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*Research Article*

# Variation parameters for heat tolerance index of wheat

Ajay Prakash Agrawal, Dinesh Pandey and Devesh Pandey*
*TCB College of Agriculture and Research Station, IGKV, Bilaspur (CG) 495 001*

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***Corresponding author***

Email : *pdp1974@rediffmail.com*
Tel. : 07752-254380



## Abstract

**Wheat is important *rabi* crop in Chhattisgarh, which is grown mostly under irrigated condition. The late sowing and early rise in the temperature during winter season are the major causes of the lower productivity. One hundred genotypes were evaluated on two dates of sowing under late sown conditions and Heat Tolerance Index (HTI) was calculated for seed yield and seven component characters. Most of the characters recorded high coefficient of variation for HTI except days to maturity. HTI for days to flowering ranged from 0.12 (EBWYT 524) to 0.76 (CG 8047). Forty three genotypes have negative index indicating high grains per spike in second sowing date, moreover, genotypes Raj 4187, LBPY 06-14, ESWYT 104 and CG 8040 have zero HTI and YCSN 102(09), Raj 4174 have near stable grains per spike in two sowing dates. Three genotypes IBWSN 1156, EIGN 8-83 and HD 2932 (C) recorded the zero HTI for tillers per plant. The average 1000 seed weight was 33.49 percent higher in first sowing date as compare to second date. The minimum index value is 0.04 for EGPY 5, CG 8017, moreover SBR-48, EBWYT 519 and ESWYT 528 recorded less than 0.10 index, indicating stable seed weight over different sowing dates. The seed yield per plot ranged from 260 g for IBWSN 1156 to 1100 g for CG 8046 with average yield of 608.5 grams per plot first date of sowing. Under January sown conditions, mean seed yield was 357.7 gram per plot resulting in 70 percent reduction in seed yield. The seed yield per plot ranged from 180 grams for Lok 1 to 575 grams for IBWSN 1133. The HTI ranged from 0.00 (tolerance) to 0.72 (Susceptible). CG 8020, CG 8038 and LBPY 6-13 recorded the 0.00 index, but these varieties are poor yielder than the check, hence can only be used as parent for heat tolerance.**

**Keywords:** Productivity, heat tolerance index, variability

## 1. Introduction

Wheat is cultivated as second crop after paddy harvest in the Chhattisgarh state as well as in many parts of the country. Late harvesting of *kharif* paddy (main crop of the area) delays the sowing of wheat in the state. Winter is short in the state (about 80-90 days) & normally the day (max.) temperature rises gradually after third week of January and reaches higher rate of increasing trends after 20th February. The wheat crop requires favorable winter for about 100-110 days for producing its potential yields. Therefore, the heat tolerant wheat variety is still one of the priority of agricultural research, because above the optimum temperature (22-24°C) wheat yield is drastically affected. About 50 per cent of the wheat in Chhattisgarh is planted after first week of the December and suffer from heat stress resulting in significantly yield losses. Late planted wheat suffers drastic yield losses which may exceed to 40-50 per cent. It has already been established that heat stress can be a significant factor in reducing the yield and quality of wheat (Stone & Nicolas 1995). Heat stress is a major challenge to wheat productivity in India (Joshi *et al.*, 2007). The productivity of wheat in the state is around 12.50 qt $ha^{-1}$ which is far lower than the national productivity (29 qt $ha^{-1}$). The late sowing and early rise in the temperature during winter season are the chief causes of the lower productivity. Further non-availability of wheat varieties with better late heat tolerance index coupled with

higher yield lead to the lower productivity. Therefore, there is a dire need to develop/identify genotypes that are either tolerant to terminal heat stress or that mature early without appreciable yield losses.

## 2. Materials and methods

An experiment was carried out in late (December) and very late (January) sown conditions at TCB College of Agriculture & Research Station, Bilaspur during 2010-11. Experiment was taken to expose the crop in normal and high temperature environments, respectively under irrigated late sown condition after paddy harvest. Experiment was laid out in split plot design with two-replications with plot size 0.72 m X 4.0 m. Hundred wheat cultivars were used with 7 checks i.e. GW366, Lok 1, HI 1544, HD 2864, HD 2932, DBW 14 and Raj 3765. Date of sowing was 03 Dec. 2010 ($D_1$) & 03 Jan. 2011 ($D_2$). Climate was favourable up to 5$^{th}$ standard meteorological week (SMW) *i.e.* Jan.29- Feb.04 with mean temperature less than 22$^0$C after which shoot-up onwards 6$^{th}$ standard meteorological week *i.e.* Feb.05-11 with mean temperature more than 23$^0$C and remained higher up-to crop maturity. Intermittent rains in 9 and 10 SMW created some favourable environment but the mean temperature remained more than 23$^0$C. The first date sown crop was exposed to first 60 days crop growth period with less than 22$^0$C mean temperature, however the January sown crop had only 30 days exposure to less than 22$^0$c mean temperature. This provided a good opportunity for screening the wheat varieties for heat tolerance and calculation of heat tolerance index for different component characters. Eight quantitative characters were recorded in all 100 wheat genotype sown in two replications in two sowing dates. Observations likes days to flowering, days to maturity and seed yield (g) were recorded on plot basis, however number of grains per spike, plant height (cm) and spike length (cm) recorded with five randomly selected plants. Number of tillers per 0.5 meter was recorded by counting of effective tillers in 0.5 meter stick length thrown twice randomly in each plot. Test weight was recorded with random chosen 1000 seeds from the plot yield. The heat tolerance index of all the characters and all genotypes were calculated by using following formula:

Heat tolerance index = Yield loss due to stress/ Yield under normal sowing conditions

The HTI values ranged between ±1, zero or near to zero, heat tolerance values indicated that plus values indicating the sensitivity to heat and negative values indicating positive performance under adverse conditions.

## 3. Results and discussion

Genetic parameters of seed yield and yield attributing characters for HTI with *per se* performance are presented in Table 1. Days to flowering ranged from 64 days (YCSN 8-70) to 83 days (IBWSN 1133) with an average of 72.05 days in $D_1$ and 42 (CG 8047) to 65 days (YCSN 8-60, RWP 2008-5, UP 2729) with mean value of 57.37 days in $D_2$. There is reduction of 13.86 days in flowering by 31 days delayed in sowing. The reason behind this is that high temperature (short winter) reduces the crop cycle of the wheat cultivation (Pandey and Parihar, 1997). The heat tolerance index for days to flowering are ranged from 0.12 (EBWYT 524) to 0.76 (CG 8047) indicating that days to flowering of EBWYT 524 is least affected (only 7 days) and CG 8047 is highly sensitivity (28 days) genotype for the delayed sowing. Coefficient of variation for HTI is very high and for *per-se* performance is low, indicating the better chances for selections for HTI. Heat tolerance index ranged from -0.48 (UP 2729) to 0.62 (EIGN-8-62). Average numbers of grains per spike was 41.74 in $D_1$ and 38.5 in $D_2$ indicating that this character is less influenced by delay in sowing, but the actual reason for low difference in mean value is due to negative HTI of forty three genotypes for the characters. Four genotypes Raj 4187, LBPY 06-14, ESWYT 104 and CG 8040 have zero index and YCSN 102(09), Raj 4174 have near stable grains per spike in two sowing dates indicating that grains per spike of these genotypes were not affected by delayed in sowing. The coefficient of variation for HTI and *per-se* performance of this character is high, indicating positive improvement with selection.

Average number of tillers per half meter running length is 41.59 in first date of sowing and 34.94 in second date of sowing with average HTI of 0.15. UP 2729 recorded the lowest (28) and SAWYT 316, CIMMYT 8-23 recorded highest numbers (55) of tillers per half meter running length in first date of sowing. Similarly in second date of sowing, tiller numbers ranged from 13 (VL 892) to 56 (EBWYT 530) indicating high range and sensitivity of wheat genotypes under delayed sowing conditions. HTI ranged from -0.36 (EIGN-8-62) to 0.75 (VL 892), whereas twenty six genotypes had negative index indicating high numbers of tiller under late sown conditions. Three genotypes IBWSN 1156, EIGN 83 (8) and HD 2932 (C) recorded the zero index for tillers per plant. The average 1000 seed weight (g) was 33.49 percent higher in first sowing date as compare to second date. The higher seed weight in D1 might be due to more number of favourable temperature days (< 22$^O$C) as compare to second date. The minimum index value is 0.04 for EGPYT 5, CG 8017, moreover SBR-48, EBWYT 519 and ESWYT 528 recorded less than 0.10 index indicating stable seed weight over different sowing dates, but having less than 40 grams seed weight. ESWYT-147 recorded highest index of 0.45 showing its sensitivity towards the forced maturity under high temperature conditions and recorded maximum reduction in seed weight (20 grams/1000 seeds). Three genotypes LBPY-7-15, LBPY-06-13 and CG 9021 have more than 40 grams test weight under late sown conditions

and more than 50 grams under normal sown conditions. These can be used as higher seed weight parent for developing terminal heat stress wheat genotypes.

The average days to maturity of 100 genotypes reduced by 20.81 days by 31 days delay of sowing from 3rd December to 3rd January indicating sensitivity of wheat genotype for high temperature in post flowering period causing force maturity. In first date of sowing, mean days to maturity was 113.3 days ranging from 108 days for 12 genotypes to 118 days for 13 different genotypes. It ranged from 87 days for VL 892, YCSN 70(08), VW 514 to 97 days for KPY 637 with an average duration of 92.47 days in second date of sowing. CG 8018 and CG 8037 recorded the lowest index of 0.12 and 0.13 respectively indicating that locally bred genotypes have good compatibility with changing environmental conditions and days to maturity reduced by only 13&14 days. VW 514 recorded highest index (0.23) with 26 days reduction in maturity by 31 days delay in sowing.

**Table 1.** Variation parameters for eight characters in wheat

| Character | | Mean | Range | | | | Standard | CV % |
|---|---|---|---|---|---|---|---|---|
| | | | Min | Genotype | Max | Genotype | Deviation | |
| Days to flowering | $D_1$ | 72.05 | 64.0 | YCSN 8-70 | 83.0 | IBWSN 1133 | 3.81 | 5.29 |
| | $D_2$ | 57.37 | 42.0 | CG 8047 | 65.0 | YCSN 60 (8), RWP 2008-5, UP 2729 | 4.02 | 7.01 |
| | HTI | 0.26 | 0.12 | EBWYT 524 | 0.76 | CG 8047 | 0.07 | 28.90 |
| Grains / spike | $D_1$ | 41.74 | 25.0 | YCSN 8-60 | 63.0 | ESWYT 528 | 8.11 | 19.43 |
| | $D_2$ | 38.5 | 20.0 | EIGN 8-62 | 53.0 | GW 2008-15 | 5.12 | 13.31 |
| | HTI | 0.04 | -0.48 | UP 2729 | 0.62 | EIGN 8-62 | 0.21 | 478.38 |
| Tillers / 0.5 meter | $D_1$ | 41.59 | 28.0 | UP 2729 | 55.0 | SAWYT 316 CIMMYT 8-23 | 6.58 | 15.82 |
| | $D_2$ | 34.79 | 13.0 | VL 892 | 56.0 | EBWYT 530 | 7.98 | 22.94 |
| | HTI | 0.15 | -0.36 | EIGN 8-62 | 0.75 | VL 892 | 0.22 | 151.96 |
| Test weight | $D_1$ | 41.25 | 28.1 | AKAW 4510 | 56.7 | LBPY -06-13 | 1.10 | 13.32 |
| | $D_2$ | 30.9 | 23.15 | ESWYT 147 | 42.4 | LBPY -7-15 | 0.83 | 13.43 |
| | HTI | 0.25 | 0.04 | EGPYT 5, CG 8017 | 0.45 | ESWYT 147 | 0.09 | 35.62 |
| Days to maturity | $D_1$ | 113.3 | 108 | Many | 118 | Many | 3.06 | 2.70 |
| | $D_2$ | 92.47 | 87.0 | VL 892, YCSN 70(08), VW 514 | 97 | KYP 637 | 2.38 | 2.58 |
| | HTI | 0.18 | 0.12 | CG 8018 | 0.23 | VW 514 | 0.02 | 11.08 |
| Plant height | $D_1$ | 92.63 | 73.6 | DBW 14 | 124.6 | SBR -02 | 10.55 | 11.39 |
| | $D_2$ | 80.06 | 63.00 | VW0648 | 105.0 | CG 8018 | 7.47 | 9.33 |
| | HTI | 0.13 | -0.05 | CG 8126 | 0.34 | YCSN 8-69 | 0.08 | 60.16 |
| Spike length | $D_1$ | 9.17 | 7.25 | EIGN 8-69 | 12.50 | VW 514 | 1.08 | 11.73 |
| | $D_2$ | 8.35 | 6.25 | SBR-48, HI 1544(c), SAWYT 316, CG 8031 | 10.75 | GW 2008-15 | 1.01 | 12.14 |
| | HTI | 0.08 | -0.29 | CG 8038 | 0.38 | CG 8031 | 0.12 | 144.73 |
| Seed yield | $D_1$ | 608.5 | 260 | IBWSN 1156 | 1100 | CG 8046 | 145.79 | 23.96 |
| | $D_2$ | 357.7 | 180 | Lok 1 | 575 | IBWSN 1133 | 85.43 | 23.88 |
| | HTI | 0.39 | 0.00 | LBPY -06-13, CG 8020, CG 8038 | 0.72 | CG 8027 | 0.16 | 42.21 |

Plant height of 22 genotypes was not affected (± 5cm) and plant height of LBPY-7-17, CG 9021, YCSN 69 (8) reduced more than 25 cm by delay of sowing and index ranged from -0.05 to 0.34. Index for spike length ranged from -0.29(CG 8038) to 0.38 (CG 8031). Twenty five genotypes have ± 0.5cm length difference in two dates of sowing.

The seed yield per plot ranged from 260 g for IBWSN 1156 to 1100 g for CG 8046 with average yield of 608.5 g per plot in first date of sowing. Under January sown conditions, mean seed yield was 357.7 g per plot resulting 70 percent reduction in seed yield. Photosynthetic rate in maximum at 20-22$^0$C and heat stress injuries of the photosynthetic apparatus during reproductive growth of wheat diminish source activity and sink capacity which results in reduced productivity (Harding *et al.*, 1990). Source activity is damaged by heat, because both leaf area and photosynthesis is reduced**.** Heat injury limits sink growth potential particularly when stress is imposed during early sink developmental stages. Grain yield was negatively related to the thermal time accumulated above the base temperature of 31$^0$C (Mian *et al.*, 2007). High temperature above 32$^0$C has been reported reducing grain yield and grain weight (Wardlaw *et al.*, 2002). The seed yield per plot ranged from 180 grams for Lok 1 to 575 grams for IBWSN 1133. The heat tolerance index is ranged from 0.00 (tolerance) to 0.72 (susceptible). CG 8020, CG 8038 and LBPY 6-13 recorded the 0.00 index but these varieties are poor yielder than the check, hence can only be used as parent for heat tolerance. Under late sown conditions many genotypes yielded higher than the checks when corresponding seed yield under normal sown condition are considered. Considering both sowing dates, five varieties had given better yield than the best checks; *i.e.* IBWSN 1131, EBWYT 524, EIGN 1 (9) and CG 8046 with HTI of 0.38, 0.43, 0.50 and 0.66, respectively.

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