Combining ability studies on terminal heat tolerance in wheat (*Triticum aestivum L.*) under late sown irrigated condition using Line X Tester analysis

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DOI: [https://doi.org/10.22271/chemi.2020.v8.i5k.10393](https://doi.org/10.22271/chemi.2020.v8.i5k.10393)

Abstract

The present investigation entitled “Combining ability studies on terminal heat tolerance in wheat (*Triticum aestivum L.*) under late sown irrigated condition using Line X Tester design” was carried out during rabi 2017-18 and 2018-19 at the All India Co-ordinated Wheat and Barley Improvement Project, B.T.C. College of Agriculture and Research Station (IGKV), Bilaspur (C.G.). The experiment was conducted in RBD involving six lines, three testers and 18 F$_2$ hybrids of wheat with two replications for study of character associated with yield and yield contributing traits. The analysis indicated that variance due to treatments was highly significant for all the characters under studied. All the characters except spike weight were highly significant. GCA, SCA and additive effect was found highest for character of harvest index. Among the lines, CG 1015 (Chhattisgarh Gehu)-04 was found good general combining ability (GCA) effect for the character of peduncle length, spike length, number of seed per plant and biological yield per plant. MP 3336 was found good GCA effect for chlorophyll reflection index, harvest index and number of tillers per plant. HD 2285 was found good GCA effect for days to maturity, 1000 seed weight and canopy temperature depreciation. Among the testers, Halna was good GCA effect for the character of days to 50% flowering, days to maturity and spike length. PHSL 10 was good GCA effect for number of tillers per plant, spike weight, seed yield per plant and harvest index. Among the crosses, CG 1015 (Chhattisgarh Gehu-04) X HUW 661 was good specific combining ability (SCA) effect for seed yield per plant. MP 3336 X PHSL 10 was good SCA effect for number of spikelet per spike and number of seed per plant. HD 2932 X Halna was good SCA effect for spike weight and 1000 seed weight and crosses HD 2864 X Halna was good SCA effect for the character of canopy temperature depreciation and biological yield per plant.

Keywords: combining ability studies, wheat, line X tester, terminal heat tolerance, GCA and SCA effect, late sown irrigated condition

Introduction

Wheat is grown in Chhattisgarh mainly after the harvest of soybean kharif crops. Wheat seeding is usually delayed after November-December, due to late paddy harvesting. In these cases the growth and yields of wheat are adversely affected during growth and reproduction phases due to high temperatures. The line X tester analysis was used to estimate yield and components of both General Combining Capacity Effects (G.C.A.) and Unique Combining Capacity Effects (S.C.A.) and other essential agronomic characteristics of wheat. It was confirmed that both additive and non-additive inheritance influenced many of the traits. At the other hand, Barot et al., (2014) observed that the magnitude of the general combining ability variances was higher than that of the individual combining ability variances for all characters indicating the inheritance preponderance of the additive gene action.

Materials and methods

The present research was conducted in two seasons of rabi in 2017-18 and 2018-19 at All India Co-ordinated Wheat and Barley Improvement Project at B.T.C. College of Agriculture
and Research Station (Indira Gandhi Krishi Vishwavidyalaya), Bilaspur, Chhattisgarh, India. Nine wheat genotypes including six lines and three testers were crossed in a Line X Tester mating design and developed 18 F1 hybrids during *rabi* 2017-18, Kempthorne (1957) [3] (Table 1). The experiment was laid out with 18 hybrids and 9 parents in a randomized block design with two replication during *rabi* 2018-19. Five competitive plants were randomly selected to record the observation on 15 characters viz. days to 50% flowering, days to maturity, plant height, peduncle length, spike length, number of tillers, number of spikelet per spike, number of seeds per spike, spike weight, seed yield per plant, 1000 seed weight, canopy temperature depreciation, chlorophyll reflection index, biological yield per plant and harvest index.

**Result and discussion**

**Analysis of variance for combining ability**

Analysis of variance for combining ability was estimated for all the traits as per procedure described by Kempthorne (1957) [3]. The analysis indicated that variance due to treatments was highly significant for all the characters under studied (Table 4). All the characters except spike weight were highly significant. None of replication variance was significant indicating the validity of the experiment. The variance due to parents found highly significant for more of character except spike length and spike weight. The variance due to parents vs. crosses showed significant result for all character except characters spike length, and spike weight. Similar results observed by Singh et al., (2013)

**GCA, SCA and additive effect**

The highest general combining ability, specific combining ability and additive effect was found for the character of harvest index (Table-2). Similar results observed by Raj and khandalak (2003)

**GCA effect of female (line) parents**

Among the lines, CG 1015 (Chhattisgarh Gehu) was found good GCA effect for the character of harvest index. Similar results observed by Jatav et al., (2003)

**GCA effect of male (tester) parents**

Among the testers, Halna was good GCA effect for the character of days to 50% flowering, days to maturity and spike length. (Table-3) PHSL 10 was good GCA effect for number of tillers per plant, spike weight, seed yield per plant and harvest index. Similar results observed by Jatav et al., (2003)

**SCA effect of hybrids (crosses)**

Among the crosses, CG 1015 (Chhattisgarh Gehu-04) X HUW 661 was good specific combining ability (SCA) effect for seed yield per plant. Hussan et al., (2007) [6] MP 3336 X PHSL 10 was good SCA effect for number of spikelet per spike and number of seed per plant. HD 2932 X Halna was good SCA effect for spike weight and 1000 seed weight. Gupta et al., (2017) [7] and crosses HD 2864 X Halna was good SCA effect for the character of canopy temperature depreciation and biological yield per plant. (Table-3)

**Conclusion**

The analysis indicated that variance due to treatments was highly significant for all the characters under studied. All the characters except spike weight were highly significant. None of replication variance was significant indicating the validity of the experiment. The highest general combining ability, specific combining ability and additive effect was found for the character of harvest index. Among the line (female) CG 1015 Chhattisgarh Gehu-04, MP 3336 and HD 2285 was found good general combining ability (GCA) effects for more number of characters. Among the tester (male) Halna and PHSL 10 was found good GCA effects for more number of characters. Among the hybrids (crosses) CG 1015 (Chhattisgarh Gehu-04) X HUW 661, MP 3336 X PHSL 10, HD 2932 X Halna and HD 2864 X Halna were good specific combining ability (SCA) effects for more number of traits. The findings of the experiment could be helpful in wheat breeding programmes under late sown irrigated and terminal heat stress condition.

**Table 1: Details of parents used in study**

| S. No. | Genotypes          | Notificat-ion year | Parentage          | Released by | Farming condition |
|--------|--------------------|--------------------|--------------------|-------------|-------------------|
| 1      | Halna              | 2002               | HD 1982/K816       | SVRC        | Late sown         |
| 2      | HUW 661            | 2016-17            | NASN 2016-17(32)   | -           | -                 |
| 3      | PHSL 10            | 2016-17(83)        | NASN 2016-17(83)   | -           | -                 |
|        | Female/ Line       |                    |                    |             |                   |
| 1      | Chhattisgarh Gehu 4 | 2017               | NI 908/BL 1986     | SVRC        | Late sown         |
| 2      | HD-2932            | 2008               | KAUZ/STAR//HD2643  | CVRC        | Late sown         |
| 3      | HD-2864            | 2004               | DL 509-2/DL 377-8  | CVRC        | Late sown         |
| 4      | Raj-4238           | 2013               | HW 2021/RAJ 3765   | CVRC        | Late sown         |
| 5      | MP-3336            | 2013               | HD 2402/GW 173     | CVRC        | Late sown         |
| 6      | HD 2285            | 1984               | HD 1918/HD 1592/HD 1962/E 4870/K-65/4/HD 2160/5/HD 2180 | CVRC | Late sown         |

**Table 2: GCA and SCA effects**

| S. No. | Character               | GCA effect | SCA effect | Additive effect |
|--------|-------------------------|------------|------------|-----------------|
| 1      | Days to 50% flowering   | 0.28       | 3.92       | 0.57            |
| 2      | Days to maturity        | 0.98       | 0.38       | 1.97            |
| 3      | Plant height (cm)       | 6.52       | -5.35      | 11.09           |
| 4      | Peduncle length (cm)    | 2.15       | 4.53       | 2.22            |
| S. No. | Lines/ Testers/ Crosses | Days to 50% flowering (days) | Days to maturity (days) | Plant height (cm) | Peduncle length (cm) | Spike length (cm) |
|--------|-------------------------|-----------------------------|------------------------|------------------|-------------------|------------------|
| 1      | CG 1015                 | 2.60**                      | 0.88**                 | 0.84             | -3.81**           | 0.58*            |
| 2      | HD 2864                 | -1.16**                     | -0.88**                | -6.17**          | 2.77**            | -0.32            |
| 3      | HD 2932                 | 1.20**                      | 0.76**                 | -0.63            | 0.26              | -0.22            |
| 4      | RAJ 4238                | -2.42*                      | 0.51                   | -2.11**          | -2.62**           | 0.02             |
| 5      | MP 3336                 | -2.41**                     | 0.63**                 | 2.61**           | 3.40**            | 0.08             |
| 6      | HD 2285                 | 0.45                        | -1.38**                | 5.01**           | 1.13              | -0.50*           |
|        | SE(m)+                  | 0.62                        | 0.45                   | 2.6              | 1.08              | 0.42             |
| 7      | Halna                   | -0.68**                     | -1.12**                | 0.21             | -0.86             | -0.02            |
| 8      | HUW 661                 | 0.63**                      | 1.02**                 | -1.77            | -0.11             | 0.20**           |
| 9      | PHSL 10                 | 0.02                        | 0.68**                 | -1.88            | 1.04              | -0.45            |
|        | SE(m)+                  | 0.37                        | 0.27                   | 1.59             | 0.65              | 0.26             |
| 10     | CG1015 X Halna          | 0.19                        | 1.89**                 | -2.86            | -0.63             | 0.37             |
| 11     | CG1015 X HUW661         | 1.87**                      | -0.27                  | -3.79            | -1.48             | -0.8             |
| 12     | CG1015 X PHSL10         | -0.52                       | 0.13                   | 2.06             | -2.93**           | -1.47*           |
| 13     | HD 2864 X Halna         | -1.43**                     | -0.98                  | 4.92             | -1.08             | -0.88            |
| 14     | HD 2864 X HUW661        | 0.38                        | -1.53**                | 5.53*            | 4.89**            | 1.08*            |
| 15     | HD 2864 X PHSL10        | -1.77**                     | -0.19                  | -2.59            | -0.65             | -1.28*           |
| 16     | HD 2932 X Halna         | -1.43**                     | -0.98                  | 4.92             | -1.08             | -0.88            |
| 17     | HD 2932 X HUW661        | 0.72                        | 3.36                   | -2.35**          | 1.00*             |                 |
| 18     | HD 2285 X PHSL10        | -0.65                       | -1.31**                | -7.59**          | 2.11**            | -0.23            |
| 19     | RAJ 4238 X Halna        | 0.19                        | -0.73                  | 8.41**           | 0.37              | 1.12*            |
| 20     | RAJ 4238 X HUW661       | -2.13**                     | 0.59                   | -6.17**          | -1.6              | -0.67            |
| 21     | RAJ 4238 X PHSL10       | 1.48**                      | 0.43                   | -1.12            | 1.23              | -0.26            |
| 22     | MP 3336 X Halna         | -1.30*                      | -0.86*                 | -6.71**          | -0.89             | -1.18*           |
| 23     | MP 3336 X HUW661        | -2.13**                     | 0.47                   | 3.68             | 0.96              | 0.64             |
| 24     | MP 3336 X PHSL10        | 2.47**                      | 0.80                   | 2.77             | -1                | 1.56*            |
| 25     | HD 2285 X Halna         | 2.81**                      | -0.86*                 | -3.47            | -1.94             | 0.12             |
| 26     | HD 2285 X HUW661        | -2.51**                     | 0.47                   | 1.85             | 0.97              | -0.46            |
| 27     | HD 2285 X PHSL10        | -0.4                        | -0.19                  | 2.63             | 0.89              | -0.28            |
|        | SE(m)+                  | 1.07                        | 0.77                   | 4.5              | 1.87              | 0.73             |

*Significant at p=0.05% level, **Significant at p=0.01% level

Continue……
| Source | Replication | Treatment | Testsers | Lines | Testers vs Lines | Crosses | Parents vs. Crosses | Error | SE(m)+ | CD (%) | CV (%) |
|--------|-------------|-----------|----------|-------|-----------------|--------|-------------------|-------|--------|---------|--------|
| Days to 50% flowering (days) | 13.63** | 5.55** | 6.38** | 7.67** | 1.70** | 10.00** | 0.19** | 0.03 | 1.76 | 4.99 | 0.81 |
| Days to maturity (days) | 22.35** | 10.21** | 12.28** | 26.38** | 32.17** | 47.95** | 19.05** | 2.0 | 1.32 | 3.45 | 0.9 |
| Plant height (cm) | 18.10** | 10.16** | 21.53** | 45.62** | 38.36** | 47.95** | 27.68** | 0.4 | 0.22 | 1.84 | 0.01 |
| Peduncle length (cm) | 3.69** | 36.32** | 19.21** | 23.46** | 33.74** | 47.95** | 16.61** | 0.0 | 0.07 | 1.43 | 0.81 |
| Spike length (cm) | 2.03** | 21.92** | 15.47** | 47.95** | 38.72** | 47.95** | 10.26** | 0.0 | 0.02 | 1.32 | 0.05 |
| Number of tillers (per plant) | 36.32** | 21.92** | 15.47** | 47.95** | 38.72** | 47.95** | 16.61** | 0.0 | 0.07 | 1.43 | 0.81 |
| Number of spikelets per spike | 30 ** | 20.56 | 9.11 | 8.57 | 20.56 | 9.11 | 8.57 | 0.0 | 0.02 | 1.32 | 0.05 |

*Significant at p=0.05% level, **Significant at p=0.01% level

Table 4: Analysis of variance for combining ability

Table 4: Continue...

| S. No. | Lines/ Testers/ Crosses | 1000 seed weight (g) | Canopy temperature depreciation (°C) | Chlorophyll reflection index | Biological yield per plant (g) | Harvest index (%) |
|--------|-------------------------|----------------------|-------------------------------------|-----------------------------|-----------------------------|-------------------|
| 1      | CG 1015                 | -2.78**              | 0                                   | -1.04                       | 1.21**                      | -3.81**           |
| 2      | HD 2864                 | -1.35                | 0.25**                              | -2.65**                     | -1.19**                     | 0.44              |
| 3      | HD 2932                 | 2.42**               | -0.97**                             | 0.28                        | 0.22                        | -0.61             |
| 4      | RAJ 4238                | -0.92                | 0.03                                | 3.18**                      | -1.46**                     | 3.84**            |
| 5      | MP 3336                 | 0.97                 | -0.63**                             | 2.50**                      | -1.57**                     | 7.70**            |
| 6      | HD2285                  | 3.44**               | 0.47**                              | 0.008                       | 0.49                        | 1.22              |
| 7      | SE(m)+                  | 1.52                 | 0.19                                | 1.15                        | 0.98                        | 2.27              |
| 8      | Halna                   | -0.77                | -0.02                               | -0.09                       | -1.14                       | -1.52*            |
| 9      | HUW 661                 | -0.01                | 0.28**                              | -0.23                       | 1.14                        | 1.4               |
| 10     | PHSL 10                 | -0.90**              | -0.1                                | -0.35                       | 0.61                        | 4.75**            |

*Significant at p=0.05% level, **Significant at p=0.01% level

Table 4: 4:

| S. No. | Lines/ Testers/ Crosses | 1000 seed weight (g) | Canopy temperature depreciation (°C) | Chlorophyll reflection index | Biological yield per plant (g) | Harvest index (%) |
|--------|-------------------------|----------------------|-------------------------------------|-----------------------------|-----------------------------|-------------------|
| 1      | CG 1015                 | -7.43**              | -0.41                               | 1.19                        | -0.61                       | -0.2              |
| 2      | CG1015 X HUW661         | 4.35**               | 0.19                                | -1.94                       | 0.23                        | 7.27**            |
| 3      | CG1015 X PHSL 10        | 1.1                  | -0.33                               | -0.74                       | -2.10*                      | -5.46*            |
| 4      | HD 2864 X Halna         | -0.45                | 0.72**                              | 0.55                        | 3.27**                      | -3.26             |
| 5      | HD 2864 X HUW661        | 2.58                 | 0.16                                | -0.25                       | -0.37                       | 1.65              |
| 6      | HD 2864 X PHSL10        | -1.42                | -0.40*                              | 2.26                        | -0.26                       | 3.23              |
| 7      | HD 2932 X Halna         | 9.87**               | 0.02                                | 0.46                        | 1.22                        | 2.17              |
| 8      | HD 2932 X HUW661        | -7.81**              | 0.46*                               | 5.85**                      | -0.81                       | -12.92**          |
| 9      | HD 2932 X PHSL10        | -1.18                | -0.04                               | -1.72                       | -2.34*                      | 7.50**            |
| 10     | RAJ 4238 X Halna        | -4.31**              | 0.40*                               | -4.38**                     | -0.37                       | -7.11**           |
| 11     | RAJ 4238 X HUW661       | 1.08                 | -0.84**                             | -1.85                       | -0.65                       | 6.06              |
| 12     | RAJ 4238 X PHSL10       | 1.9                  | -0.72**                             | -3.56**                     | 1.24                        | 6.64              |
| 13     | MP 3336 X Halna         | 2.38                 | -0.41                               | 4.28**                      | -1.85                       | 0.7               |
| 14     | MP 3336 X HUW661        | 1.05                 | 0.26                                | 0.03                        | 1.23                        | -0.3              |
| 15     | MP 3336 X PHSL10        | -2.91                | 0.46*                               | -1.74                       | 2.66*                       | -0.66             |
| 16     | HD 2285 X Halna         | -1.04                | -0.62**                             | -0.45                       | -2.25*                      | 7.39**            |
| 17     | HD 2285 X HUW661        | -0.68                | 0.17                                | 0.23                        | 2.15*                       | -6.39**           |
| 18     | HD 2285 X PHSL10        | 2.34                 | 0.29                                | -0.19                       | 1.48                        | -3.51             |

*Significant at p=0.05% level, **Significant at p=0.01% level
Table 4: Continued…

| Source             | Df | Spike weight (g) | Yield per plant (g) | 1000 seed weight (g) | Canopy temperature depreciation (°C) | Chlorophyll reflection index | Biological yield per plant (g) | Harvest index (%) |
|--------------------|----|------------------|---------------------|----------------------|-------------------------------------|-----------------------------|-------------------------------|--------------------|
| Replication        | 1  | 0.06             | 0.004               | 0.622                | 0.007                               | 0.221                       | 0.16                          | 0.32               |
| Treatment          | 26 | 0.21*            | 4.81**              | 25.38**              | 3.08**                              | 22.45**                     | 19.64**                       | 102.66**           |
| Parents            | 8  | 0.12             | 4.37**              | 13.91**              | 3.00**                              | 22.33**                     | 6.34**                        | 108.61**           |
| Testers            | 2  | 0.21             | 5.84**              | 6.42**               | 1.03                                | 1.40                        | 7.19**                        | 93.20**            |
| Lines              | 5  | 0.07             | 4.47**              | 18.37**              | 1.10                                | 28.47**                     | 6.25**                        | 110.67**           |
| Testers vs Lines   | 1  | 0.10             | 0.02                | 1.73                 | 0.009                               | 1.79                        | 8.58**                        | 114.73**           |
| Crosses            | 17 | 0.25             | 5.24**              | 29.81**              | 0.98                                | 23.31**                     | 10.44**                       | 101.43**           |
| Parents vs. Crosses| 1  | 0.16             | 1.04**              | 7.49**               | 5.98**                              | 65.63**                     | 20.79**                       | 311.87**           |
| Error              | 26 | 0.10             | 2.37                | 29.65                | 0.17                                | 18.52                       | 8.93                          | 53.89              |
| SE(m)              |    | 0.24             | 1.09                | 3.86                 | 0.29                                | 3.05                        | 2.11                          | 5.19               |
| CD (5%)            |    | 0.65             | 3.10                | 10.95                | 0.85                                | 8.65                        | 6.02                          | 14.74              |
| CV (%)             |    | 14.84            | 13.64               | 14.51                | 14.93                               | 8.12                        | 13.57                         | 14.27              |

*Significant at p=0.05% level, **Significant at p=0.01% level

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