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# Effect of $A_1$ cytoplasm on the combining ability for smut severity in pearl millet

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**Abstract** Among the various available sources of male-sterile cytoplasm in pearl millet [*Pennisetum glaucum* (L.) R.Br.], the $A_1$ source has been exploited the most for the breeding of commercial $F_1$ hybrids. The effect of this source on the combining ability (CA) for smut severity was studied since it is the CA that determines the performance of hybrids. The effect was estimated by comparing the CA estimates of 5 pairs of lines and 35 pairs of crosses with and without $A_1$ cytoplasm. The cytoplasm showed either a significantly desirable or at least no adverse effect on the CA of 4 out of the 5 line pairs and 56 out of 70 pairs of comparison of crosses in two environments. The differential effect of cytoplasm in some pairs might be due to its interaction with nuclear genes. These results further substantiated that the $A_1$ cytoplasm is not linked with increased smut severity in pearl millet hybrids.

**Key words** *Pennisetum glaucum* · Pearl millet · *Tolyposporium penicillariae* · Smut · Combining ability · Disease resistance

## Introduction

In pearl millet [*Pennisetum glaucum* (L.) R.Br.], the commercial $F_1$ hybrids are produced utilizing cytoplasmic-genic male sterility. Among the various available sources of male-sterile cytoplasm, the $A_1$ source has been the most exploited in the production of commercial hybrids of pearl millet in India (Dave 1987). Since the cultivation of high-yielding hybrids, not only the productivity has been increased but the incidence of smut [*Tolyposporium penicillariae* Bref.] and other diseases has also increased. The $A_1$ source of male-sterile cytoplasm has often been blamed for the increased incidence of smut in hybrids but Yadav et al. (1992) were able to show that this source is not linked with higher smut severity.

In breeding programmes based on cytoplasmic male sterility plant breeders are quite concerned with the effect of the introduced cytoplasm. Cytoplasmic effects on the expression of agronomic traits have been reported in pearl millet (ICRISAT 1992) and other crops, corn (Kalsy and Sharma 1972) and rice (Lin and Yuan 1980; Young and Virmani 1990). However, information on the influence of the cytoplasm on combining ability for smut severity is lacking. Such information assumes importance because it is the combining ability of parental lines that ultimately determines the potential of the hybrids (Hallauer and Miranda 1981). This paper reports the effect of $A_1$ cytoplasm on the combining ability for smut severity in pearl millet.

## Materials and methods

The 5 male sterile (A) lines possessing $A_1$ cytoplasm and their corresponding maintainer (B) lines (111 A/B, 81 A/B, 841 A/B, 5141 A/B and 10 A/B) were crossed with 7 genetically diverse pollinator (R) lines (ICMPS-101-1, ICMPS-904-3, ICMPS-1600-4, H 90/4-5, H 833-2, H 77/181-4 and H 77/245-7) to produce 70 (35 A/R and 35 B/R) hybrids. These hybrids were grown in randomized block design with three replications at the Haryana Agricultural University, Hisar (29 °N) in northern India, which is considered to be a hot spot location of smut disease. The material was grown under two environments created by different sowing dates, i.e. July 7 and 25, 1985. Disease severity was recorded more under the second sowing. Details regarding inoculum, inoculation and smut scoring have been fully described by Yadav et al. (1992).

The analysis of combining ability was carried out following the procedure developed by Kempthorne (1957). The cytoplasmic effects were estimated by comparing the general combining ability (GCA) of the A and B lines and specific combining ability (SCA) of the A/R and corresponding (B/R) combinations and testing the significance of the differences with LSD (0.05).

## Results and discussion

The analysis of variance indicated significant mean squares due to lines, pollinators and lines × pollinators in both environments (data not presented). Thus, lines differed for their

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**Table 1** Effect of $A_1$ cytoplasm on general combining ability (GCA) for smut severity in pearl millet in two environments ($E_1$ and $E_2$)

| Line pair | Difference in GCA effects in environment | |
|---|---|---|
| | $E_1$ | $E_2$ |
| 111 A/B | −2.3* | −6.0* |
| 81 A/B | 6.7* | 4.4* |
| 841 A/B | −1.5 | 0.1 |
| 5141 A/B | −0.6 | −1.6 |
| 10 A/B | −1.0 | −5.7* |

* Significant at $P = 0.05$

GCA effects and crosses for their SCA effects, enabling further analysis to be carried out.

The A and B lines in pearl millet are genetically similar and differ in their cytoplasmic constitution only. Thus, the difference in their GCA estimates could be attributed to the $A_1$ cytoplasm or its interaction with nuclear genes. The effect of the $A_1$ cytoplasm on GCA is given in Table 1. In all of the pairs except 81 A/B, the cytoplasmic effects were either significantly desirable (negative values) or non-significant. This indicates that the $A_1$ cytoplasm did not confer any additional ability to the parental lines to transfer the disease severity to their progeny. In other words, it showed no undesirable influence on the combining ability of the parental lines. Similar observations have been made in downy mildew disease of pearl millet (Yadav et al. 1993). The differential effect of cytoplasm in pair 81 A/B might have occurred as a result of cytoplasm interaction with the nuclear genes. Such interactions were observed to be significant in the first part of this study (Yadav et al. 1992).

Since the A and B lines of each pair were used us females in crosses with the R lines, the A/R hybrid received $A_1$ male-sterile cytoplasm and the corresponding B/R hybrid inherited normal cytoplasm. Genetically they are similar. Thus, the difference in the SCA estimates of the A/R and counterpart B/R cross could again be reasoned to result from their cytoplasmic difference.

The SCA estimates of the A/R and corresponding B/R crosses were similar in 40 out of 70 combinations in two environments (Table 2). Of the remaining 30 combinations, 16 A/R and 14 B/R combinations showed significantly lower SCA estimates (considered desirable) than their corresponding pair. This indicates that the $A_1$ cytoplasm did not show any undesirable effect on the SCA estimates of crosses. However, the cytoplasmic effects on SCA estimates seems to be inconsistent over environments. The environmental sensitivity of cytoplasm has been reported earlier in pearl millet (Singh et al. 1985; ICRISAT 1992), maize (Bhat and Dhawan 1969; Kalsy and Sharma 1972) and rice (Young and Virmani 1990).

The results of the present study reveal that the $A_1$ cytoplasm has no adverse effect on the combining ability for smut severity, and this should be considered as further proof that this source of cytoplasm is not linked with the increased incidence of smut in pearl millet hybrids.

**Table 2** Effect of $A_1$ cytoplasm on specific combining ability (SCA) for smut severity in pearl millet in two environments

| Cross (A/B × R)[a] | Difference in SCA effects in environment | |
|---|---|---|
| | $E_1$ | $E_2$ |
| 111 A/B × 1 | −26.1* | −27.5* |
| × 2 | −5.8 | −8.5* |
| × 3 | 2.3 | 21.6* |
| × 4 | 2.3 | 3.9 |
| × 5 | 2.3 | −7.2* |
| × 6 | 22.7* | 16.5* |
| × 7 | 2.3 | 1.0 |
| 81 A/B × 1 | −0.1 | 13.4* |
| × 2 | 4.6 | 31.8* |
| × 3 | −1.7 | −2.4 |
| × 4 | 1.1 | −8.8* |
| × 5 | 9.6* | −6.2 |
| × 6 | −6.6* | −5.8 |
| × 7 | −6.7* | 4.4 |
| 841 A/B × 1 | −15.5* | −0.1 |
| × 2 | −10.1* | 6.3 |
| × 3 | 6.8* | 16.4* |
| × 4 | 1.5 | 3.0 |
| × 5 | 15.0* | −16.6* |
| × 6 | −4.4 | −2.4 |
| × 7 | 6.5* | −6.5 |
| 5141 A/B × 1 | 0.6 | 19.1* |
| × 2 | −2.0 | 13.4* |
| × 3 | 0.5 | 4.7 |
| × 4 | 2.6 | −14.0* |
| × 5 | −27.7* | −22.0* |
| × 6 | 20.7* | 5.4 |
| × 7 | 5.2 | −6.7* |
| 10 A/B × 1 | 0.9 | 5.8 |
| × 2 | 0.9 | 2.5 |
| × 3 | 4.2 | 5.7 |
| × 4 | −4.0 | −7.1* |
| × 5 | 1.0 | −11.8* |
| × 6 | 1.0 | 8.9* |
| × 7 | −4.0 | −3.8 |

* Significant at $P = 0.05$

[a] 1, ICMPS-101-1; 2, ICMPS-904-3; 3, ICMPS-1600-4; 4, H 90/4-5; 5, H 833-2; 6, H 77/181-4; 7, H 77/245-7

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