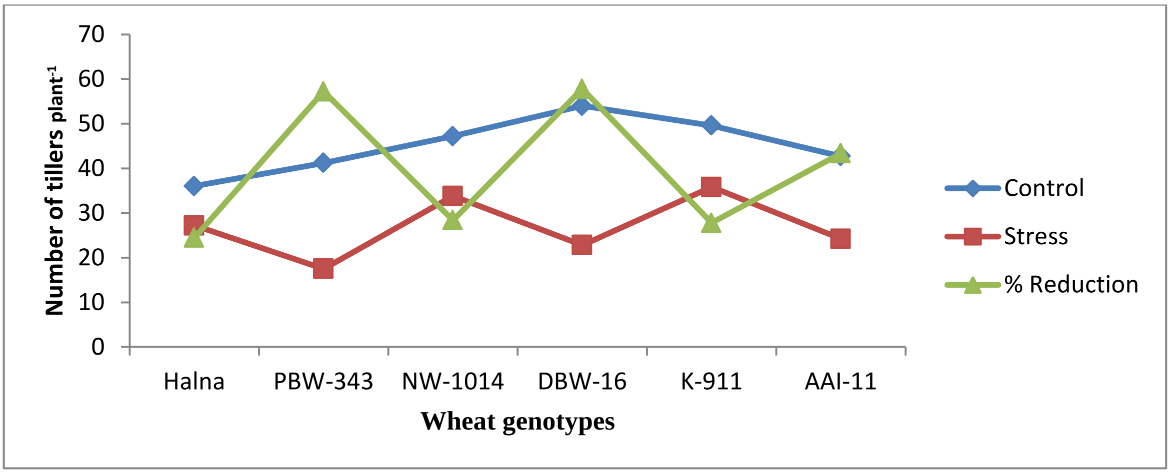
RESULT AND DISCUSSION

Fig. 1: Effect of heat stress on Plant height (cm) of wheat genotype under stress condition



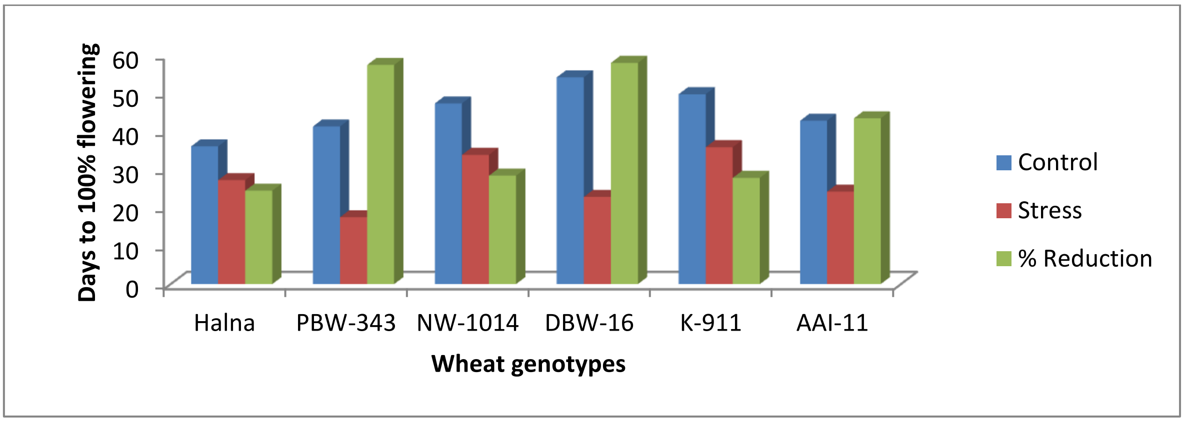
Wheat genotypes showed genetic variability in plant height. Heat stress significantly reduced the plant height under very late condition (Fig.1). In irrespective genotypes, more reduction was noted significantly high in very late in comparatively timely sown condition. High reduction was recorded in PBW 343 (50.64%), DBW 16 (32.2%), K 911 (31.65%), while low in Halna (24.36%), NW 1014 (28.57%), and AAI 11 (30.72%) under heat over normal condition. If temperature conditions are unfavorable, the physiological processes may be defective, with negative consequences for both vegetative and generative developmental processes and even height[14].

Fig. 2: Effect of heat stress on number of tillers per plant of wheat genotypes under heat stress condition



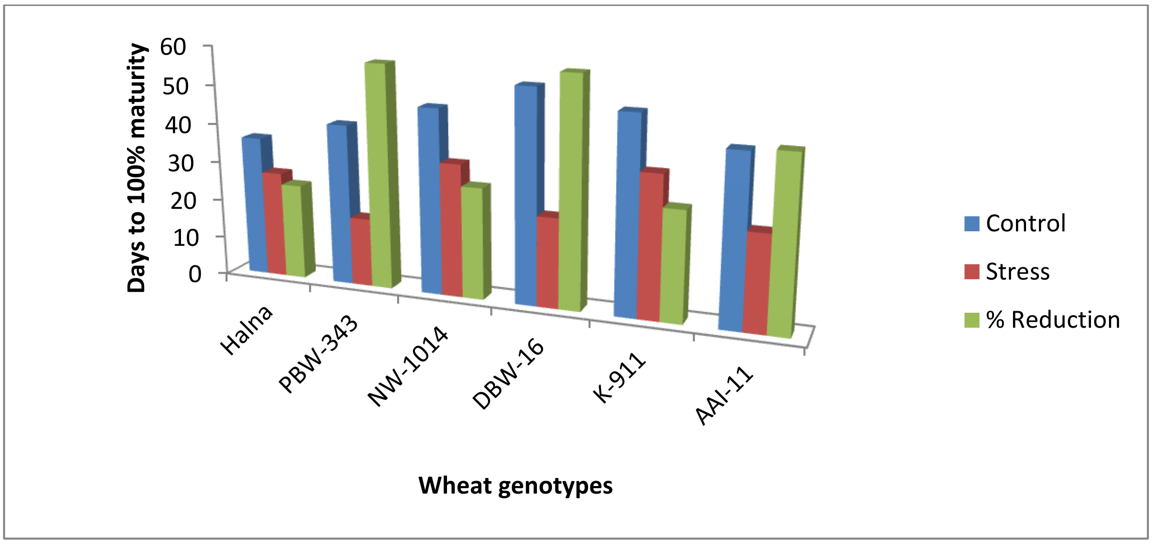
The number of tillers in wheat genotypes showed significant variability (Fig.2). High temperature reduced the No. of tillers under very late sown condition. In all these genotypes, more reduction was recorded in PBW 343 (43.74%), DBW 16 (35.0%), AAI 11 (32.0%), while low in Halna (20.0%), NW 1014 (25.0%), K 911(30.0%) under very late condition. The elevation temperature during formation of tillers decrease the numbering of tiller formation. The temperature is of key importance for plant development, influencing the rate of tillering, the appearance of the nodes, flowering and even grain filling. Each phenophase has a specific temperature range within which it takes place normally to the benefit of the whole plant[14].

Fig. 3: Effect of heat stress on days to 100% flowering of wheat geneotypes under heat stress condition



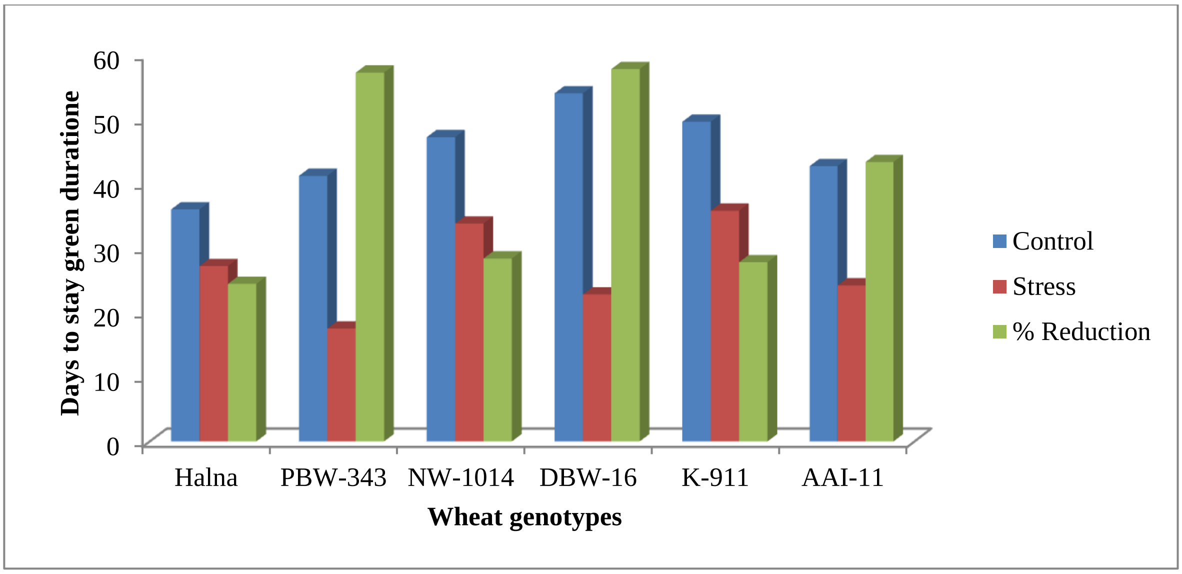
The wheat genotype showed genetic variability for Days to 100% flowering under elevated temperature, (fig.3). Under very late condition high reduction was recorded in K-911(28.27%), PBW-343(27.09%), NW-1014(26.58%) and low in Halna (23.43%), DBW-16(23.98%), AAI-11(24.48%) in heat stress over normal condition. The high temperature forcedly decrease the number of days for 100% flowering than timely sown condition. Several events during this phenostage that influence grain number include spike and spikelet initiation, floral organ differentiation, male and female sporogenesis, pollination and fertilization.

Fig. 4: Effect of heat stress on days to 100% maturity of wheat genotype under different date of sowing



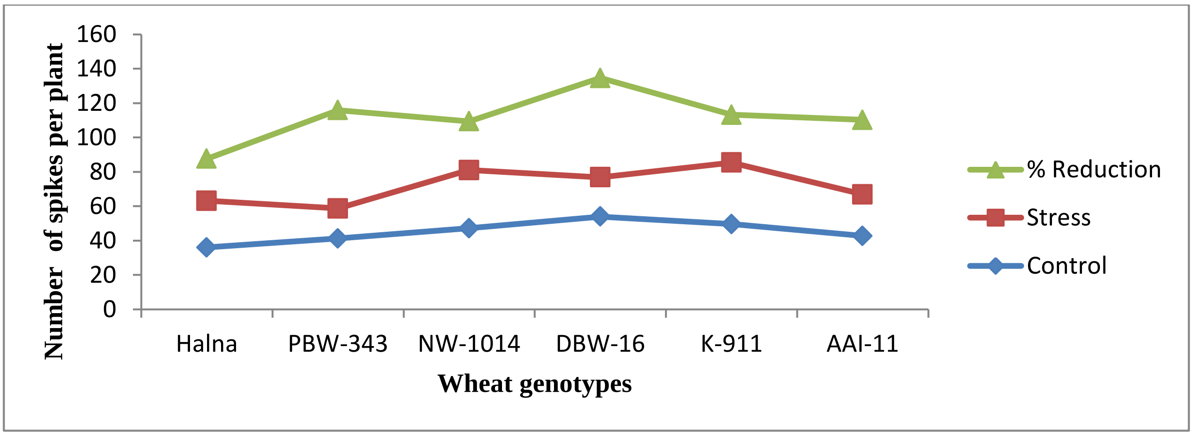
The wheat genotypes showed genetic variability in days to 100% maturity (fig.4). Under very late sown condition high reduction was recorded in DBW 16 (29.03%), PBW 343 (28.18%), AAI 11 (29.6%) and low in Halna (20.5%), K 911 (25.2%), NW 1014 (26.0%) in heat stress over timely sown condition. The increasing temperature(30-35^{o}C) during maturation of seed forcely mature the seed under heat stress condition than normal condition and reduce the number of days to 100% maturity than normal. High temperatures accelerate growth[6], they also reduce the phenology,which is not compensated by the increased growth rate[17,18]. Therefore, when temperatures are elevated between anthesis to grain maturity, grain yield is reduced because of the reduced time to capture resources.

Fig.5: **Effect of heat stress on days to stay green duration of wheat varieties under late and normal sown condition**



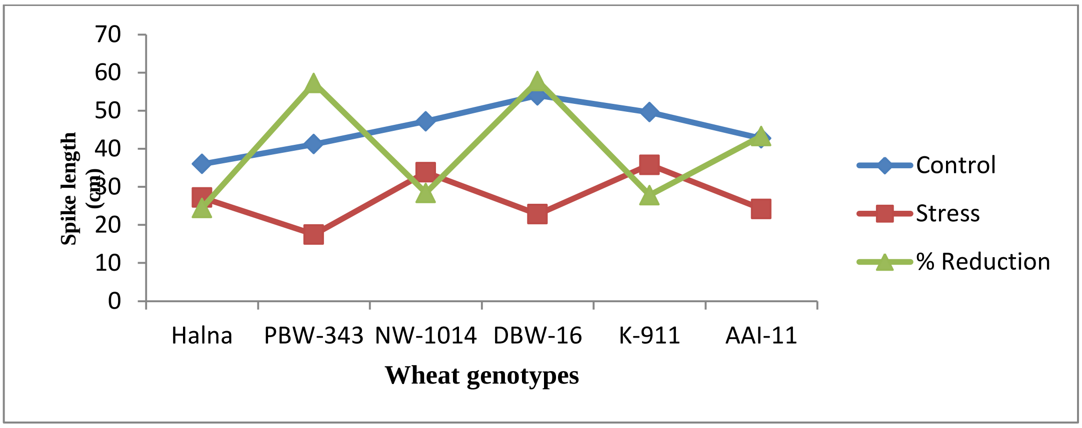
Wheat genotypes showed genetic variability under very late sown condition for stay green duration (fig.5). In heat stress condition, stay green duration are reduces in very late sown condition over normal. The high percentage of reduction was recorded in AAI 11 (38.6%), PBW 343 (37.96%), DBW 16 (36.44%), K 911 (37.6%) while low in Halna (25.0%) and NW 1014 (28.28%) under high temperature than normal. Leaf senescence starts early in response to heat stress, particularly when these stresses occur during post-flowering stages of grain filling. Therefore, maintenance of leaf chlorophyll and photosynthetic capacity, called 'stay-green,' is considered an indicator of heat tolerance[5]. Because the loss of chlorophyll is associated with less assimilation of current carbon into grains.

Fig.6: Effect of heat stress on number of spikes per plant of wheat genotypes under late and timely sown condition



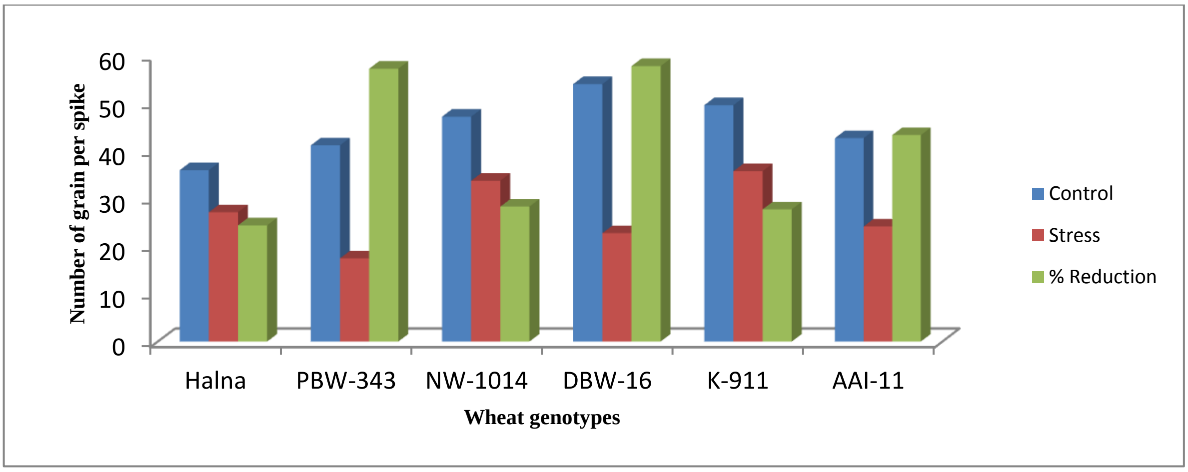
In wheat genotypes spike no./plant showed genetic variability significantly under heat stress condition (Fig.6). More reduction was recorded in PBW 343 (48.93%), DBW 16 (33.9%), AAI 11 (24.0%), while low in NW 1014 (20.88%), Halna (20.83%), K 911 (20.0%) under very late condition over normal sown condition. The high temperature during spikes formation reduces the number of spike per Plant. In late sown wheat, terminal heat stress is the main cause of yield reduction which is responsible for shortening of grain growth period and improper grain filling[13].

Fig.7: Effect of heat stress on Spike length (cm) of wheat genotypes under late and timely sown condition



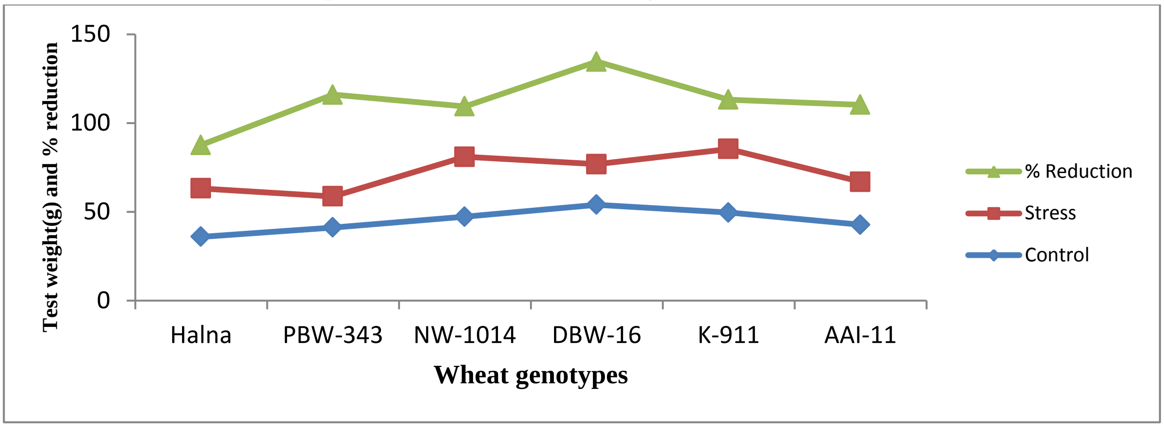
The length of spike (cm) in wheat genotypes showed genetic variability significantly under heat stress condition (Fig.7). During growth of spike high temperature reduces the development of length of spike and grain number. High reduction in spike length was recorded in AAI 11 (27.96%), PBW 343 (33.9%), DBW 16 (27.27%), and low in Halna (25.77%), NW 1014 (26.78%), K 911 (26.95%), in very late over normal sown condition. The reserves accumulated in vegetative plant parts before anthesis may safeguard grain yield when conditions become averse to photosynthesis and mineral uptake during grain filling[20].

Fig.8: Effect of heat stress on number of grain per spike of wheat genotypes under late and timely sown condition



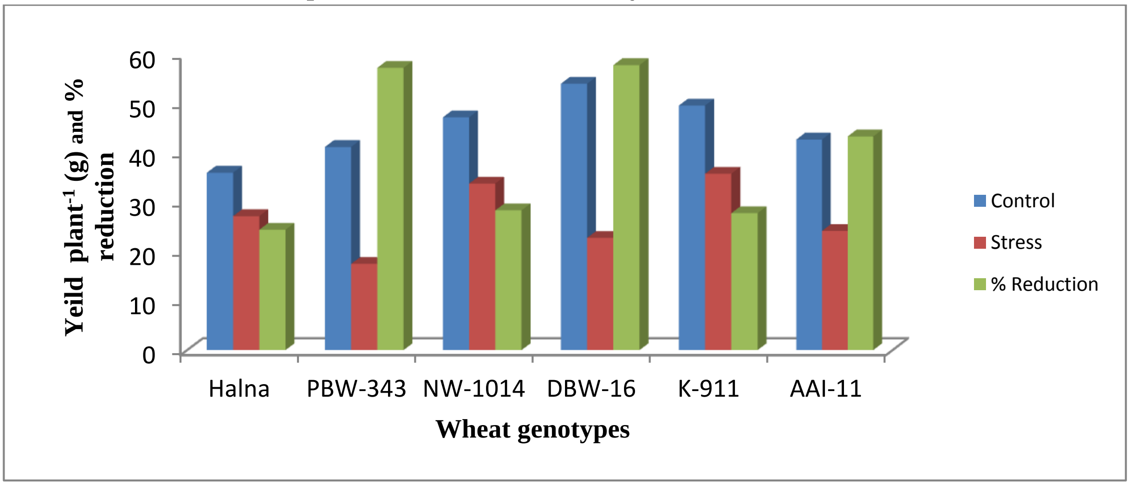
Grain number spike^{-1} significantly varied among wheat genotypes (fig.8). Heat stress reduce the grain number spike^{-1} under very late sown condition showed high reduction in compare to normal sown condition. Under very late sown condition high reduction was recorded in PBW 343 (57.22%), DBW 16 (57.77%), AAI 11 (43.34%) while low in Halna (24.44%), K 911 (27.8%), and NW 1014 (28.38%) over timely sown condition. Heat stress reduces the number of grain per spike when temperature exceed above 32°C. Temperatures above 20°C may substantially reduce grain number per spike[15]. Several events during this phenostage that influence grain number include spikelet initiation, floral organ differentiation, male and female sporogenesis, pollination and fertilization.

Fig. 9: Effect of heat stress on test weight of wheat genotypes under different date of sowing and its percent reduction over timely sown condition



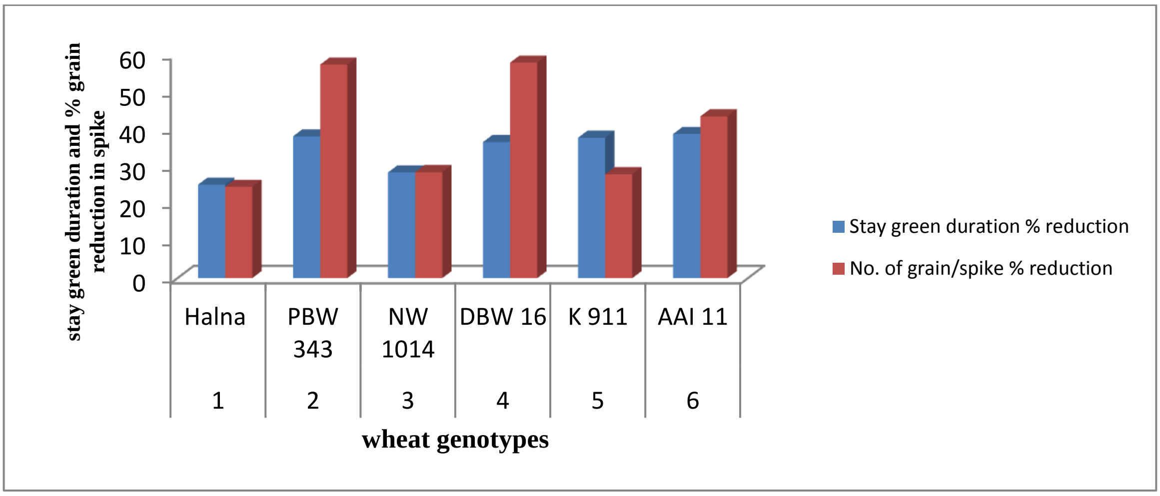
The wheat genotypes showed genetic variability in 1000 grain weight under heat stress condition (fig.9). Heat stress significantly reduce the test weight under very late sown condition. The genotypes under very late sown condition showed high percentage reduction comparatively timey sown condition. Under very late sown condition high percentage of reduction was recorded in PBW 343 (58.74%), DBW 16 (34.9%), K 911 (37.7%) and low in Halna (25.11%), NW 1014 (28.57%), and AAI 11 (28.81%) in heat over timely sown condition. Starch accounts for approximately 70% of wheat grain dry weight, and reduced starch deposition is the main reason of reductions in grain weight[2]. The increasing temperature (from 25-35^{o}C) during grain growth decrease grain size and promotes grain shrinking, Thus reduction of individual grain weight. In wheat both grain weight and grain number appeared to be sensitive to heat stress as the number of grain per ear at maturity decline with increasing temperature[4].

Fig. 10: Effect of heat stress on yield plant^{1} (g) of wheat genotypes under different date of sowing and its percent reduction over timely sown condition



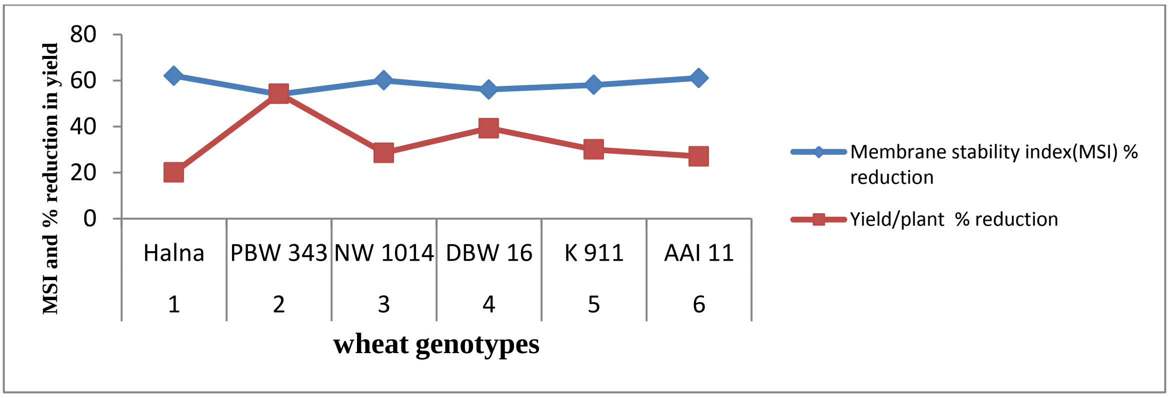
Wheat genotypes showed genetic variability in grain yield plant^{-1} (Fig.10). High reduction was noted significantly high in very late sown condition in comparatively normal sown condition. High reduction was recorded in PBW 343 (54.23%), DBW 16 (39.2%), K 911 (30.0%) while low in Halna (20.0%), NW 1014 (28.5%), and in AAI 11 (27.0%) under heat stress over timely sown condition. Heat stress significantly reduce the grain yield under very late sown condition over normal sown condition. Heat treatment significantly decreased the grain yield per plant in all the tested wheat genotypes at anthesis stage[7].

Fig. 11: Correlation between stay green duration and number of grains per spike percent reduction



Maintenance of leaf chlorophyll and photosynthetic capacity called stay green. High stay green duration reduction was recorded in PBW 343 (37.96%), AAI 11 (38.6%), DBW 16 (34.44%), K 911 (37.6%) while low percent reduction was recorded in Halna (25%), and NW 1014 (28.28%) under heat stress over timely sown condition. Heat stress reduces the number of grain per spike when temperature exceed above 32°C. High reduction was recorded in PBW 343 (57.22%), DBW 16 (57.77%), AAI 11 (43.34%) and low in Halna (24.44%), K 911 (27.8%), and NW 1014 (28.38%) in heat stress over timely sown condition. According to both correlation stay green duration can be taken as indicator of heat stress tolerance.

Fig. 12: Correlation between membrane stability index (MSI) and yield per plant percent reduction



Integrity of cell membrane disrupts under heat stress and it measure as electrolyte leakage by MSI. Tolerant plant showed less leakage due to accumulation of high saturated fatty acids and monounsaturated fatty acids. Tolerant plant showed less leakage due to accumulation of high saturated fatty acids and monounsaturated fatty acids[21]. wheat genotypes. The wheat genotypes that had high membrane stability and stay green duration showed less reduction in yield and yields components. Therefore, High membrane stability and stay green duration at the time of grain filling stage can be used as phsysiological indices for screening heat tolerance wheat geneotypes.

CONCLUSION

The heat stress at time of grain filling reduced grain yield and its components irrespective of

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