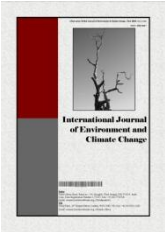

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Assessment of Growth and Yield Performance of Wheat Genotypes (*Triticum aestivum* L) under Heat Stress Environment

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was laid out with six wheat genotypes K-9162, K910-30, DBW-16, AAI-16, K-911, and NW-1014. This study was conducted during winter season 2020-2021 at the Student Instructional Farm and in the laboratory of Plant Molecular Biology and Genetic Engineering at Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya –224 229 (U.P.) in Randomized Block Design (R.B.D.) The wheat genotypes were exposed to heat stress by delayed sowing of 60 days from the normal date of sowing (15 January 2021) so that reproductive stage of wheat can experience heat stress. The field preparation and normal agronomic practices were followed as per need of the crop. The wheat genotypes K-9162, K910-30 and K-911 showed less reduction in yield and yield components over the DBW-16, AAI-16 and NW-1014 wheat

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genotypes. Therefore, on the basis of less reduction in yield and yield components under heat stress, K-910-30, K-911 and K-9162 were showed the significant tolerant while the other genotypes like DBW-16, NW-1014 and AAI-16 were found high yielding under normal condition but also showed high reduction in yield under heat stress condition.

Keywords: Heat stress; genotypes; growth; yield.

1. INTRODUCTION

The wheat is the important wheat crop in India as we as many parts of the world. Wheat is the second most important food crop in the country after rice both in area and production. It is one of the major food crops in food security mission of India. About 14% of the total cropped area in the country is under wheat cultivation. It is grown over around 30mha area and 87.04 mt production [1]. The Uttar Pradesh has highest area and production while Haryana has first position in productivity among the states in the country. It consist carbohydrates (72%), protein (11%), lipids (2.5 %) and minerals (2%) and vitamins and phytochemicals in very less amount (< 1%) [2].

The wheat faces a number of abiotic and biotic stresses during its life span among which high temperature stress is becoming major constraint for wheat production in India as well as many parts of the world. In India, Terminal heat stress is a common abiotic factor for reducing yield of wheat crop in North- Western part of India. “The reproductive phase of many crop species is relatively more sensitive to heat stress than the vegetative phase” [3,4]. “Vegetative growth and the reproductive phase in wheat differ in their sensitivity to temperature” [5].

“Plant growth and crop yield depend on temperature and its extremes. The optimum temperature range for C_3 crops is 15-20 °C and for C_4 crops it is 25-30°C” [6]. High temperature reduces the photosynthesis and enhances photo respiration. Photosynthetic enzymes of C3 plants are highly susceptible to temperature above 30^0C. “High temperature stress affects the metabolic pathways at every stage of growth and development of wheat finally leading to yield reduction. The effect of high temperature is particularly severe during grain filling; these losses may be up to 40% under severe stress” [7,8].When temperature remains around 35/20oC from weak after anthesis up to maturity, it reduces grain number (>60%) and grain weight (>30%) by reducing number of spike, number of fertile spikes per plant and number of grains per spike.

Heat stress reduces the growth period of crop and low biomass accumulation. Late sown wheat crop faces with poor plant population, less tiller number, reduce vegetative growth and early occurrence of reproductive stage. Terminal heat stress induces early senescence and limits the photosynthetic activity and photosynthates translocation. In this way it reduces grain growth period, grain setting and number of grain per spike. High temperature also reduces filling period and induces forced maturity resultantly grain become thin shriveled with low test weight [9].

The identification terminal heat tolerant wheat genotypes are primary concern to of this paper to reduce the yield losses under heat stress regimes. Tolerant heat genotypes able to maintain its growth and yield up to some extent under heat stress by less reduction in yield and yield components. The exposure and selection of heat tolerant wheat genotype can be done on the basis of recording growth and yield parameters under normal heat stress condition.

2. MATERIALS AND METHODS

Wheat genotypes K-9162, K-910-30, DBW-16, AAI-16, K-911, NW-1014 sown at Student Instructional Farm and use of deign R.B.D. of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya. (U.P.) during rabi season 2020-21. Geographically, Ayodhya comes under sub-tropical climatic zone of Indo-Gangetic alluvium of eastern Uttar Pradesh, India. It is situated at 24.4^0 to 26.56^0 N latitude and 82.12^0 to 83.98^0 east longitude at an altitude of 113 meter above Mean Sea Level (MSL). The average annual rainfall of this region is about 1100 mm. Heat stress was given by delayed sowing of 60 days from normal sowing (15 November) so that reproductive stage of wheat genotypes could experienced severe heat stress environment. 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. Plant height was recorded from base of plant to base of spike of three plants and average out to one. Tiller number of three plants were recorded separately and average out to one. Number of spikes of three plants were recorded and average out to one as spike plant^{-1}. Main Spike length of three plants were recorded and average out to one as spike length. “Seed weight of three randomly selected plants were recorded and average out to one as grain yield plant^{-1}.Test weight was recorded as weight of 1000 seeds in gram” [10].

3. RESULTS AND DISCUSSION

Wheat genotypes showed genetic variability in plant height (Fig. 1). The maximum plant height was recorded in K-910-30 (119.50) and minimum in DBW-16 (85.00) under control condition. The Stability in plant was highly fluctuated under heat stress in wheat genotypes due to their generic level of heat tolerance. The maximum reduction was recorded in AAI-16 (42.30) followed by DBW-16 (39.61) and K-910-30 (39.47) while minimum in K-911 (33.27) followed by NW-1014 (37.89), and K-9162 (38.57) in terms of percent reduction over control.

“The severity of the possible damage to crop is determined by the developmental stage at which the plant is exposed to high temperature” [11]. “Reduction in plant height of wheat genotypes due to late sowing and high temperature stress” is also reported by [12].

“Wheat genotypes showed significant variability in number of tillers per plant (Fig. 2). Under control condition the maximum tiller number was recorded in DBW-16 (19.83) and minimum in K-911 (6.16). The heat stress had significant effect on tiller number per plant and reduced it in all wheat genotypes” [10].

“The minimum percent reduction in tiller numbers was recorded in K-9162 (13.76) and maximum in K-910-30 (58.76) in heat stress regimes.K-9162 (13.76), K-911 (26.94) and DBW-16 (47.90) showed superiority over other genotypes due to low per cent reduction in tiller number over control heat stress condition. Heat stress during early vegetative stage affects the tiller numbers and resultantly it also affects the number of spikelet per plant, resulting in reduced sink capacity and future source capability of the plants” [13-15].

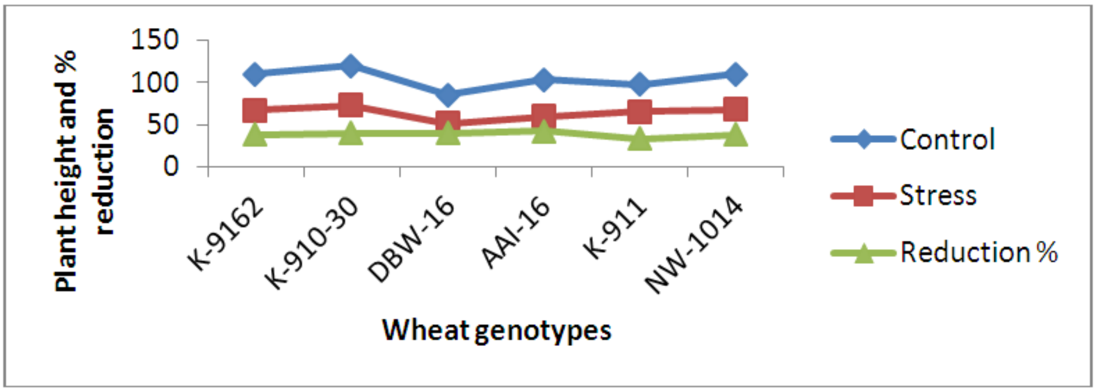

Fig. 1. Effect of heat stress on plant height (cm) of wheat genotypes

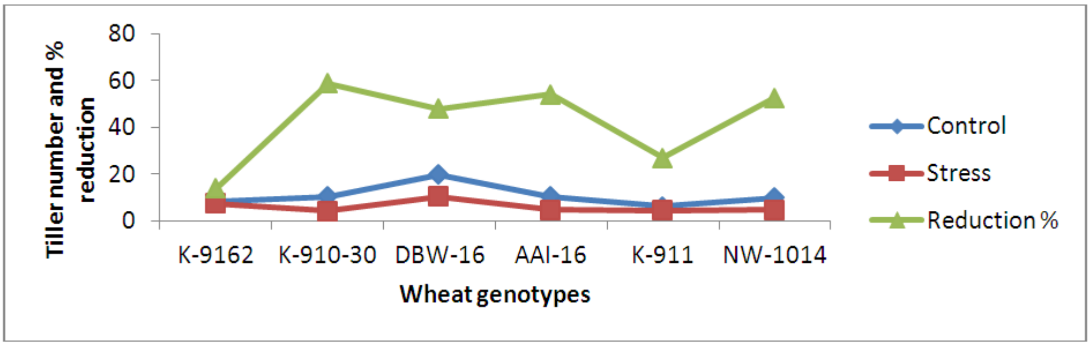

Fig. 2. Effect of heat stress on tiller number of wheat genotypes

There were significant variations in spike length in different wheat genotypes under control condition and heat stress condition. The maximum spike length was noted in K-911 (13.33), K-910-30 (13.16) and AAI-16 (12.33) minimum NW-1014(11.00), K-9162 (11.50) and DBW-16 (12.00) under the control conditions (Fig. 3). Under heat stress conditions the length of spike was not maintained as under control condition. Heat stress significantly reduced spike length. Genotypes showed like K-910-30 (22.79), K-9162 (24.69) and DBW-16 (26.41) per cent reduction respectively over control and statistically superior over other variety. The high per cent reduction was recorded in K-911 (33.75), NW-1014 (27.27) and AAI-16 (27.00).

Terminal heat stress is a common abiotic factor for reducing yield of wheat crop in north western part of India. It reduces grain grow period, grain setting, number of grain per spike. High temperature also reduces filling period and resultantly grain become thin shriveled with low test weight [16]. “Spike length has strong indirect influence on grain weight / plant through no. of spikelet / spike” [17].

Wheat genotypes showed genetic variability in number of grains spike^{-1} under control and stress condition (Fig. 4). High number of grains in main spike was noted in DBW-16 (66.16), AAI-16 (65.83) and K-911 (63.00) while a smaller number of grains recorded in NW-1014 (52.50), K-910-30 (52.66) and K-9162 (58.66). Heat stress reduction the grains in main spike irrespective of wheat genotypes. High reduction in number of grains in main spike was obtained inK-911 (43.65), AAI-16 (39.75) and DBW-16 (37.27) while less in K-910-30 (14.24), K-9162 (29.25) and NW-1014 (30.47) under heat stress regions.

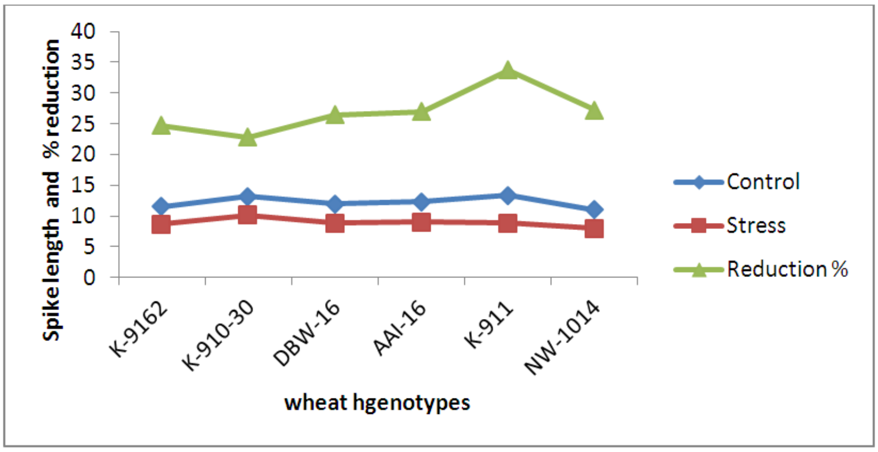

Fig. 3. Effect of heat stress on spike length (cm) of wheat genotypes

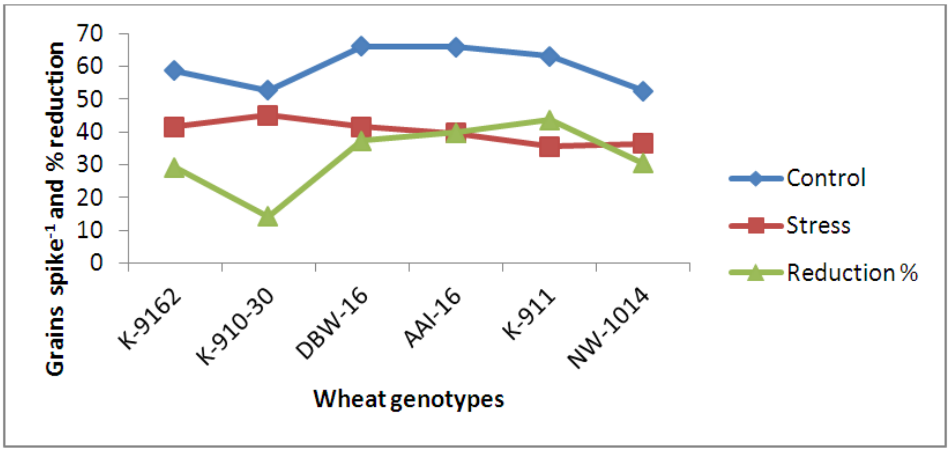

Fig. 4. Effect of heat stress on no. of grains in main spike of wheat genotypes

"The genetic variability was recorded in yield per plant of wheat varieties (Fig. 5). Under control condition DBW-16, AAI-16 and K-910-30 showed 37.98 gm, 21.59 gm and 21.31 gm grain yield per plant respectively and superior over other varieties. But under stress condition its persistency was not maintained as control condition and thus maximum per cent reduction was recorded in AAI-16 (82.86%) followed by DBW-16 (80.88%) and K-910-30 (76.02%). The minimum per cent reduction was noted in K-9162 (58.57%) and statistically significant over other in yield persistency under heat stress condition" [10].

Yield is the summation of yield contributing factors [18]. The activity of these factors like productive tillers, functional leaves, spike length and grain per spike and grain weight reduces as per intensity and duration stress [19]. "The improvement in yield related parameters in this wheat cultivar may be attributed to its stay green character and better grain filling in heat stress conditions" [20]. "Genotypes which possess stay-green character are considered best regarding their grain filling in elevated temperature" [21].

There was significant variation in test weight recorded in wheat varieties under control and heat stress condition .The varieties that showed maximum test weight under control condition were AAI-16 (45.76), K-911 (44.56), K-910-30 (42.07) and lowest test weight containing varieties were DBW-16 (33.54), K-9162 (37.16), NW-1014 (39.44). The test weight of all varieties was markedly reduced in heat stress condition. The per cent reduction becomes high as temperature increased. The maximum reduction under control heat stress was recorded in AAI-16 (40.86%) and followed by NW-1014 (28.98%) and K-910-30 (26.97%). The minimum reduction was recorded in K-9162 (20.34%), DBW-16 (23.49%), K-911 (25.74%) showed tolerance under heat stress regimes.

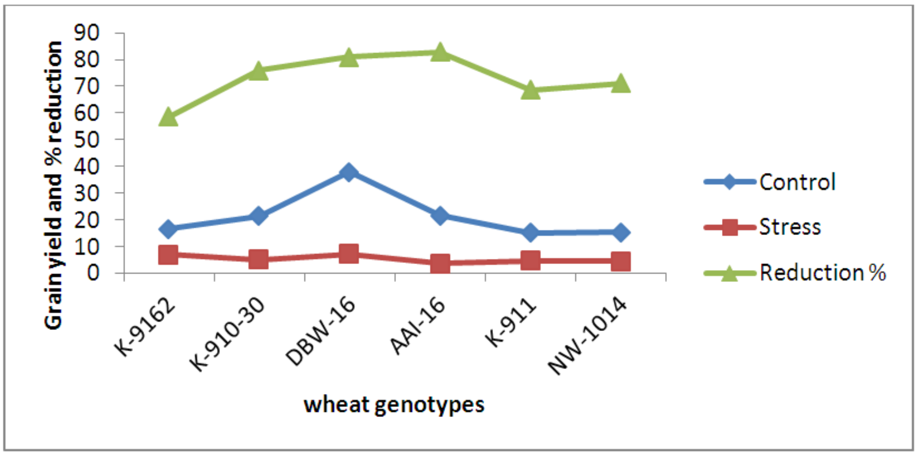

Fig. 5. Effect of heat stress on grain yield (g) of wheat genotypes

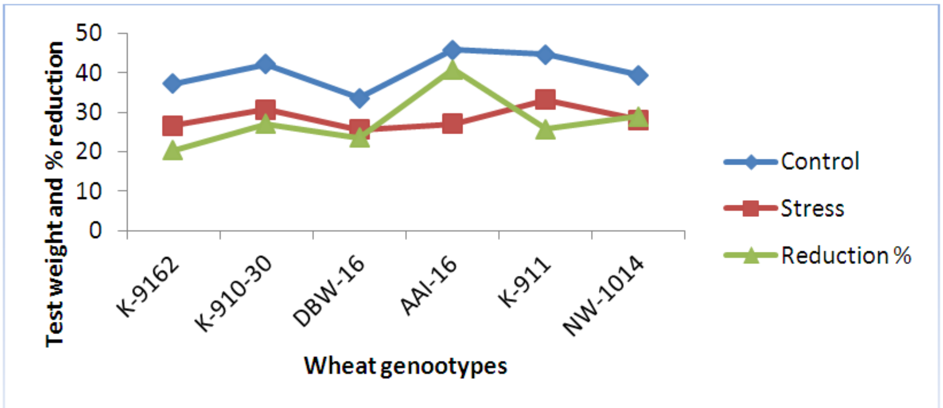

Fig. 6. Effect of heat stress on test weight (g) of wheat genotypes

Heat stress inhibits biosynthesis of chlorophyll [22] "with increase in leaf senescence. Grain weight and grains per spike were also highest in heat resistant cultivar i.e. Mairaj-2008. Maintenance of grain weight during heat stress is also an indication of heat tolerance during grain filling period" [23,24] and "high potential grain weight in heat stress may be important criteria for selection of cultivars for heat tolerance" [25].

4. CONCLUSION

Heat stress was given by delayed sowing of 60 days from normal sowing (15 November) so that reproductive stage of wheat genotypes could experienced severe heat stress environment. The wheat genotypes K-910-30, K-911 and K-9162 showed less reduction in yield and yield components under heat stress condition. Under normal condition DBW-16, NW-1014 and AAI-16 showed high grain number spike-^{1}, test weight and yield but performed poorly under heat stress condition.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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