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# RESPONSE TO SELECTION FOR COLD TOLERANCE IN MAIZE

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## ABSTRACT

**A strain developed through three cycles of selection for tolerance to nonfreezing cold stress (least yellowing of leaves) in maize (*Zea mays* L.) cv. Partap was evaluated for per se performance and combining ability in diallel crosses under four environments comprising two locations and two plant densities. It showed significantly less leaf yellowing than Partap, and better general combining ability. However, it did not differ from Partap with regard to freezing injury due to frost.**

**Key words:** *Zea mays* L., maize, population improvement, cold tolerance, combining ability.

Maize (*Zea mays* L.) should possess a good level of cold tolerance for high and stable yield performance in winter season. In the present study response to selection for cold tolerance is analysed with respect to per se performance and combining ability.

## MATERIALS AND METHODS

Primarily three cycles of selection were carried out in Partap (CO), a random mating population, under field condition for cold tolerance and high grain yield [1]. In addition, resistance to diseases (common rust, late wilt, charcoal rot and *Fusarium* rot) was also considered. Selection for cold tolerance was based on yellowing of leaves (nonfreezing injury), plants showing least yellowing of leaves were taken as tolerant. In the first cycle, mass selection was carried out with or without pollen control. The resulting $S_1$ and half-sibs were evaluated in the next winter. Selection between and within families was carried out for cold tolerance and resistance to common rust at preflowering stage, and 2-3 selected plants in the selected families were selfed. Final selection between and within families was based on cold tolerance, grain yield, and resistance to diseases. An equal quantity of seed of the selected plants from selected families was bulked and grown in isolation during monsoon season. The resulting half-sibs were evaluated in the next winter. Selection between and within half-sib families was carried out as in the second cycle and an improved version, Partap WCYC3,was synthesized.

The performance of WCYC3 per se and in diallel crosses was investigated along with CO (Partap) and three other strains of Partap (MYC4, LDEC4 and

HDEC4). MYC4 has been developed through four cycles of modified full-sib selection for grain yield [2] and LDEC4 and HDEC4 have been developed through four cycles of modified full-sib selection for number of ears/plant in low and high plant population densities, respectively [3].

Two experiments were laid in winter 1983–84. In one experiment CO and its four strains were evaluated and in second experiment 10 crosses (diallel crosses with reciprocals bulked) among these populations were studied. These experiments were conducted at two locations (Ludhiana and Gurdaspur) under two plant densities in randomized complete blocks with four replications. A plot comprised two rows of 5 m length using with 60 × 20 cm spacing in the low-density experiment (83,333 plants/ha), and 40 × 20 cm in high-density experiment (1,25,000 plants/ha). Data were recorded on yellowing of leaves due to low temperature and mild frost, and on freezing injury

**Table 1. Pooled analysis of variance of populations and combining ability of diallel crosses**

| Source† | d.f. | Mean squares | |
|---|---|---|---|
| | | yellowing | freezing injury |
| *Populations* | | | |
| P | 4 | 0.85** | 0.34 |
| P × L | 4 | 0.11 | 0.72 |
| P × D | 4 | 0.15 | 0.48 |
| P × L × D | 4 | 0.10 | 0.19 |
| Pooled error | 48 | 0.23 | 0.39 |
| *Diallel crosses* | | | |
| gca | 4 | 0.60** | 0.18 |
| sca | 5 | 0.21** | 0.64** |
| gca × L | 4 | 0.01 | 0.05 |
| sca × L | 5 | 0.03 | 0.09 |
| gca × D | 4 | 0.04 | 0.10 |
| sca × D | 5 | 0.08 | 0.24* |
| gca × L × D | 4 | 0.01 | 0.09 |
| sca × L × D | 5 | 0.19* | 0.19* |
| Pooled error | 108 | 0.06 | 0.08 |

*, ** Significant at 5 and 1% levels, respectively.
† P—populations, gca—general combining ability, sca—specific combining ability, L—locations, and D—densities.

where leaves became oily and dried due to severe frost using 1–9 grades on plot basis. Grade 1 implied no yellowing (green) or no freezing injury, and grade 9 meant maximum damage. Besides intensity of yellowing, number of plants and proportion of leaf area affected were also recorded while rating for yellowing and freezing injury. Data were subjected to the analysis of the design [4] and diallel crosses [5].

## RESULTS AND DISCUSSION

Analysis of variance showed significant differences among strains for yellowing of leaves (Table 1). WCYC3 was significantly better than CO (Table 2). Mean squares due to general combining ability (gca) revealed that the populations differ significantly for their gca (Table 1). Mean squares due to specific combining ability (sca) of hybrids and sca × locations (L) × densities (D) interactions were also significant, indicating significant differences due to sca and also that the expression of sca was differentially influenced by locations and densities. WCYC3 had the lowest gca effect and was the best general combiner (Table 2). Thus, selection for cold tolerance was effective in improving per se performance as well as gca. Improvement in per se performance of the populations developed through selection for cold tolerance was reported earlier [1, 6].

The sca effects for leaf yellowing of all the hybrids involving WCYC3 were not significantly different from zero (Table 3). Only cross CO × LDEC4 showed desirable sca effect. It recorded significant sca estimates in all environments, except in low density at Ludhiana.

**Table 2. Mean and gca effects of population in the pooled analysis**

| Population | Yellowing | |
|---|---|---|
| | mean | gca |
| CO | 4.25 | 0.01 |
| WCYC3 | 3.69 | −0.31* |
| MYC4 | 4.22 | 0.02 |
| LDEC4 | 4.15 | −0.05 |
| HDEC4 | 4.00 | 0.32* |
| SE | ±0.12 | ±0.06 |
| $LSD_{0.05}$ | 0.34 | 0.19 |

* Significantly different from zero at 5% level.

For freezing injury, mean squares due to populations per se and their gca were not significant (Table 1). However, mean squares due to sca, sca × D and sca × L × D interactions were significant. In the individual environment analysis, the differences due to sca were significant in high density experiments only [7]. The correlation between yellowing and freezing injury of 10 hybrids, averaged over four environments, was nonsignificant (r=0.014). Thus, selection for least yellowing of leaves did not seem to influence tolerance to freezing injury.

**Table 3. Estimates of sca effects in pooled and individual environment analyses**

| Hybrid | sca effects for yellowing | | | | Pooled |
|---|---|---|---|---|---|
| | Ludhiana | | Gurdaspur | | |
| | LD | HD | LD | HD | |
| CO × WCYC3 | −0.04 | −0.12 | 0.52* | −0.23 | 0.03 |
| CO × MYC4 | 0.21 | 0.21 | −0.44* | 0.19 | 0.04* |
| CO × LDEC4 | 0.04 | −0.50* | −0.52* | −0.31* | −0.32* |
| CO × HDEC4 | −0.21 | 0.42* | 0.44* | 0.35* | 0.25* |
| WCYC3 × MYC4 | −0.12 | −0.25 | 0.10 | −0.02 | −0.07 |
| WCYC3 × LDEC4 | −0.04 | 0.54* | −0.23 | 0.35* | 0.16 |
| WCYC3 × HDEC4 | 0.21 | −0.17 | −0.40 | −0.10 | 0.11 |
| MYC4 × LDEC4 | −0.04 | 0.12 | 0.56* | 0.02 | 0.17 |
| MYC4 × HDEC4 | −0.04 | −0.08 | −0.23 | −0.19 | −0.14 |
| LDEC4 × HDEC4 | 0.04 | −0.17 | 0.19 | −0.06 | 0.00 |
| SE ($\hat{s}_{ij}$) | ±0.18 | ±0.16 | ±0.19 | ±0.14 | ±0.08 |
| LSD ($\hat{s}_{ij}-\hat{s}_{il}$) 0.05 | — | 0.52 | 0.64 | 0.47 | 0.27 |
| LSD ($\hat{s}_{ij}-\hat{s}_{kl}$) 0.05 | — | 0.37 | 0.45 | 0.33 | 0.19 |

* Significantly different from zero at 5% level.
LD—low plant density, HD—high plant density.

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