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Original Research Article

Evaluation of Wheat (*Triticum aestivum* L.) Lines at Reproductive Stage for Heat Stress Tolerance

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A B S T R A C T

An experiment was carried out during rabi season (2016-17) at the Student Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj Faizabad-224229 (U.P.), India. Five wheat lines NWL-10-14, NWL-12-13, KO-307, NWL-12-2, and NWL-12-4 were exposed to heat stress by delay sowing of forty days from normal date 15 November so that wheat lines could experienced severe heat stress at grain filling stage. The screening of wheat genotypes was done on the basis of plant height, tiller number per plant, stay green duration, number of grain per spike, test weight and yield plant^{-1}. The heat stress at time of grain filling reduced grain yield and its components irrespective of wheat lines. Among the five wheat genotypes KO-307(12.72%), NWL-12-13(14.92%) showed tolerant on the basis of stability in chlorophyll content and stay green duration.

Keywords

Chlorophyll, Stay green duration, Wheat, Heat stress, Yield components

Introduction

Wheat (*Triticum aestivum* L.), a member of family Poaceae is one of the leading cereals of many countries of the world including India. Being most important food crop of India, it is a main source of protein and energy. In India, wheat is the second most important food crop after rice both in terms of area and production. The northern and western part of India has maximum area and production under wheat cultivation.In India, Uttar Pradesh, Punjab and Haryana are the three major wheat producing states. As a C3 plant wheat is capable of growing in cool environments. Optimal growth of wheat occurs at an average temperature of 25°C, with minimums at times as low as 3°C to 4°C and maximums of 30°C to 32°C.(Curtis *et al.*, 2002).

Abiotic stress factors such as heat, cold, drought, salinity, and nutrient stress have a huge impact on world agriculture, and it has been suggested that they reduce average yields by >50% for most major crop plants (Wang *et al.*, 2003). Heat stress is an important constraint to wheat productivity affecting different growth stages specially anthesis and grain filling. Heat stress may be defined as “the rise in temperature beyond a threshold level for a period of time sufficient to cause irreversible damage to plant growth and development. It has already been established that heat stress can be a significant factor in reducing the yield and quality of wheat (Stone *et al.*, 1995).Terminal heat stress is a common abiotic factor for reducing the yield in certain areas of West Asia and North Africa (Ferrera *et al*., 1993).High temperature above 32ºC has been reported reducing grain yield and grain weight (Bluementhal *et al*., 1995, Wardlaw *et al*., 2002).Stay green is a trait that has been used to indicate heat tolerance in hot environment (Acevedo *et al.*, 1991).

Materials and Methods

Five wheat lines NWL-10-14, NWL-12-13, KO-307, NWL-12-2, and NWL-12-4 were selected for heat treatment at reproductive stage. The experiment was conducted at Instructional farm of N.D. University of Agriculture and Technology, Kumarganj, Faizabad in rabi season 2016-17. Heat stress was given by delayed sowing of 40 days from normal date of sowing (15 November, 2016) so that the reproductive phase of wheat could experience severe heat stress. General agronomical practices were adopted time to time as per need of the crop. The temperature at the time of grain filling stage varied from 36^0C to 39^0C in delayed sown wheat crop. Total chlorophyll content was recorded at reproductive stage as SPAD (Minolta *et al.*,1989). 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. Days to 100% flowering was recorded from date of sowing to 100% flowering of five plants and average out to one as considered. Days to 100% maturity was recorded from sowing to 100% physiological maturity of five plants and average out to one as considered. Number of spikes of five plants were recorded and average out to one as spike plant^{-1}. Main Spike length of five plants were recorded and average out to one as spike length. Number of grain spike^{-1} were recorded by selecting main spike of five plants and average out to one as considered grains spike^{-1}. Test weight was recorded as weight of 1000 seeds in gram. Seed weight of five randomly selected plants were recorded and average out to one as grain yield plant^{-1}.

Results and Discussion

The Chlorophyll content in wheat lines showed genetic variability significantly under heat stress condition (Fig.1). High reduction in chlorophyll content was recorded in, NWL-12-4(20.21%), NWL-10-14(19.38%), NWL-12-2 (18.58%) and low in, KO-307(12.72%), NWL-12-13(14.92%) in late over normal sown condition. Heat stress at reproductive stage altered the chlorophyll content due to enhance senescence activity. High Chlorophyll and stay green at reproductive stage is an indication of heat tolerance. Heat tolerant wheat genotypes maintain it stay green due production high antioxidant enzymes and less chlorophyll activity. Long stay green increases the grain filling duration and grain yield (Nikolaeva *et al.,* 2010). The total chlorophyll content (SPAD) significantly varied among wheat genotypes under normal, late and very late sown condition at anthesis.

Wheat lines showed genetic variability under late sown condition for stay green duration (Fig.2). In heat stress condition, stay green duration are reduces in late sown condition over normal. The high percentage of reduction was recorded in NWL-10-14(23.63%), NWL-12-4(21.45%), while low in NWL-12-13(17.29%), KO-307(17.39%), NWL-12-2(19.04%) under high temperature than normal. Heat stress enhances the senescence by reducing total chlorophyll content at grain filling stage. Tolerant wheat varieties maintain leaf chlorophyll and stay green under heat stress regimes. Stay green at anthesis is an indicator of heat tolerant trait (Harris *et al.*, 2006).

Wheat lines showed genetic variability in plant height (Fig.3). Heat stress significantly reduced the plant height under late condition. In irrespective genotypes, more reduction was noted significantly high in late in comparatively timely sown condition. High reduction was recorded in NWL-12-2(26.29%), NWL-12-4(26.29%), NWL-10-14(21.22%) while low in KO-307(13.07%), NWL-12-13 (18.52%) 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 (Rehman *et al.*, 2009).

Tiller initiation reduced under heat stress due to suppress growth of wheat lines (Fig.4). High temperature reduced the No. of tillers under very late sown condition. In all these lines, more reduction was recorded in NWL-12-2(57.44%), NWL-10-14 (54.54%) while low in KO-307(21.73%), NWL-12-13(25%), NWL-12-4(26.92%)under late condition. Some time number of tiller remains as same as control but its growth reduces or become bushy (Tiller initiation reduced under heat stress due to suppress growth of wheat plant (Saadalla *et al.*, 2011).

The length of spike (cm) in wheat lines showed genetic variability significantly under heat stress condition (Fig.5) . During growth of spike high temperature reduces the development of length of spike and grain number. High reduction in spike length was recorded inNWL-10-14(23.59%), NWL-12-4(19.60%)and low in, KO-307(13.33%), NWL-12-2(14.85%), NWL-12-13(16.85%) in late over normal sown condition spike length influence by reduces cell division and cell elongation process (Punia *et al.*, 2011).

Fig.1 Effect of heat stress on chlorophyll content (SPAD) of wheat lines at reproductive stage

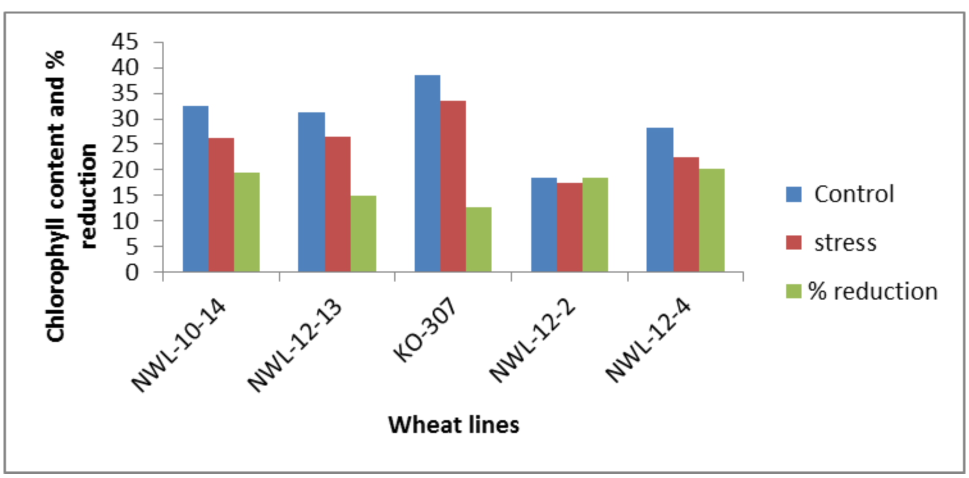


Fig.2 Effect of heat stress on days to stay green duration (days) of wheat lines

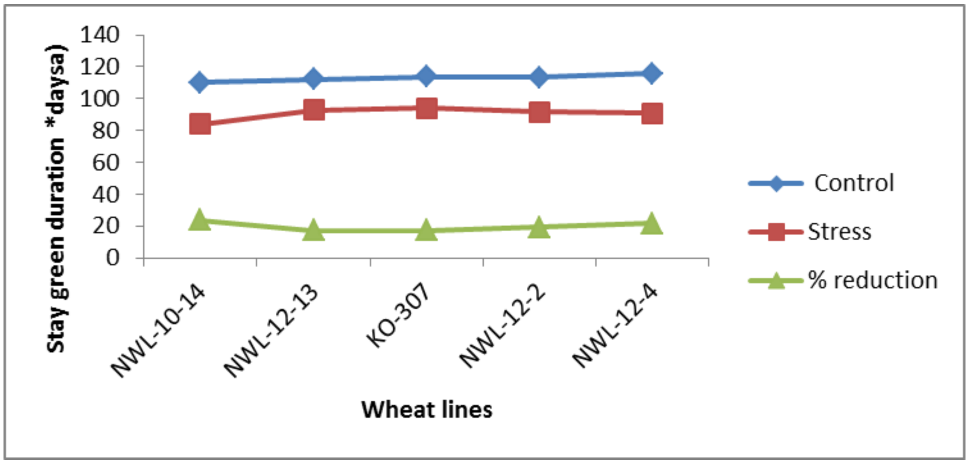


Fig.3 Effect of heat stress on plant height (cm) of wheat lines

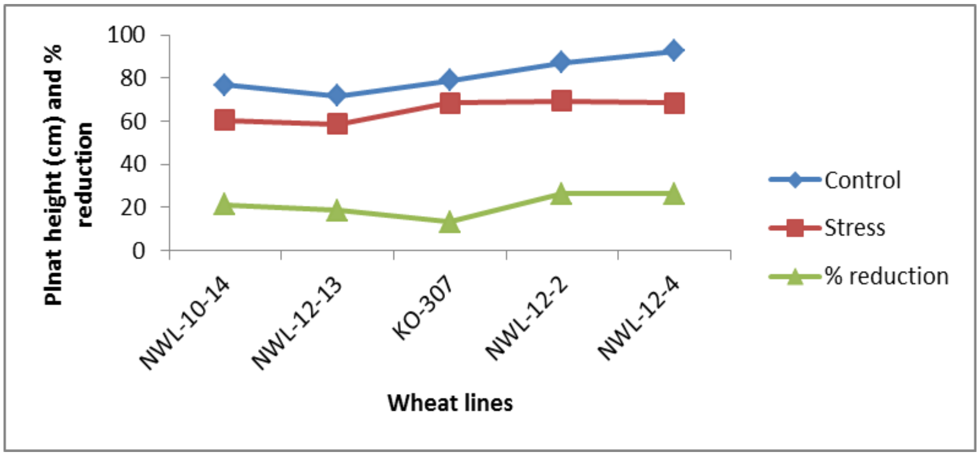


Fig.4 Effect of heat stress on number of tillers per plant of wheat lines

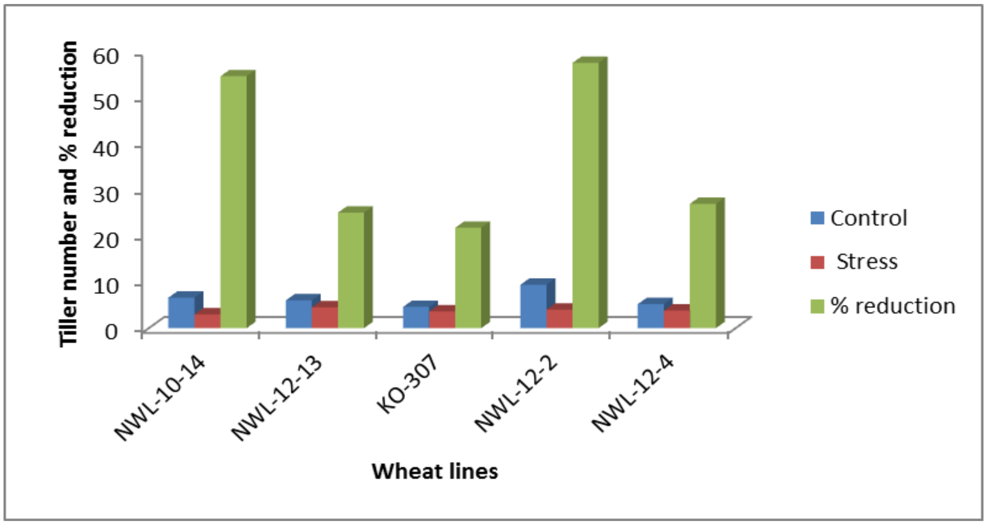


Fig.5 Effect of heat stress on Spike length (cm) of wheat lines

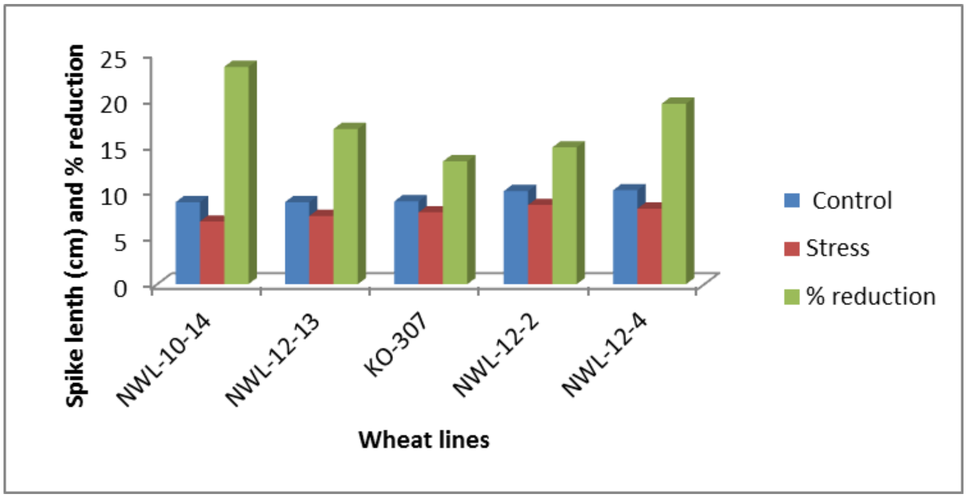


Fig.6 Effect of heat stress on number of grain per spike of wheat lines

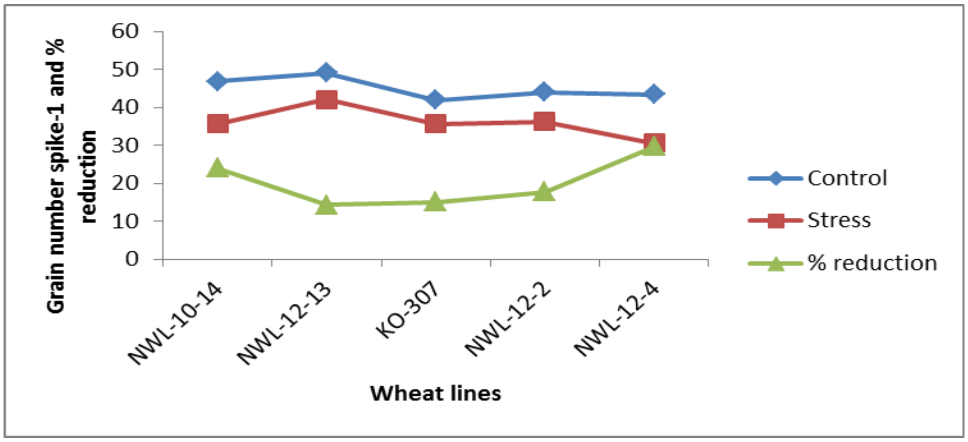


Fig.7 Effect of heat stress on test weight (g) of wheat lines

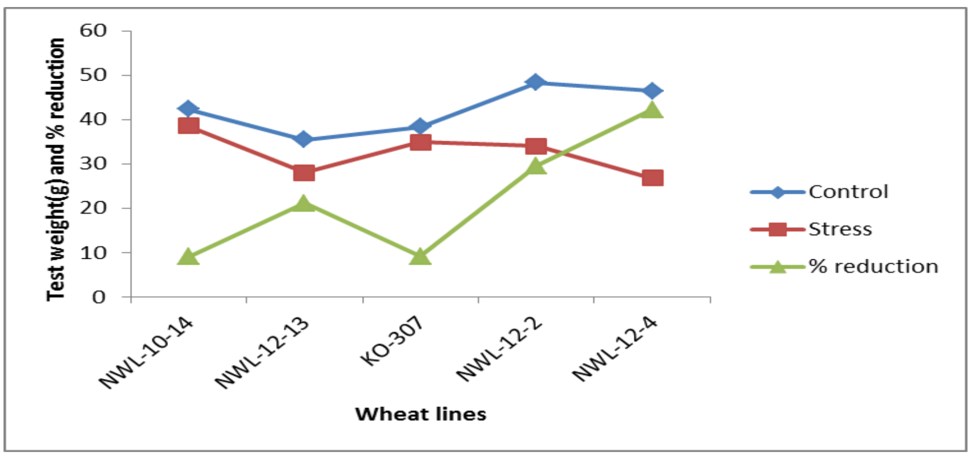
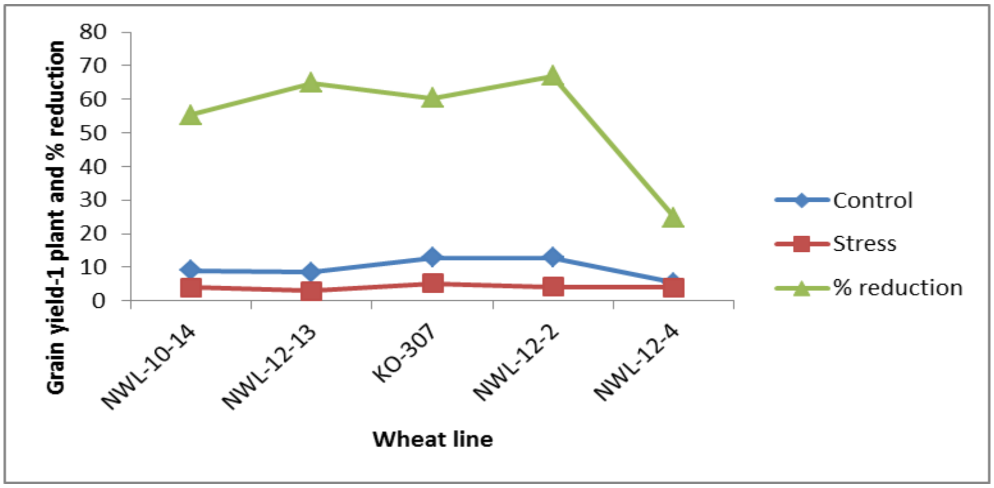


Fig.8 Effect of heat stress on yield plant^{-1} (g) of wheat genotypes



Grain number spike^{-1} significantly varied among wheat lines (Fig.6). Heat stress reduce the grain number spike-1 under late sown condition showed high reduction in compare to normal sown condition. Under late sown condition high reduction was recorded inNWL-12-4(29.72%), NWL-10-14(23.93%) while low in NWL-12-13(14.28%), KO-307 (15.01%), NWL-12-2 (17.72%)over timely sown condition. Heat stress reduces the number of grains per spike when temperature exceed above 32^{0}C. It affects spikelet initiation, floral organ differentiation, pollination and fertilization. High temperature speedup spike development, spikelet number and ultimately reduces grains per spike (Zhao *et al.*, 2008).

The wheat lines showed genetic variability in 1000 grain weight under heat stress condition (Fig. 7). Heat stress significantly reduce the test weight under late sown condition. The genotypes under late sown condition showed high percentage reduction comparatively timey sown condition. Under late sown condition high percentage of reduction was recorded inNWL-12-4 (41.86%), NWL-12-2(29.61%), and low in KO-307 (14.53%), NWL-10-14(20.82%),NWL-12-13(21.15%)in heat over timely sown condition. The wheat varieties showed genetic variability in test weight and grain yield, The test weight and grain is a product of accumulative effects of all metabolic processes. In this condition wheat grain become shriveled and less in size and resultantly test weight reduces (Bala *et al.*, 2014)

Wheat lines showed genetic variability in grain yield plant-1(Fig. 8). High reduction was noted significantly high in late sown condition in comparatively normal sown condition. High reduction was recorded in NWL-12-2(66.95%), NWL-12-13(64.87%), KO-307 (60.34%) while low in NWL-12-4 (24.81%), NWL-10-14 (55.35%) under heat stress over timely sown condition. Heat stress significantly reduce the grain yield under very late sown condition over normal sown condition. The increasing temperatures (from 25/14 to 31/20ºC), during grain growth, decreases grain size and promotes grain shrinking, thus implicating a reduction of individual grain weight (Dias *et al.*, 2008). In wheat, both grain weight and grain number appeared to be sensitive to heat stress, as the number of grains per ear at maturity declined with increasing temperature (Ferris *et al.*, 1998).

In conclusion, the wheat genotypes that had high CSI and stay green duration showed less reduction in yield and yield components. The heat stress at time of grain filling reduced grain yield and its components irrespective of wheat genotypes. Among the five wheat genotypes KO-307(12.72%), NWL-12-13(14.92%) showed tolerant on the basis of CSI and Stay green duration.

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