Response of *Eucalyptus* Species to Field Infection by *Puccinia psidii*

J. C. DIANESE, Associate Professor, Departamento de Biologia Vegetal, Universidade de Brasilia, 70910, Brasilia, DF, Brazil; T. S. DE A. MORAES, Forest Researcher, Santa Bárbara Agriculture & Forestry Company, 30000 Belo Horizonte, MG, Brazil; and A. R. SILVA, Forest Researcher, Rio Doce Forest Company, 30000 Belo Horizonte, MG, Brazil

ABSTRACT

Dianese, J. C., Moraes, T. S., de A., and Silva, A. R. 1984. Response of *Eucalyptus* species to field infection by *Puccinia psidii*. Plant Disease 68:314-316.

Thirteen species of *Eucalyptus* with a total of 23 provenances (prs) were tested for resistance to *Puccinia psidii* in a field experiment with four replicates of 25 plants. Provenances were rated according to a scale based on the percentage of plants infected and the number of rust pustules. *E. grandis* pr South Africa was highly susceptible; *E. grandis* prs Coff's Harbour, Kiogle Tablelands, and Garça, *E. cloeziana* prs Carbonita and Transvaal, and *E. citriodora* pr Florasa and *E. saligna* pr Cesanook were susceptible; *E. urophylla* pr Australia 9003, *E. camaldulensis* prs Gibb River and Petford, *E. tereticornis* pr S. Helenvale, *E. pirocarpa* pr Woolgoolga, *E. paniculata* pr Florasa, *E. punctata* pr Manduri, *E. maculata* pr Bom Despacho, and *E. saligna* pr Mt. Scanzi were moderately susceptible; *E. pellita* pr N. Australia 10966, *E. microcorys* pr Fabriciano, and *E. urophylla* pr Australia 10136 were resistant; and *E. pellita* prs Helenvale, Mt. Pandanus, and NE Coen were highly resistant. Rust did not affect height growth of two susceptible and four moderately susceptible provenances but did suppress growth of three other susceptible provenances. Except for *E. grandis* pr South Africa, all provenances were free of rust 1 yr after exposure to inoculum.

Additional key words: rust resistance

Brazil has 3.6 million hectares (ha) of planted forests (13), with more than 720,000 ha in the state of Minas Gerais (MG), where *Eucalyptus* spp. predominate (12). Along the Rio Doce Valley in this state, *Eucalyptus* spp. cover 160,000 ha (W. Suiter Filho, *personal communication*). In this area, *E. grandis* W. Hill ex Maiden of a South African provenance suffered extensive losses due to attack by *Puccinia psidii* Winter, which is common there on wild *Eugenia jambos* L. (3). This rust, which naturally infects eight genera of native plants belonging to the Myrtaceae (14), was first found by Joffily (10) on exotic *E. citriodora* Hook. in 1943. Now it affects many species of *Eucalyptus* in three states (4,11). Expansion of the rust-affected areas made it necessary to screen for disease resistance. In this study, 23 provenances of 13 *Eucalyptus* spp. were exposed to high levels of natural rust inoculum to study their response to infection by *P. psidii*.

Accepted for publication 4 October 1983.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

MATERIALS AND METHODS

In Belo Oriente, MG, Brazil, a 486-ha plantation of *E. grandis* (South African provenance) uniformly infected with *P. psidii* was partially cleared to delimit plots where experimental trees were planted. In each plot, 25 plants of a given provenance were spaced 1.5 m apart, with 3 m between rows, surrounded by a line of severely pruned, 4-yr-old plants of *E. grandis* saved from the original plantation. These served as an inoculum source. Twenty-three provenances were tested and four replicates were used. All observations were done on the nine central plants in each of the 92 plots. Provenances are listed in Table 1.

Seventy-day-old seedlings of each provenance, produced in plastic bags (15 cm high by 6.5 cm in diameter) containing methyl bromide-treated soil, were transplanted to the field plots. The first rust assessment was made 40 days after transplanting. The number of infected plants per plot and the number of rust pustules detected on the top 10 leaves of 10 branches taken at random for each measurement per plant were recorded. If the plants did not have 10 branches, as many as 100 leaves from each plant were surveyed for pustules. Similar observations were made nine times at 14- to 26-day intervals during a period of 160 days.

The mean percentage of plants infected (I) and the average number of pustules per plant (P) per plot were determined for each provenance. A rust index (RI) was calculated using the formula $RI = P \times I/100$. Rust assessments were also performed 272 and 365 days after the transplanting.

Table 1. Performance of *Eucalyptus* spp. exposed to field infection by *Puccinia psidii* at Belo Oriente, Minas Gerais, Brazil

Species	Provenance	Seed source[a]	Infected plants (%)[b] (aI)	Pustules per plant[c] (aP)	aRI[d]	RI[e]	Response to infection[f]
E. grandis	South Africa[g]	RD	99.0	76.2	76.4	41.6	HS
E. grandis	Coff's Harbour	RD	48.6	31.4	15.3	0.9	S
E. grandis	Kiogle Tablelands	RD	43.3	27.2	11.8	0.3	S
E. grandis	Garça	SB	38.4	27.8	11.4	0.5	S
E. cloeziana F. Muell.	Carbonita	SB	52.1	20.5	10.7	3.7	S
E. citriodora Hook in Mitch.	Florasa	AC	39.2	21.9	8.6	0.0	S
E. cloeziana	Transvaal	AC	34.5	18.3	6.3	0.2	S
E. saligna Sm.	Cesanook	RD	36.4	12.1	4.4	0.0	S
E. urophylla S. T. Blake	Aust. 9003	RD	24.6	13.0	3.2	0.0	MS
E. camaldulensis Dehnh.	Gibb River	SB	30.5	10.2	3.1	0.0	MS
E. tereticornis Sm.	Helenvale	SB	18.5	14.6	2.7	0.0	MS
E. camaldulensis	Petford	SB	22.3	10.3	2.3	0.0	MS
E. pirocarpa L. Johnson, D. Blaxell.	Woolgoolga	RD	25.3	7.9	2.0	0.0	MS
E. paniculata Sm.	Florasa	AC	17.6	9.1	1.6	0.0	MS
E. punctata DC.	Manduri	AC	17.4	8.0	1.4	0.0	MS
E. maculata Hook.	Bom Despacho	SB	18.8	6.4	1.2	0.0	MS
E. saligna Sm.	Mt. Scanzi	RD	16.8	7.1	1.2	0.0	MS
E. pellita F. Muell.	Australia 10966	RD	8.4	4.8	0.4	0.0	R
E. microcorys F. Muell.	Fabriciano 766-C	SB	6.8	2.9	0.2	0.0	R
E. urophylla	Australia 10136	RD	6.8	2.9	0.2	0.0	R
E. pellita	Helenvale	SB	5.8	1.4	0.08	0.0	HR
E. pellita	Mt. Pandanus	SB	4.0	1.0	0.04	0.0	HR
E. pellita	NE Coen	SB	3.7	0.8	0.03	0.0	HR

[a] Seed sources: RD = Florestas Rio Doce S/A, 30000 Belo Horizonte, MG, Brazil; SB = Companhia Agrícola e Flores Santa Bárbara, 30000 Belo Horizonte, MG, Brazil; and AC = Acesita Florestal S/A, 30000 Belo Horizonte, MG, Brazil.
[b] Average of nine successive readings, at 15- to 26-day intervals, of four replicates with nine plants each (aI).
[c] Average of nine successive readings of the number of pustules on 10 leaves from 10 branches chosen at random on each of nine plants replicated four times (aP).
[d] aRI = (aI) × (aP)/100, the average rust index.
[e] RI = $I \times P/100$, the rust index 272 days after transplanting to the experimental area. I = percent of infected plants and P = average number of pustules per plant.
[f] HS = highly susceptible, S = susceptible, MS = moderately susceptible, R = resistant, and HR = highly resistant.
[g] The only provenance infected by *P. psidii* 1 yr after transplanting (RI = 43.2).

Relative humidity, temperature, and rainfall were monitored within the experimental area with a M-701F thermohygrograph (Meteorological Weather Manufacturing Co., Sacramento, CA 94841) and a pluviometer.

To estimate the growth impact of *P. psidii* on *Eucalyptus* spp., heights of all rustfree plants available per provenance 200 days after transplanting were compared at the 5% probability level with the heights of the same number of paired, infected individuals belonging to the same provenance. Because of statistical requirements, only provenances presenting four or more available pairs could be compared (Table 2).

Table 2. Effect of infection by *Puccinia psidii* on growth of six species of *Eucalyptus* 200 days after transplanting to the field in Belo Oriente, MG, Brazil, in 1982

Species	Provenance	Response to infection[a]	Average height (m)[b] Infected plants	Average height (m)[b] Healthy plants
E. grandis	Coff's Harbour	S	2.05 y	2.37 y (11)[c]
E. grandis	Kiogle Tablelands	S	1.49 y	2.31 z (13)
E. grandis	Garça	S	1.03 y	2.30 z (8)
E. cloeziana	Carboniata	S	1.03 y	1.47 z (12)
E. citriodora	Florasa	S	2.05 y	2.73 y (4)
E. urophylla	Australia 9003	MS	2.03 y	2.11 y (4)
E. camaldulensis	Gibb River	MS	2.93 y	2.95 y (4)
E. camaldulensis	Petford	MS	3.01 y	2.95 y (6)
E. paniculata	Florasa	MS	2.08 y	2.45 y (4)

[a] MS = moderately susceptible, S = susceptible.
[b] Numbers on the same line followed by the same letter are not significantly different ($P = 0.05$).
[c] Numbers in parentheses indicate the number of pairs of plants compared in each case.

RESULTS

The different species of *Eucalyptus* varied in apparent susceptibility to *P. psidii* and this variability also occurred among provenances of the same species. Averages of the first nine values of *I*, *P*, and RI (aI, aP, and aRI, respectively) are shown in Table 1. The provenances were divided into five classes of susceptibility and resistance. *E. grandis* (South African provenance) (aRI >50) was rated highly susceptible, followed by groups of seven susceptible provenances (aRI = 4–15.3), nine moderately susceptible, three resistant, and three highly resistant (Table 1). Observations 272 days after transplanting indicated that only provenances of *E. grandis* and *E. cloeziana* were still infected with rust (Table 1). One year after transplanting, rust was found only on *E. grandis* of the South African provenance.

Some of the more susceptible provenances tolerated the fungal infection, as shown by the growth of infected versus uninfected plants (Table 2). Rust development on four species was analyzed in relation to weather data (Fig. 1).

DISCUSSION

For the first time, screening for rust resistance in *Eucalyptus* spp. using a broad genetic base (13 species) was performed in Brazil. Recently, Moraes et al (11) reported the effect of *P. psidii* on two provenances of *E. cloeziana* and another of *E. grandis* and found a trend toward decreasing growth only when infection occurred on the more susceptible provenances. In this study, rust tolerance was present in susceptible and moderately susceptible provenances, indicating that fungal attack does not always lead to yield losses. In three provenances, however, *P. psidii* caused significant growth reduction (Table 2). Nine months after transplanting, only provenances of *E. cloeziana* and *E. grandis* did not show complete recovery from infection (Table 1), whereas after 1 yr, only *E. grandis* of the South African provenance was still

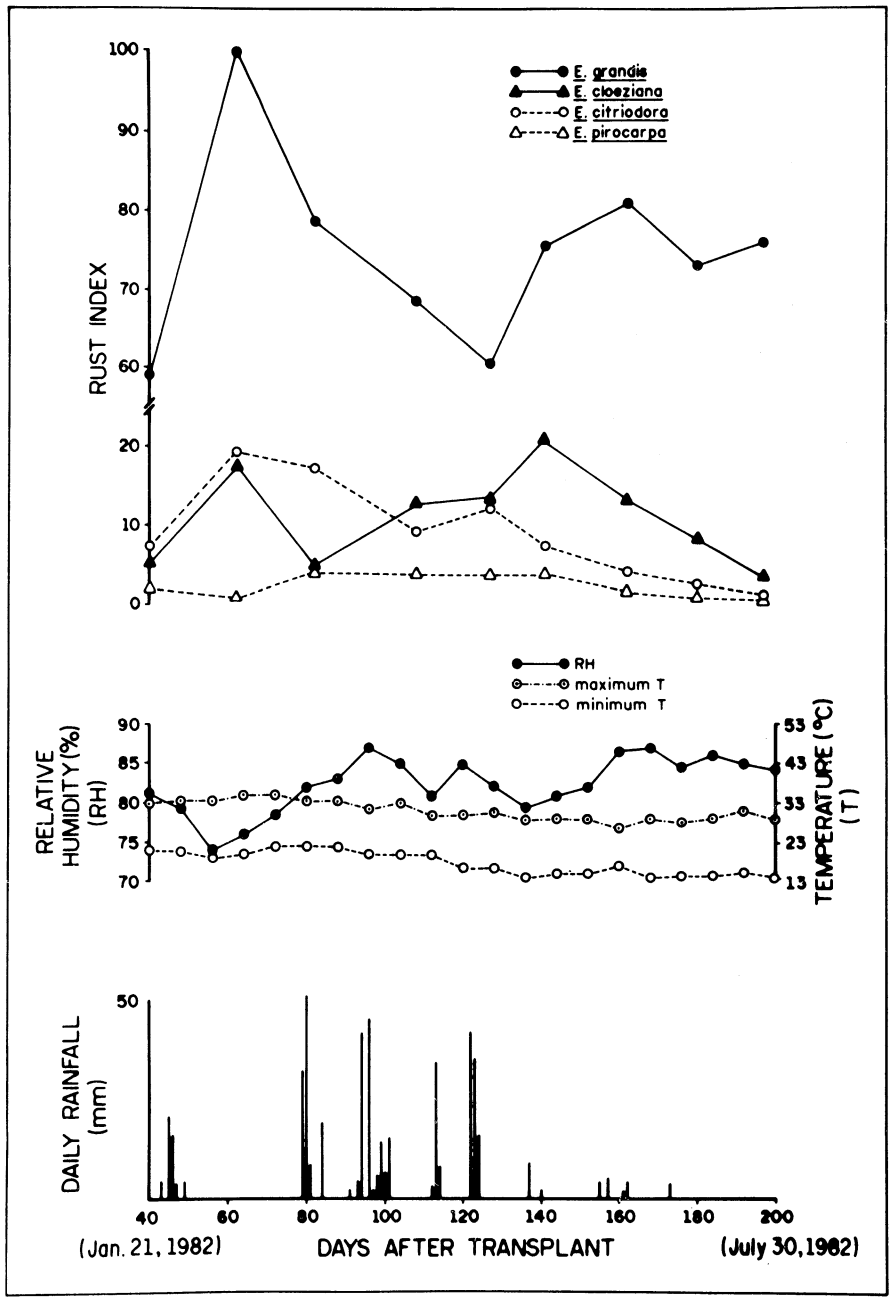

Fig. 1. Effect of relative humidity, temperature, and rainfall on disease progress of *Puccinia psidii* on *Eucalyptus grandis* provenance (pr) South Africa, *E. cloeziana* pr Carbonita, *E. citriodora* pr Florasa, and *E. pirocarpa* pr Woolgoolga during 160 days (21 January–30 July 1982), expressed by change in the rust index (RI = $P \times I/100$), where P is the mean number of pustules per plant and I the percentage of plants infected.

infected. Studies on the epidemiology and physiopathology of *P. psidii* are needed to explain this aspect of the disease.

Results showed no correlation between temperature or relative humidity and rust infection on four *Eucalyptus* spp., but an increase in rainfall was associated with reduced rust on *E. grandis* (South African provenance), *E. citriodora* (Florasa provenance), and *E. cloeziana* (Carbonita provenance) (Fig. 1). The data agreed with field observations that rust is most prevalent during the dry season (April through June).

Susceptibility to *P. psidii* varied among provenances of the same species and among the different species (Table 1), confirming previous observations involving *E. grandis, E. saligna,* and *E. cloeziana* (4,11). Although *E. grandis* is well adapted to the area and is somewhat resistant to the canker organism *Cryphonectria cubensis* (5,7,9), we do not recommend planting rust-susceptible provenances. Uniform forests produced by cloning selected trees is a common practice in Brazil (2). Because most *Eucalyptus* spp. show some natural cross-pollination (1), even seeds from resistant stocks can produce individual plants susceptible to *P. psidii*, so it is always recommended that selected trees be tested for resistance to *P. psidii.*

Research using the rust-resistant provenances identified in Table 1 must emphasize their silvicultural performance and resistance to other diseases and pests (8) before release for extensive cultivation. Because races of *P. psidii* have not been studied, we do not know if the inoculum from *E. grandis* contained one or more races of the fungus. It is now important to discover the life cycle of *P. psidii*, which is presently unknown (6), and to determine the predominant race(s) in different regions as a basis for future work on epidemiology and disease control.

ACKNOWLEDGMENTS

We thank João B. C. de Souza for the drawing, Nestor Bezerra for the photographic work, and Diassis Anélio and Francisco Geraldo Sá for technical assistance. Research partially supported by Santa Barbara Agriculture and Forestry Co. and Rio Doce Forest Co., Belo Horizonte, MG, Brazil. We thank J. R. Frazão for typing the manuscript.

LITERATURE CITED

1. Brune, A., and Zobel, B. 1981. Genetic base populations, gene pools and breeding populations for *Eucalyptus* in Brazil. Silvae Genet. 30:146-149.
2. Eldridge, K. G. 1981. *Eucalyptus* seed supply for Minas Gerais, Brazil. FO:DP/BRA/78/003 Field Doc. 1, UNDF/FAO/IBDF, Brasília. 69 pp.
3. Ferreira, F. A. 1981. Ferrugem do eucalipto-ocorrências, temperatura para germinação de uredosporos, produção de teliosporos, hospedeiro alternativo e resistência. Fitopatol. Bras. 6:603-604.
4. Ferreira, F. A., and Silva, A. R. 1982. Comportamento de procedências de *Eucalyptus grandis* e *E. saligna* á ferrugem. Fitopathol. Bras. 7:23-27.
5. Golfari, L. 1975. O problema do cancro do eucalipto causado por *Diaporthe cubensis* Bruner, sob o pronto de vista ecológico. Bras. Flor. 6:3-8.
6. Hennen, J. F. 1982. Life cycles of rust fungi. Fitopatol. Bras. 7:461-462.
7. Hodges, C. S. 1980. The taxonomy of *Diaporthe cubensis.* Mycologia 72:542-548.
8. Hodges, C. S., and Reis, M. S. 1975. Status of forest diseases and insects in Latin America. FO:BRA/75/545 Working Doc. 12, Rio de Janeiro. 10 pp.
9. Hodges, C. S., Reis, M. S., Ferreira, F. A., and Henfling, J. D. M. 1976. O cancro do eucalipto causado por *Diaporthe cubensis.* Fitopatol. Bras. 1:129-170.
10. Joffily, J. 1944. Ferrugem do eucalipto. Bragantia 4:475-487.
11. Moraes, T. S. de A., Gonçalves, E. L., Rezende, G. C., Mendes, C. J., and Suiter, Fo., W. 1982. Evolução da ferrugem causada pela *Puccinia psidii* em *Eucalyptus* spp. Cinc. Téc. 144. IPEF, Piracicaba. 12 pp.
12. Nogueira, U.B. 1982. Produção de carvão vegetal de eucalipto no sul da Bahia. Bras. Flor. 12(49):23-31.
13. Reis, M. S., and Carneiro, C. M. R. 1982. Consideração sobre as atividades do setor florestal brasileiro. Bras. Flor. 12(52):7-18.
14. Viegas, A. P. 1961. Índice de Fungos da América do Sul. Inst. Agron. Campinas. 921 pp.