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PRECISE PHENOTYPING APPROACH OR CHARACTERIZATION OF TERMINAL HEAT TOLERANCE IN BREAD WHEAT (TRITICUM AESTIVUM L.)

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Abstract

The investigation of study of terminal heat tolerance carried out at experimental field of Krishi Vigyan Kendra, Banasthali Vidyapith, Rajasthan during crop season 2020-2021. The experiments were established in a precise phenotyping approach with 3 replications. Germination rate, days to heading (DTH), plant vigor, canopy temperature data was collected. A vital quality to improve establishment is plant vigour, water- use efficiency and grain yield for wheat. Dates of heading were determined when 50% of the plant in a field had reached under TS and LS conditions. The traits days to heading should be invariably considered for wheat improvement. The plant vigour and germination rate data have been reported. The average value of germination rate of the genotypes under timely and late sown were 59.51 and 65.91 respectively. When compared to timely sowing, the genotypes germination rates for late sowing were higher. The effects of temperature were more on LS as compared to TS. The ten genotypes examined showed fairly diverse variability for the various traits evaluated and were significantly associated with yields that could be used in breeding programs in wheat breeding.

Keywords: Wheat, Days to heading (DTH), Germination rate, Plant vigour, Canopy temperature.

INTRODUCTION

Wheat is an essential crop and sustains billions of family daily while its production is approximately reduced under high temperature. (Rehman et al.2021). In India wheat is sown in November and December and harvested in April & May. 12-22ºC temperature required for the for the timely planted wheat crop during reproductive and vegetative growth period especially during anthesis & grain filling stages (Rehman et al. 2021). Heat stress break off important biochemical and physiological development in plant. Knowledge of the physiological, biochemical, and morphological effects of heat stress is crucial for creating novel crop types that can withstand changing climatic conditions. Heat stress interrupts the important physiological and biochemical process of the plant (Poudel et al., 2020). Pandey et al., 2013 phenotypic selection's challenges in tolerance and marker-assisted selection (MAS) has been regarded as a successful strategy for enhancing plant stress resistance due to the overall complexity of abiotic stress tolerance.

Spielmeyer et al., 2007 Wheat crops with greater early vigour shade the soil surface more rapidly and reduce water loss. Evaporation losses impair water utilization, especially in arid where most precipitation is reduced before the canopy closes, in the early growing season. Duan et al., 2016 the vitality of young plants is an important physiological property for improving wheat colonization, water utilization efficiency and grain yield. Previous studies assessing the increase in small genotypes of young plants have shown the potential to boost grain and biomass production through vitality selection in the Mediterranean environment Whan et al., 1991. Khan et al., 2007 therefore, high temperatures during late development of wheat, especially at the beginning and a later flowering (terminal or late heat stress), are treated to key factors limiting wheat production in different wheat developing areas. Improving the heat resistance of late planted wheat is actual important for increasing and stabilizing the production of wheat in the country. Therefore, breeding or selected genotypes with improved heat resistance is one of the key goals of the wheat improvement program.

Zadok's growth scale

This scale uses a 1- 11 numbering system, with each number representing a new growth event. To further define a stage, each number can be sub divided using decimals. When more than half of the plants in wheat field have progressed to the next growth stage, the field has reached a new growth stage Zadok et al., 1974.

MATERIAL AND METHODS

Plant material

10 wheat genotypes (*Triticum aestivum* L.) viz., GW322, HI617, K0402, K68, Raj 4037, Raj 3765, GW496, Raj 3777, Raj 4238 and K9423 were selected for field experiments for the support of heat tolerance & heat susceptibility will be sown at the research plot of KVK for distinct agro climatic conditions admitted the plant material for present study.

Plot information and data collection

Sowing system was aimed in 2019/2020. The experiment comprising two date of sowing dates for timely and late sowing (22 November and 22 December). A complete block design was used for the field trials randomized in three replicates. The plot area was 72msq. Irrigation was performed as needed fertilizer application followed recommended agricultural packages and practices. Observations were recorded for bio-phenology & yield-related traits of all genotypes. The considered traits were plant vigour, germination rate, days to heading (DTH), canopy temperature. The days of heading were determined when 50% of the plant in a field had reached under TS and LS conditions. Canopy temperature is an integrative trait that reflects canopy coolness, or the balance between the shoot transpiration and root water uptake. Canopy temperature is measured with a portable infrared thermometer (Lepekhov et al., 2022).

Table 1: Pedigree and origin of 10 wheat genotypes used in the study.

S.NO	Wheat type	Varieties/Genotypes	Pedigree	Year of release	Origin
1	Hexaploid (Bread wheat)	GW322	GW173/GW196	2002	RARS, Vijapur
2	Bread wheat	HI617 (Sujata)	Selection from C 306	1982	IARI RS, Indore
3	Bread wheat	K0402 (Mahi)	HP1731/UP2425	2013	CSAUA&T, Kanpur
4	Bread wheat	K 68	NP773/K 13	1968	Agriculture Deptt, UP
5	Bread wheat	Raj 4037	DL 788-2/RAJ 3717	2004	RARI, Durgapura
6	Bread wheat	Raj 3765	HD 2402/VL639	1996	RARI, Durgapura
7	Bread wheat	GW496 (Gujarat Wheat 496)	HD2285/4/CNO/NO//CC/INIA 66/3/KAL/BB	1990	JAU, Junagadh
8	Bread wheat	Raj3777	RAJ3160/HD2449	2006	RARI, Durgapura
9	Bread wheat	Raj4238	HW 2021/ RAJ 3765	2016	RARI, Durgapura
10	Bread wheat	K9423(Unnat halna)	HP 1633/KAL/UP262	2005	CSAUA&T, Kanpur

Table 2: Shape and size of wheat genotype.

Genotypes	Seed size	Shape
GW322	5 mm	Oval shape
HI617	6 mm	Oval shape
K0402	6 mm	Oval shape
K68	6 mm	Oval shape
Raj4037	6 mm	Oval shape
Raj 3765	7 mm	Oval shape
GW496	6 mm	Oval shape
Raj3777	6 mm	Oval shape
Raj4238	6 mm	Oval shape
K9423	5 mm	Oval shape

Soil sample report

EC	PH	OC %	N (kg/ha)	P (kg/ha)	K2O (kg/ha)	S (PPM)	Zn (PPM)	Fe (PPM)	Mn (PPM)	Cu (PPM)	B (PPM)
0.76	7.92	0.42	224.3	33.06	362.88	10.0	2.31	4.03	3.60	1.31	0.73

Table 3: Table shows soil sample

RESULTS

Plant vigour:

The genotypes that produces greater early vitality grows faster after germination and blooms to increase leaf area and biomass Lopez et al., 1994.The morphological factors that contribute to the early vitality phenotype and wheat is apparent for early leaf development defined Rebetzke et al., 1999. Fig. 1 depicts the spreading kind of plant as being heat tolerant and the erect type of plant as being heat sensitive.

Observation in field conditions

In field condition plant vigour data were taken showed semi spread, spread and erect type behavior.

(1.) **(2.)** **(3.)**

Figure 1: Scoring plant type at seedling stage 1. Spread 2. Semi spread 3. Erect.

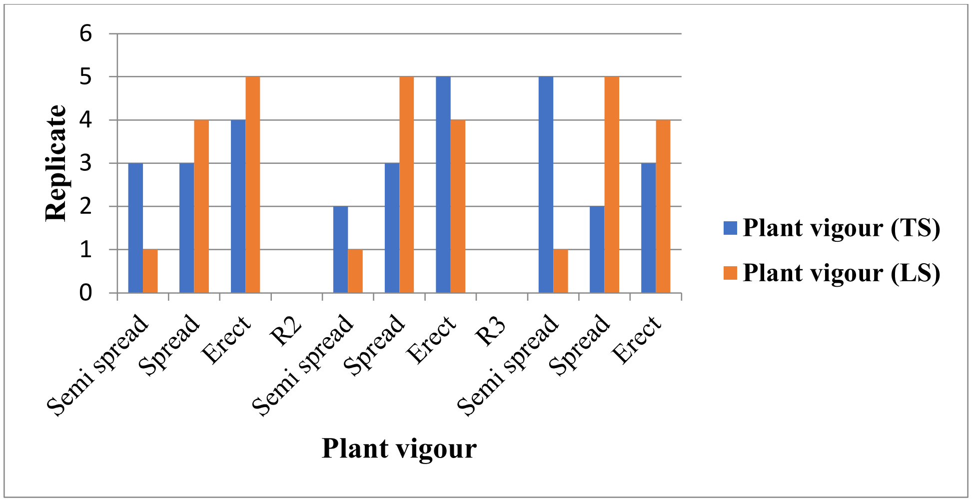


Figure 2: . The plant vigour of genotypes with three replications, R1, R2, and R3, is depicted on a graph under conditions of timely and late sowing.

In timely sown conditions, in R1 replication, the erect type displayed a higher value, ie., 4, while the spread and semi-spread types displayed the lowest value, ie., 3. In R2, erect type had the highest value, 5, while semi-spread type displayed the lowest value, 2, while in R3, semi-spread displayed the highest value, 5, while spread displayed the lowest value, 2. In R1 replication under late-sown conditions, the erect type displayed a higher value of 5, and the semi-spread type displayed the lowest value of 1. Spread type displayed a greater value in R2 replication, 5; semi spread type displayed a lower value, 1, Spread type demonstrated a greater value in R3 replication 5, while semi-spread demonstrated a lower value of 1.

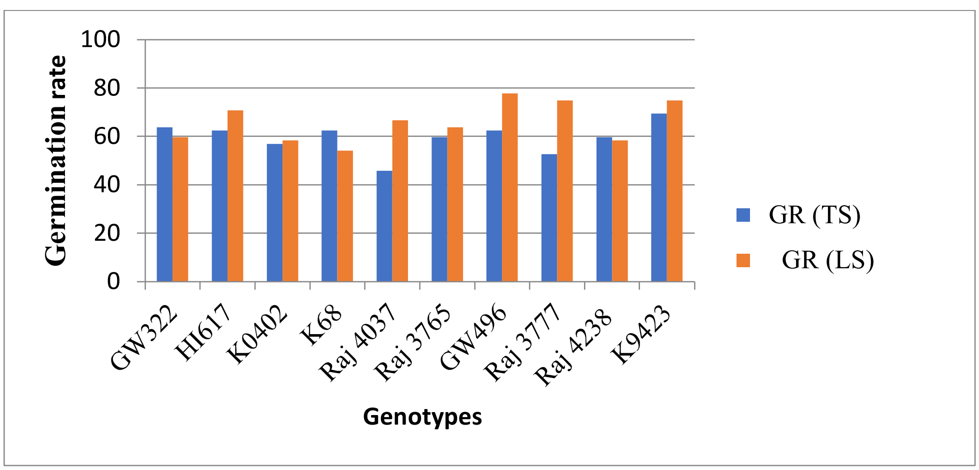


Figure 3: The genotypes germination rates for timely and late sowing are depicted in a graph.

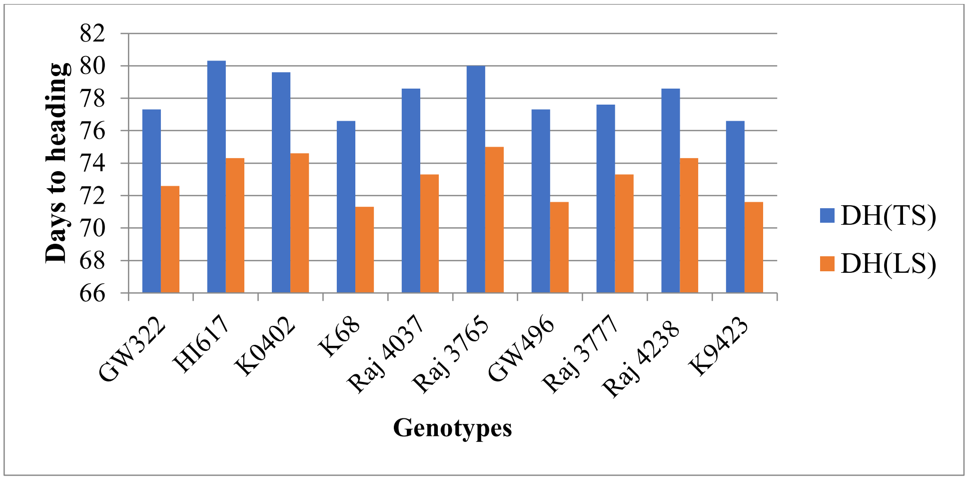


Figure 4: The graph displays the genotypes' days to heading under TS and LS.

Germination rate

After seeding under TS and LS, germination data was collected after 25 days. The genotypes average germination rates under timely and late sowing were 59.51 and 65.91 respectively. In timely sown genotype K9423 showed higher germination rate ie., 69.4 and Raj4037 showed lowest germination rate 45.8 and in late sown genotype GW498 showed highest average value ie., 77.7 and genotype K68 showed lowest value ie., 54.1. In fig.3, the genotype germination rate of late-sown seeds was higher than that of timely-sown seeds. Thermal stress in the range of 28-30°C can change growth time of plant by shortening the germination and maturation time of seeds (Yamamoto et al., 2008). Result revealed that the both factors ie., genotype and temperature as well as their interaction significantly affected the germination percentage and other seed vigour parameters. Germination rate increase with increase in temperature in all the genotypes under late sown. Heat stress clearly has a negative impact on the growth and development of wheat plants.

Krupnik et al., 2015 report on this early sowing resulted in wheat escaping heat stress and late sown staggered wheat growth over a period of time. During that time high temperature occurs which ultimately leads to thermal stress and reduced yields. According to Llveras et al. (2004), the appropriate seeding rate differs significantly from region to region because of variations in environmental conditions, soil types, sowing dates, and wheat genotypes.

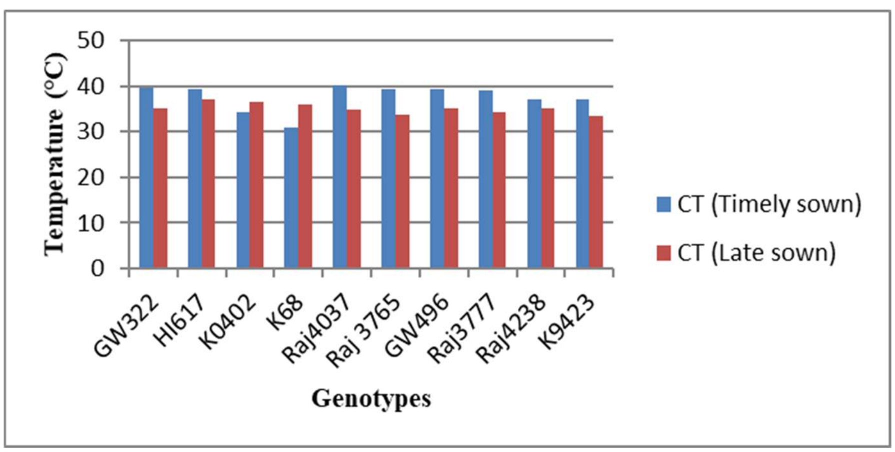
Analysis of Days to heading:


Figure 5: Wheat growth stage – Heading stage.

Under TS and LS conditions, the average values of wheat genotype days to heading were noted. According to their average values, due to the effect of temperature, the number of days for late sown was reduced compared to early sowing in fig. 4. In timely sown, Genotype HI617 headed earliest with the highest average value 80.3 and two genotypes K68 and K9423 was last with the lowest average value ie., 76.6 and in late sown genotype Raj3765 headed earliest with highest average value 75 and genotype K68 was last with the lowest value 71.3. In fig.4, timely sown showed higher days to heading as compared to late sown. This is probably due to the final heat stress. Late-sown wheat types typically face extreme temperature stress, which reduce the number of days to heading Akter et al., 2017.

Canopy temperature

Figure 6: Graph shows the canopy temperature of genotypes under timely and late sown conditions.



The average values of canopy temperature of wheat genotypes under TS and LS were recorded. In timely sown, genotype Raj 4037 showed higher average temperature ie., 40.3°C and K68 showed the lowest average temperature ie., 30.9°C. In late sown, genotype HI617 showed higher average temperature ie., 37.2°C and genotype K9423 showed lowest temperature ie., 33.3°C.

DISCUSSION

Field-based research provides a better way to study final heat resistance. Late sowing provides a better opportunity to assess genotype for adaptability to high temperatures. From early growth stage to maturity, this is usually a sudden spurt in temperature that impacts timely sown growing crops.

Variation in performance may also be attributable to seasonal influences. The temperature of the soil in late planting season is projected to be below 10 °C affecting stand establishment and seed germination. Like other cool-season crops, wheat is frequently sown early to ensure optimal development, growth, and maturity. Due to differences in genetic potential, the response of wheat genotypes to the day of planting depends on the traits that promote yield.

As a result of the interaction between date of sowing and genotype, very significant mean differences were observed for all genotypes. In general, all genotypes took more days to germinate with normal sowing than in late sowing Khan et al., 2007. Under normal planting conditions the deterioration is more noticeable in field trials that requires more days for heading. The length of the heading period shortens as the temperature rises (Soliman et al., 2006). Because early sowing delivers larger yields than late sowing due to the longer time, late planting has an impact on wheat growth, yield, and quality. Lower and high temperatures change plant function and productivity. Wheat breeding for yield selection uses canopy temperature (CT), which exhibits a strong and dependable correlation with heat-stressed yield, but little is known about its genetic control Pierre et al; 2010. CT is an indirect measurement of total culture level and instantaneous transpiration of plant water status Araus et al; 200, Reynolds et al; 2001. Canopy temperature is recognized as a crucial screening criterion to identifying potential genotypes that can avoid the effect of heat stress by more efficiently obtaining water from soils with good root systems Singh et al., 2022. The substantial correlation between grain yield and CT provided support for its usage as a selection criterion to increase heat tolerance. In late wheat, the low temperature during germination has a great effect on germination and seedling germination (Timmermans et al., 2007). When sowing late, early germination and seedling growth are very important for a better wheat harvest. This may be due to its ability to withstand low temperatures during germination.

CONCLUSION

The overall finding suggested that timely seeded crops performed better in terms of wheat yield and growth. High temperature adversely reduced the development and growth of wheat by inhibiting physiological process and metabolic activities. CT suitability as a choice criterion for improving stress tolerance based on association of CT and grain yield. This study finds that different wheat genotypes respond and tolerate heat stress in different ways. This may serve as a genetic stock for developing wheat tolerant varieties in breeding programs.

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Conflict of interest

The corresponding author declares that there are no competing interests on behalf of the other writers.

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