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# COMBINING ABILITY IN THE $F_1$ AND $F_2$ GENERATIONS OF DIALLEL CROSS IN HEXAPLOID TRITICALE

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## ABSTRACT

**The $F_1$ and $F_2$ progenies of a nine-parent diallel cross were analysed for combining ability for days to flowering, plant height, spike length, number of tillers, spikelets and grains, 100-grain weight, and grain yield. Significant contribution of general (gca) and specific (sca) combining abilities to the genetic variation was evident for all the traits, but the greater part of variation for days to flowering, spike length and spikelet number was due to gca. The best sca effects were obtained with the lines exhibiting either low or high gca. Further, the magnitude and direction of gca effects of parents and sca effects of crosses tended to vary from $F_1$ and $F_2$ generation.**

Key words: Diallel cross, combining ability, hexaploid triticale.

It has become a common practice for the plant breeder working with autogamous crops to obtain genetic information from diallel cross progenies. With this information the breeder can devise the best strategy for choice of parents and efficient breeding method which would guarantee the better selection gain and identification of superior plants in the early segregating generations of a cross. Using a nine-parent diallel cross of hexaploid triticale, this paper aims to describe the structure of genetic variability in terms of general and specific combining abilities.

## MATERIALS AND METHODS

Nine hexaploid triticale lines were crossed (excluding reciprocals) to provide 36 $F_1$ hybrids. The parental lines represented a broad range of genetic diversity for major yield components. The $F_1$ hybrids were selfed to obtain the $F_2$, and fresh $F_1$ crosses among the parents were repeated during the same crop season.

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The $F_1$ and $F_2$ hybrids were grown together with the parents in randomized complete block design with three replicates in the same year. The experimental rows were 2 m long, spaced 30 cm apart, and the seed within row was sown at 10 cm spacing. There were one row for each $F_1$ and parents, and ten for each $F_2$ in a replicate. The data on ten randomly selected plants from each replicates were recorded for flowering time, plant height, spikelets/spike, tillers/plant, grains/spike, 100-grain weight, and grain yield/plant. The diallel analysis of $F_1$ and $F_2$ progenies for combining ability was carried out according to Method 2 Model 1 of Griffing [1].

## RESULTS AND DISCUSSION

General (gca) and specific (sca) combining ability mean squares were highly significant for every character both in the $F_1$ and $F_2$ progenies (Table 1). This provided direct evidence that all the traits used in this study could be improved by proper choice of parents, their

**Table 1. Analysis of variance of combining ability for $F_1$ and $F_2$ diallel crosses progenies of triticale**

| Character | $F_1$ | | | | $F_2$ | | | |
|---|---|---|---|---|---|---|---|---|
| | gca | sca | error | $\frac{1}{n_1}\sum_i g_i^2 / \frac{1}{n_2}\sum_i\sum_j s_{ij}^2$ | gca | sca | error | $\frac{1}{n_1}\sum_i g_i^2 / \frac{1}{n_2}\sum_i\sum_j s_{ij}^2$ |
| Days to flowering | 75.9** | 7.33** | 1.27 | 1.12 | 65.8** | 5.16** | 0.79 | 1.35 |
| Plant height | 511.9** | 44.12** | 12.12 | 1.42 | 151.6** | 101.16** | 10.21 | 0.14 |
| Tiller number | 1.5** | 0.92** | 0.56 | 0.22 | 1.5** | 0.65** | 0.40 | 0.42 |
| Spike length | 18.2** | 0.38** | 0.16 | 7.45 | 13.2** | 0.24** | 0.04 | 5.95 |
| Spikelet number | 52.6** | 0.61* | 0.36 | 18.92 | 45.6** | 0.71** | 0.22 | 8.41 |
| Grain number | 66.9** | 18.43** | 9.93 | 0.61 | 50.5** | 29.96** | 4.85 | 0.16 |
| 100-grain weight | 0.4** | 0.27** | 0.04 | 0.09 | 0.4** | 0.03** | 0.02 | 4.00 |
| Grain yield | 11.9** | 7.51** | 3.74 | 0.20 | 12.2** | 5.94** | 2.76 | 0.27 |

*,**Significant at 5% and 1% levels, respectively.

$n_1$, $n_2$—degree of freedom of gca and sca effects, respectively.

crosses, and suitable breeding methods. Significant gca and sca effects have also been reported earlier [2-4]. Recently, Hebert and Gallais [5] compared the components of the expectations of mean squares for the fixed model as:

$$A = \frac{1}{n_1}\sum_i g_i^2 \Big/ \frac{1}{n_2}\sum_i\sum_j s_{ij}^2$$

where $n_1$ and $n_2$ are the degrees of freedom for gca and sca mean squares. This ratio indicates the preponderance of gca effects to sca effects. As shown in Table 1, the ratio was consistently greater than 1 for flowering time, spike length and spikelet number, revealing that a greater part of genetic variation was due to gca effects. Thus, the performance of progenies could easily be predicted for these traits. On the contrary, the ratio was less than one for tiller number, grain number, and grain yield. These traits exhibited higher level of sca effects than gca effects in the genotypic variation. For plant height and 100-grain weight, the preponderance of gca to sca effects varied over generations. The gca mostly involves additive and epistatic effects of additive x additive type, while sca is primarily a function of nonadditive effects which include dominance and all types of epistatic effects [6]. The greater contribution of gca in the $F_1$ and sca in the $F_2$ to the genetic variation of plant height suggests that sca involved both dominance and epistatic effects. On the other hand, the magnitude of sca relative to gca for 100-grain weight was higher in $F_1$ but lower in $F_2$. Clearly, sca involved only dominance effects and hence, half the sca might have been lost in $F_2$.

Table 2 provides the comparison between parental lines of gca effects of each character. The relative ranking of parents for gca effects was not consistent over $F_1$ and $F_2$ generations. Nevertheless, there was a general agreement between $F_1$ and $F_2$ for significance and direction of gca effects of some parents. The tallest parent, Beagle, had good combining ability in both the $F_1$ and $F_2$ generations for spike length, spikelet number, grain number,

**Table 2. General combining ability effects of parent varieties in the $F_1$ and $F_2$ generations of triticale**

| Character | Generation | UC 8825 | Yoreme | Beagle | TL 22 | TL 63 | TL 116 | JNK 70 | JNK 220 | TL 24 |
|---|---|---|---|---|---|---|---|---|---|---|
| Flowering | $F_1$ | 6.06** | –0.19 | 2.46** | –0.78* | –1.29** | –1.77* | –1.35** | –1.91** | –1.23** |
| time | $F_2$ | 5.93** | –1.33** | 1.75** | –1.17** | –1.08** | –1.70** | –0.33 | –0.86** | –1.21 |
| Height | $F_1$ | 12.64** | –4.67** | 7.77** | 1.95 | –6.77** | –8.82** | –0.25 | –0.78 | –0.04 |
| | $F_2$ | –1.97 | 1.02 | 4.67** | 4.99** | –2.72** | –5.15** | 1.56 | –3.58** | 0.92 |
| Tiller No. | $F_1$ | 0.20 | –0.33 | 0.06 | –0.24 | –0.42* | –0.01 | 0.67** | 0.39 | –0.32 |
| | $F_2$ | 0.63** | –0.51** | –0.20 | 0.18 | –0.49** | 0.11 | 0.42** | –0.18 | –0.16 |
| Spike | $F_1$ | 2.261** | –0.78** | 1.78** | –0.85** | –0.17 | –0.32** | –0.61** | –0.89** | –0.78** |
| length | $F_2$ | 2.15** | –0.52** | 1.65** | –0.77** | –0.31** | –0.43** | –0.39** | –0.66** | –0.70** |
| Spikelet No. | $F_1$ | 4.82** | –0.52** | 2.53** | –1.68** | –0.67** | –1.02** | –1.06** | –1.07** | –1.33** |
| | $F_2$ | 4.37** | –0.51** | 2.54** | –1.36** | –0.49** | –1.19** | –1.04** | –1.04** | –1.27** |
| Grain No. | $F_1$ | –1.51 | 0.51 | 3.61** | –0.88 | –0.74 | –1.96** | –3.15** | 4.23** | –0.11 |
| | $F_2$ | –0.23 | 2.62** | 2.01** | –1.14 | 0.42 | –1.69** | –3.55** | 2.72** | –1.17 |
| 100–grain wt. | $F_1$ | 0.11 | –0.24** | 0.14* | 0.23** | –0.14* | –0.08 | –0.14* | –0.02 | 0.15** |
| | $F_2$ | –0.33** | 0.06 | 0.12** | 0.24** | –0.06 | –0.02 | –0.13** | –0.14** | 0.26** |
| Grain yield | $F_1$ | 0.16 | –0.57 | 1.71** | 1.11* | –1.42** | –0.22 | –1.31* | –0.59 | –0.04 |
| | $F_2$ | –1.83** | –0.10 | 0.30 | 1.73** | –1.06* | 0.40* | –0.10 | 0.53 | 0.93 |

*,**Significant at 5% and 1% levels, respectively.

and 100-grain weight. TL 22 showed high gca effects in desirable direction for flowering time, 100-grain weight, and grain yield. The other good combining parents for different characters were: TL 63 and TL 116 for flowering time and plant height, UC 8825 for spike length and spikelet number, JNK 220 for flowering time and grain number, JNK 70 for tiller number, and TL 24 for flowering time and 100-grain weight.

In order to determine the genetic structure of parents the relationship between gca of parent ($g_i$) and variance of the specific combining abilities ($\Sigma_i s_{ij}^2$) when crossed with other parents was critically examined. In this study, the correlation coefficients were nonsignificant for all the characters (Table 3). Further, the magnitude and direction of correlations varied in $F_1$ and $F_2$ generations. Evidently, the variation between the specific combining abilities was not associated with low or high gca of the parent.

**Table 3. Correlation coefficients between gca and the sum of sca effects squared**

| Character | Correlation coefficients | |
|---|---|---|
| | $F_1$ | $F_2$ |
| Flowering time | –0.24 | 0.34 |
| Height | 0.53 | –0.26 |
| Tiller number | 0.54 | 0.50 |
| Spike length | 0.65 | 0.56 |
| Spikelet number | 0.06 | –0.10 |
| Grain number | –0.22 | –0.49 |
| 100-grain weight | –0.37 | 0.20 |
| Grain yield | –0.38 | 0.27 |

The magnitude and direction of sca effects of the crosses varied from $F_1$ to $F_2$ generation. Nevertheless, few crosses showed consistency over generations for different characters. The superior crosses were: JNK 70 x JNK 220 for early flowering, tiller number and grain yield; UC 8825 x JNK 70 for grain weight; Beagle x JNK 220 for spike length; TL 22 xTL 24 for plant height; and TL 116 x TL 24 for grain yield. These crosses exhibited high sca effects both in the $F_1$ and $F_2$ generations whether or not they included high or low gca parents. The additive x additive epistatic effects might be responsible for consistency of sca effects of these crosses. It might be expected that these crosses are likely to yield transgressive segregates which could be fixed by simple conventional breeding procedures.

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