by suspending the conidia in sterilized water to which Tween 80® was added at the rate of 10 mL $L^{-1}$. Three conidial concentrations, 100 $mL^{-1}$ (T1), 500 $mL^{-1}$ (T2), and 1000 $mL^{-1}$ (T3) were prepared by serial dilutions.

**Inoculation.** All the cultivars were arranged into three sets for inoculation with the three conidial concentrations. Using an atomizer, the tagged leaves were sprayed with inoculum to the point where run off occurred on both the sides of the leaf. This was done in the evening. Immediately after inoculation, the plants were placed in dew chambers (Clifford 1973) at 23°C to ensure wetness of the leaf surface, and held for 16 h in the dark.

**Post-inoculation treatments.** The plants were removed from the dew chamber on the morning of the following day and placed before a fan for about 30 min until the foliage had dried. They were then returned to the growth chamber and kept at 25°C for 8 h during the day (Butler et al. 1994). The plants were then returned to the dew chamber for 16 h. This alternate wet and dry period treatment was repeated for 5 days. The plants were then held in the growth chamber with 25°C constant temperature and relative humidity of 52–55% until the end of the experiment.

**Observations.** Observations on six parameters—number of lesions per leaf, total leaf area, lesion diameter, number of conidia per lesion, percentage leaf area damaged, and percentage defoliation—were recorded from 6 to 30 days after inoculation. Percentage defoliation was again recorded 45 days after inoculation.

**Results.** Disease symptoms appeared on the tagged leaves of all genotypes within 6 days after inoculation. Analysis of variance for the resistance components was done. Significant differences were found between the conidial concentrations for most of the components studied. In general, number of lesions, percentage leaf area damaged, and percentage defoliation were higher with the highest conidial concentration (1000 conidia $mL^{-1}$) used (Table 1). Number of conidia per lesion was significantly higher in susceptible genotypes than in resistant genotypes (Table 1). This parameter can be used to screen for early leaf spot resistance using a dew/growth chamber. Any of the three conidial concentrations would be satisfactory for laboratory screening based on components of resistance. The lower concentrations could be best for the study of lesion diameter, whereas the higher concentration could be more effective when measuring leaf area damage and defoliation.

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# Comparison of Whole-Plant and Detached-Leaf Methods for Studying Components of Rust Resistance in Groundnut

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Groundnut rust caused by *Puccinia arachidis* is a serious problem worldwide, causing substantial losses in crop yield in many groundnut-growing regions (Subrahmanyam et al. 1985, Ghughe et al. 1981). The use of rust-resistant, high-yielding cultivars is the best means of reducing yield losses due to the disease. Research on host-plant resistance to rust has received increasing attention over the past 15 years, and many rust-resistant groundnut genotypes have been reported (Subrahmanyam et al. 1995). A few studies have reported components of rust resistance, using either the detached-leaf or whole-plant inoculation method (Subrahmanyam et al. 1983, Liao et al. 1990). The objective of this study was to compare the two methods for estimating components of rust resistance in selected genotypes.

Components of resistance were studied in 40 rust-resistant groundnut genotypes and one susceptible cultivar TMV 2, using the whole-plant and detached-leaf methods described by Subrahmanyam et al. (1983) and Liao et al. (1990). Five components were studied—infection frequency (number of pustules $cm^{-2}$ leaf area), percentage of leaf area damaged, lesion diameter, incubation period (time taken for the appearance of 50% of the total pustules from the time of inoculation), and sporulation index (on 1–5 scale, where 1 = no sporulation, 2 = 1–25% lesion area covered with spores, 3 = 26–50% lesion area

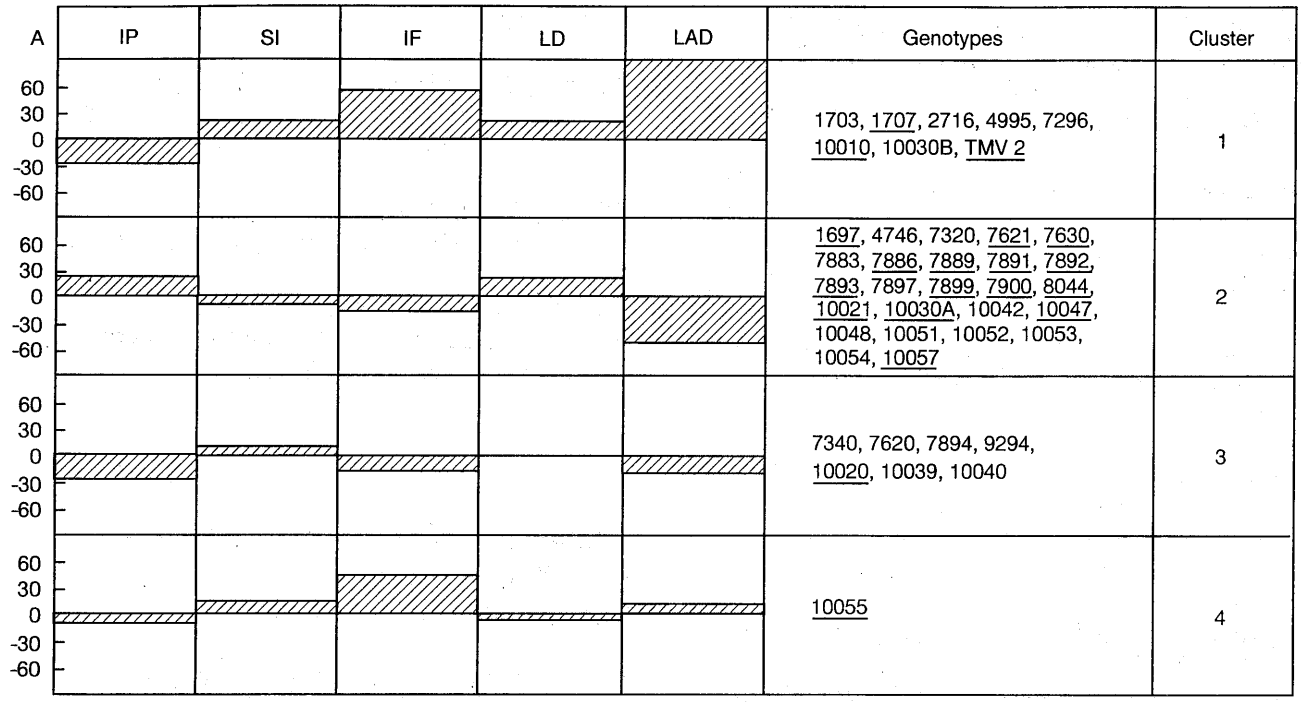


**Figure 1. Deviation (%) of cluster means from the grand mean for five components of rust resistance in the detached-leaf method.**

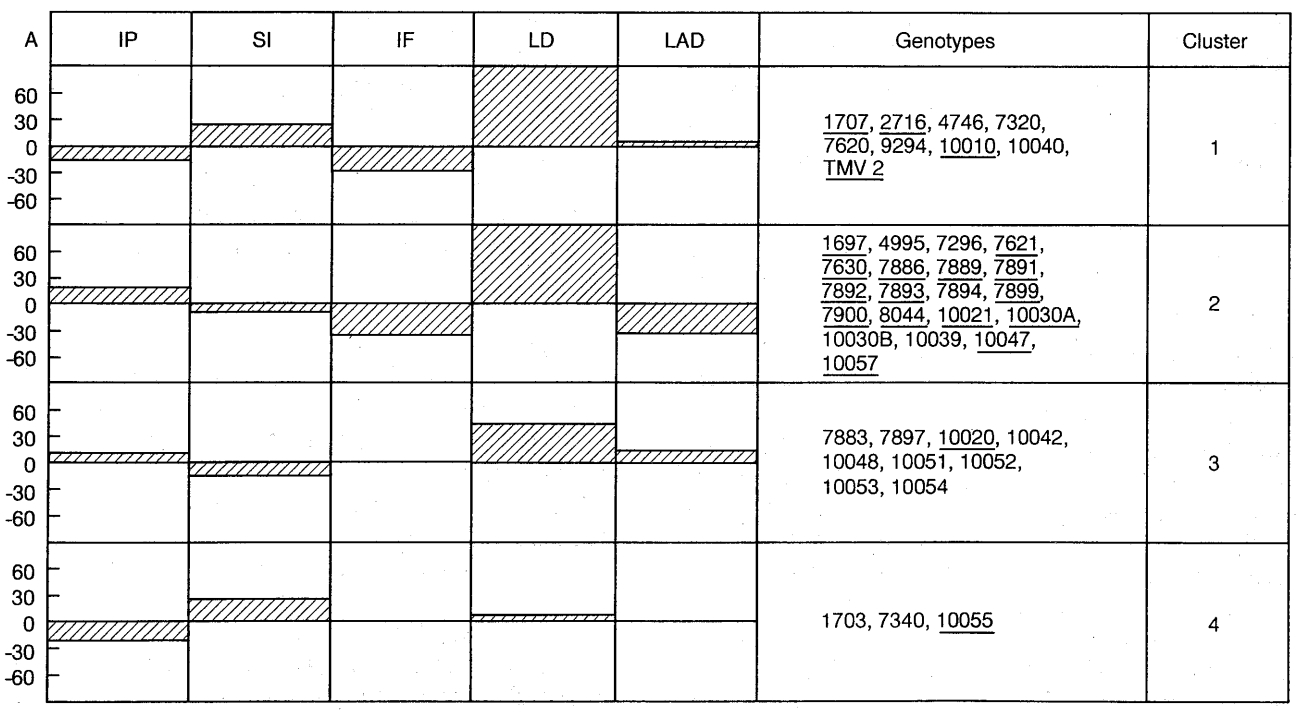


**Figure 2. Deviation (%) of cluster means from the grand mean for five components of rust resistance in the whole-plant method.**

A = deviation (%) from grand mean, IP = incubation period, SI = sporulation index, IF = infection frequency, LD = lesion diameter, LAD = percentage leaf area damaged. Underlined genotypes were grouped in the same cluster in both methods.

**Table 1. Comparison of whole-plant and detached-leaf methods for studying components of rust resistance in groundnut.**

| Component | Whole plant method[1] | Detached leaf method[1] | Paired 't' value |
|---|---|---|---|
| Incubation period | 14.5 | 13.9 | 1.63 |
| Infection frequency | 3.7 | 6.9 | 6.11** |
| Lesion diameter | 0.3 | 0.3 | 0.15 |
| Leaf area damaged (%) | 4.0 | 7.2 | 3.02** |
| Sporulation index | 3.1 | 3.1 | 0.57 |

1. Mean values for 41 genotypes.
** significant at P<0.01, df=40.

covered with spores, 4 = 51–75% lesion area covered with spores, and 5 = 76–100% sporulation).

Differences between the two methods for different components were tested by the paired 't' test (Table 1). The methods did not differ significantly for incubation period, lesion diameter, and sporulation index, but differed significantly for infection frequency and percentage of leaf area damaged. Levels of incubation period were similar in 29 (71%) genotypes in both methods. In the other 11 genotypes, minor differences in incubation period were observed between the methods. However, the genotype ICG 7296 showed a large variation in incubation period (19 days in the whole-plant method vs 9 days in the detached-leaf method).

Genotypes were clustered based on their similarity in levels of components in each method, using Ward's minimum variance method (Ward 1963). Figures 1 and 2 show clusters of genotypes and their deviation percentage from the grand mean. In both methods the largest number of genotypes (15) were in cluster 2 (Figs. 1 and 2). This cluster had genotypes with longer incubation period (positive deviation) and lower sporulation index (negative deviation) than the grand mean. This is important as these two components play a major role in slowing down rust epidemics. In both methods the susceptible control cultivar TMV 2 was grouped in cluster 1, along with genotypes showing low incubation period and moderate to high sporulation index levels.

Correlations among the components of rust resistance (except for infection frequency and sporulation index) in each method were also very similar in both direction and magnitude (Table 2). This is in agreement with the findings of Subrahmanyam et al. (1983) and Liao et al. (1990).

The results of this study clearly indicate that either method can be used to study resistance components. However, in view of space limitations and the difficulties of maintaining temperature and humidity in the greenhouse, the detached-leaf method is preferable to the whole-plant method.

**Table 2. Correlations among components of rust resistance in groundnut in the detached-leaf and whole plant methods.**

| Components[1] | Correlations: Whole-plant method | Correlations: Detached-leaf method |
|---|---|---|
| LAD and IF | 0.65** | 0.64** |
| and LD | 0.31* | 0.37* |
| and IP | –0.35* | –0.52* |
| and SI | 0.28 | 0.23 |
| IF and LD | –0.09 | 0.20 |
| and IP | –0.10 | –0.39 |
| and SI | 0.03 | 0.17 |
| LD and IP | –0.57** | –0.35 |
| and SI | 0.49** | 0.40** |
| IP and SI | –0.38* | –0.16 |

* significant at 5%, ** significant at 1%
1. LAD = percentage of leaf area damaged, IF = infection frequency, LD = lesion diameter, IP = incubation period, SI = sporulation index.

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## Variation in the Sensitivity of Groundnut Rust to Tridemorph in Central Maharashtra

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Rust (*Puccinia arachidis*) is a serious disease of groundnut worldwide (Subrahmanyam et al. 1980). Different fungicides including tridemorph are effective against rust and other foliar diseases of groundnut in India (Mayee 1979, Shastry et al. 1985, Subrahmanyam et al. 1985).

The simple leaf detached technique (SDL) was used to test isolates of the rust pathogen for sensitivity to the fungicide tridemorph. Groundnut variety SB 11 was used for the study. Fully expanded leaves from the lower, middle, and upper portions of the plants were detached, and washed 10 times with sterile distilled water. These leaves were dipped in different concentrations of tridemorph for 2 min. Uredospore suspension of the Aurangabad isolate ($3 \times 10^4$ mL$^{-1}$) was applied to the leaves with the help of a brush, and the inoculated leaves were placed on glass rods in moist plates. The petioles touched the lower surface of moist filter paper. The plates were incubated in the laboratory at 26±3°C, and moistened from time to time to maintain the required moisture and turgidity of pathogen and host.

With an increase in tridemorph concentration there was a decrease in the number of pustules. The minimum inhibitory concentration (MIC) for rust was found to be 150 µg mL$^{-1}$ (Table 1). The latent period was delayed by

**Table 1. Number of rust pustules on leaves of groundnut cv SB 11 treated with tridemorph at various intervals, studied using the simple detached leaf technique.**

| Concentration of tridemorph (µg mL$^{-1}$) | Number of rust pustules at various stages (days after inoculation) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Control | 92.50[1] | 110.00 | 122.75 | 138.25 | 152.66 | 167.25 | 182.00 | 190.33 | 199.50 | 204.50 | 208.00 | 211.50 | 214.00 | 216.00 | 217.00 | 218.00 |
| 10 | 3.00 | 6.00 | 9.50 | 12.00 | 16.00 | 20.00 | 21.50 | 25.50 | 28.25 | 30.75 | 32.50 | 33.00 | 33.33 | 34.00 | 34.00 | 34.00 |
| 50 | 1.00 | 1.25 | 4.25 | 9.75 | 11.50 | 13.50 | 14.75 | 16.25 | 18.00 | 19.66 | 20.85 | 21.66 | 22.00 | 23.00 | 23.00 | 23.00 |
| 100 | 0.00 | 0.00 | 1.50 | 2.50 | 4.50 | 6.00 | 7.33 | 8.00 | 11.00 | 12.50 | 13.25 | 14.00 | 14.50 | 15.00 | 15.00 | 15.00 |
| 150 | 0.00 | 0.00 | 0.00 | 1.00 | 2.00 | 3.33 | 4.40 | 5.50 | 6.00 | 6.30 | 7.00 | 7.60 | 8.00 | 8.60 | 8.60 | 8.60 |
| 200 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

1. Average of five replications