Conidial Dispersal of *Sphaeropsis sapinea* in Three Climatic Regions of South Africa

W. J. SWART and M. J. WINGFIELD, Plant Protection Research Institute, Private Bag X5017, Stellenbosch 7600, South Africa, and P. S. KNOX-DAVIES, Department of Plant Pathology, University of Stellenbosch, Stellenbosch 7600, South Africa

ABSTRACT

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Conidia of *Sphaeropsis sapinea* were trapped in pine plantations in regions of South Africa with summer, winter, and constant rainfall. Spore traps, made from microscope slides coated with petroleum jelly, were collected weekly over a year. Vertical slides trapped conidia deposited by impaction and were more efficient than horizontal slides that trapped those deposited by sedimentation. There was no direct relationship between mean maximum monthly temperature and monthly spore count for any of the regions. Although dispersal of *S. sapinea* conidia was strongly related to the occurrence of rainfall, peak conidial dispersal in the three regions succeeded peak rainfall by up to 16 wk. Maximum conidial production occurred in spring (October) in the winter rainfall region, in early summer (December) in the constant rainfall region, and in late summer (February) in the summer rainfall region. These results suggest that, in all three climatic regions, winter is the most desirable time for management operations such as pruning that favor infection by *S. sapinea*.

Sphaeropsis sapinea (Fr.) Dyko & Sutton (=*Diplodia pinea* (Desm.) Kickx) is an important pathogen of *Pinus* spp. in many parts of the world (7,19,20). Infection results in shoot blight, branch and bole cankers, and blue stain of timber (6,7,19–21).

Pycnidia of *S. sapinea* develop on dead pine tissue and forest litter (6,14,17,21). Conidia are released in the presence of moisture and are disseminated by rain splash and wind (2,6,16,19). Wounds caused by hail, insects, or pruning facilitate infection under optimal temperature and humidity conditions (1,8,12,14,21,22). Infection of unwounded tissue is usually restricted to the period of bud burst and shoot elongation, when host tissue is most susceptible to infection (2–5,16,17).

Strategies to avoid *S. sapinea* infection, particularly infection associated with management operations such as pruning, should be based on a sound knowledge of the conditions that favor maximum dispersal of conidia. In South Africa, *Pinus* spp. are cultivated in three climatic regions, those with rainfall in summer, in winter, and throughout the year (constant rainfall region) (18). This study was undertaken to determine the time of the year when *S. sapinea* conidia are dispersed in each of the three climatic regions and how these relate to management of pine plantations.

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MATERIALS AND METHODS

Conidia of *S. sapinea* were trapped on microscope slides coated with petroleum jelly (15) in a plantation in each of the following rainfall regions in the Cape Province: winter (Jonkershoek State Forest, Stellenbosch; 33° 58′ S, 18° 56′ E), constant (Saasveld Forest Research Centre, George; 33° 58′ S, 22° 28′ E) and summer (Isidenge State Forest, Stutterheim; 32° 40′ S, 27° 17′ E).

Spore traps were designed to trap conidia deposited by either sedimentation or impaction (9–11). Traps for sedimenting spores each had two slides held horizontally, the coated side uppermost, by clothespins mounted on a 25-mm-diameter wooden pole at a height of 1.3 m. Traps for impacting spores each had four vertical slides facing different directions and a plastic canopy (3 × 300 × 300 mm) mounted 100 mm above the slides on a 1.6-m wooden pole.

One of the three spore-trapping plots was established in a 25-yr-old stand of *Pinus radiata* D. Don at Jonkershoek. A trap with horizontal slides was erected at each corner of a square 5 × 5 m. Three traps, each with vertical slides facing northwest, northeast, southeast, and southwest, were erected 7.4 m apart on a line running diagonally across the square. Daily temperature and rainfall data were obtained from a meteorological station 0.5 km from the plantation. Slides were changed weekly from February 1985 to February 1986.

Spore dispersal was monitored at Saasveld and Isidenge from July 1985 to July 1986. In each of these regions, four traps with horizontal slides were placed 4 m apart in a straight line in a 20-yr-old stand of *P. radiata*. Traps were changed weekly for 12 mo. Maximum daily temperature and rainfall data were obtained from meteorological stations about 1 km from each trapping site.

The number of conidia trapped on each slide was determined by counting the conidia in five transects across the slide at 200×. Regional spore counts were obtained by adding the numbers of spores counted on the horizontal slides. With the vertical slides at Jonkershoek, spore counts on slides facing the same direction were added.

RESULTS

In all three regions, conidia of *S. sapinea* were more common during weeks with rain than during dry weeks (Table 1). There was apparently no direct relationship between mean maximum monthly temperature and monthly spore totals for any of the regions.

Patterns of dissemination on horizontal and vertical slides at Jonkershoek were similar (Fig. 1). Of the total spores

Table 1. *Sphaeropsis sapinea* conidia trapped during weeks with and without rain in three rainfall regions of South Africa

		Weeks with rain				Weeks without rain		
				Spores counted			Spores counted	
Trapping site[a]	Rainfall region[b]	Number of weeks	Total rainfall (mm)	Total	Per week	Number of weeks	Total	Per week
Jonkershoek	Winter	40	1,414.4	666	16.65	12	6	0.50
Jonkershoek	Winter	40	1,414.4	914	22.85	12	15	1.25
Saasveld	Constant	43	1,046.9	5,499	127.90	9	47	5.20
Isidenge	Summer	43	1,484.7	1,291	30.00	9	16	1.80

[a] Trapping periods: February 1985 to February 1986 for Jonkershoek and July 1985 to July 1986 for Saasveld and Isidenge.
[b] Eight horizontal slides collected per week in the winter and constant rainfall region; 12 vertical slides collected per week in the summer rainfall region.

collected during weeks with rain, 666 were recorded on the eight horizontal slides (av. 83.25 per slide) (Table 1). On the vertical slides, 439 occurred on the three northwest slides (av. 146.30 per slide), 283 on the northeast (av. 94.30 per slide), 100 on the southeast (av. 33.33 per slide), and 92 on the southwest (av. 30.66 per slide) slides (Table 2).

At Jonkershoek, maximum annual rainfall occurred during July, when temperatures were at their lowest (16 wk before maximum spore dispersal) (Fig. 2A). At Isidenge and Saasveld, maximum annual rainfall occurred during November and preceded maximum spore dispersal by 12 and 8 wk, respectively (Fig. 2B,C).

DISCUSSION

This study confirms previous observations (2,6,13,16,17) that *S. sapinea* conidia are dispersed primarily during rainfall periods.

The greater efficiency of vertical slides in collecting spores at Jonkershoek likely relates to the northwesterly winds that nearly always accompany rainfall in this region. Gregory and Stedman (11) have reported that at moderate to high wind speeds, vertical slides are more efficient spore traps than horizontal slides. This difference apparently results from wind resistance at the edge of horizontal slides ("edge shadow") that leads to underestimation of spore numbers. Because rainfall is generally not accompanied by wind from a particular direction at Isidenge and Saasveld, only horizontal slides were used.

Dispersal of *S. sapinea* conidia occurred only during wet weather, but maximum dispersal was not related to maximum rainfall periods (Fig. 2A–C). Maximum spore dispersal seems to be related to prevailing temperature conditions after the periods of maximum rainfall. At Jonkershoek, relatively low temperatures prevail during, and for some time after, the rainy period. Spore dispersal is therefore delayed longer than at Saasveld or Isidenge where maximum rainfall occurs during the warmer spring and early summer months. Natural infection at Jonkershoek would thus also be at a maximum during this period of shoot elongation when the tissue is most susceptible to infection (2,3,5,13,14,17).

In South Africa, it is the practice to

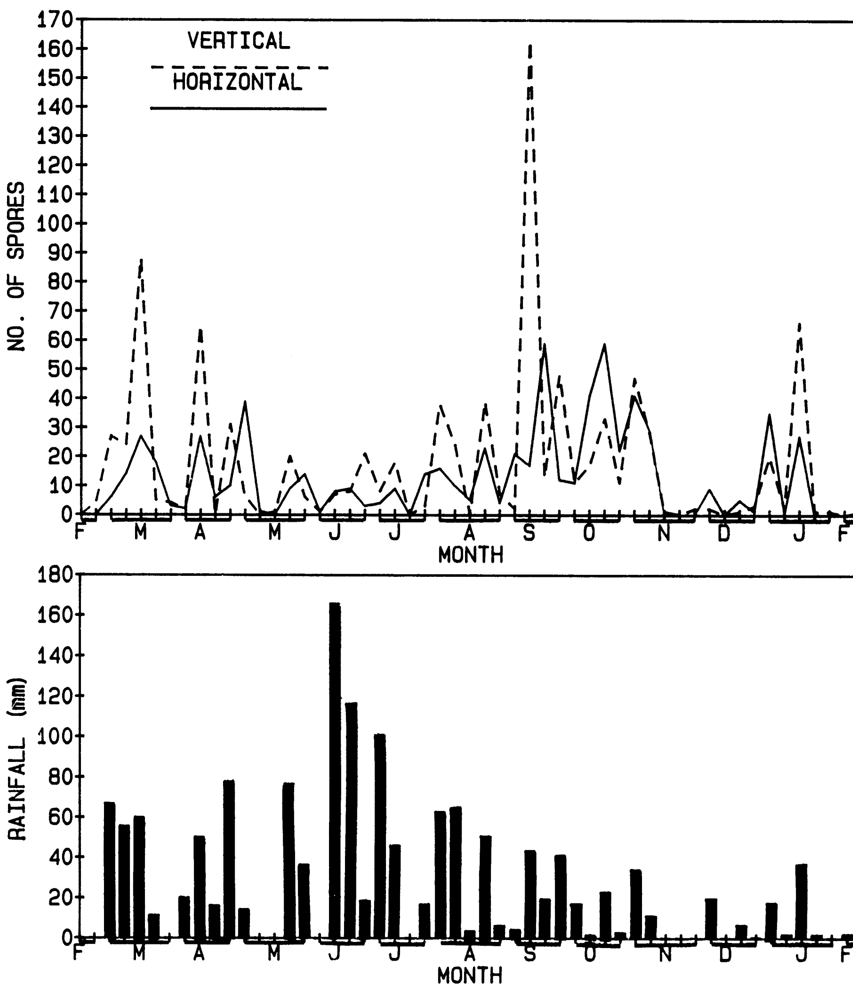

Fig. 1. (Top) Numbers of *Sphaeropsis sapinea* conidia collected by vertical and horizontal Vaseline-coated microscope slides and **(bottom)** weekly rainfall at Jonkershoek State Forest from 15 February 1985 to 14 February 1986.

Table 2. Number of *Sphaeropsis sapinea* conidia trapped at Jonkershoek on vertical slides facing four different directions

	Spores counted[a]							
	Weeks with rain[b] (direction)				Weeks without rain[c] (direction)			
Trap no.	NW	SW	SE	NE	NW	SW	SE	NE
1	129	41	35	79	1	2	1	0
2	154	18	35	115	0	3	1	2
3	156	33	30	89	1	1	3	0
Total	439	92	100	283	2	6	5	2

[a] Total number of spores counted along five transects of one slide per week.
[b] Number of weeks with rain = 40.
[c] Number of weeks without rain = 12.

prune commercially grown pine trees during dry weather. In the constant and summer rainfall regions, pruning is done during winter, and in the winter rainfall region, pruning is done during summer. The results of this study suggest that winter pruning is also justified in the winter rainfall regions. Even though most rain occurs at this time of the year, fewer *S. sapinea* conidia are available for infection of fresh pruning wounds than during spring or summer.

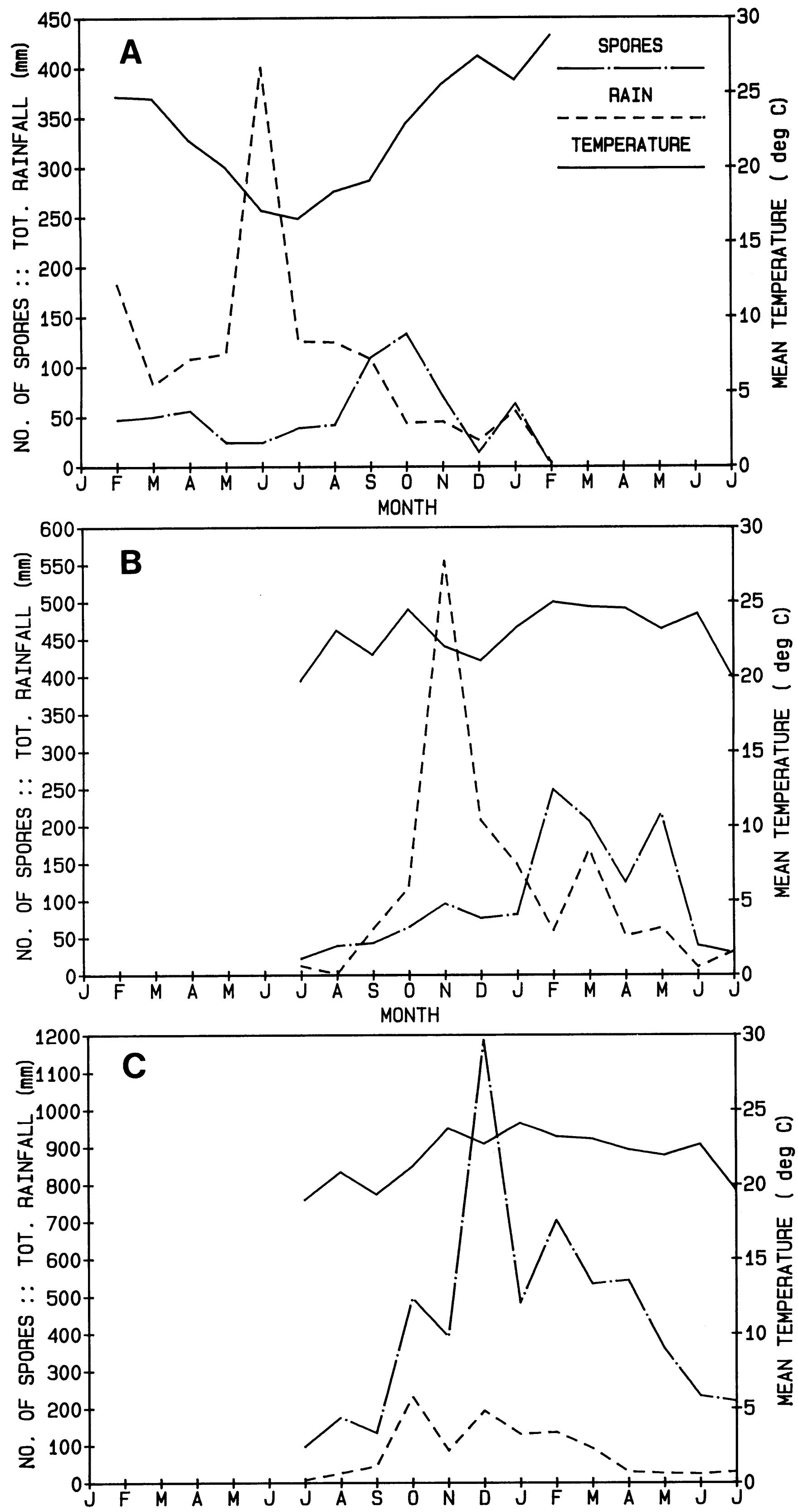

Fig. 2. Monthly rainfall, mean maximum temperatures, and totals of *Sphaeropsis sapinea* conidia collected at **(A)** Jonkershoek from February 1985 to February 1986 and **(B)** Isidenge and **(C)** Saasveld from July 1985 to July 1986.

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LITERATURE CITED

1. Bega, R. V., Smith, R. S., Martinez, A. P., and Davis, C. J. 1978. Severe damage to *Pinus radiata* and *P. pinaster* by *Diplodia* and *Lophodermium* spp. on Molokai and Lanai in Hawaii. Plant Dis. Rep. 62:329-331.
2. Brookhouser, L. W., and Peterson, G. W. 1971. Infection of Austrian, Scots and ponderosa pines by *Diplodia pinea*. Phytopathology 61:409-414.
3. Chou, C. K. S. 1976. A shoot dieback in *Pinus radiata* caused by *Diplodia pinea*. I. Symptoms, disease development, and isolation of pathogen. N.Z. J. For. Sci. 6:72-79.
4. Chou, C. K. S. 1978. Penetration of young stems of *Pinus radiata* by *Diplodia pinea*. Physiol. Plant Pathol. 13:189-192.
5. Chou, C. K. S. 1982. *Diplodia pinea* infection of *Pinus radiata* seedlings: Effect of temperature and shoot wetness duration. N.Z. J. For. Sci. 12:425-437.
6. Eldridge, K. G. 1957. *Diplodia pinea* (Desm.) Kickx, a parasite on *Pinus radiata*. M.Sc. thesis. University of Melbourne, Australia.
7. Gibson, I. A. S. 1979. Diseases of Forest Trees Widely Planted as Exotics in the Tropics and Southern Hemisphere. Part II. The Genus *Pinus*. Commonwealth Mycological Institute, Kew/ Commonwealth Forestry Institute, University of Oxford. 135 pp.
8. Gilmour, J. W. 1964. Survey of Diplodia whorl canker in *Pinus radiata*. Res. Leafl. N.Z. For. Serv. 5. 4 pp.
9. Gregory, P. H. 1950. Deposition of air-borne particles on trap surfaces. Nature 166:487-488.
10. Gregory, P. H. 1973. The Microbiology of the Atmosphere. Leonard Hill, London. 251 pp.
11. Gregory, P. H., and Stedman, O. J. 1953. Deposition of air-borne *Lycopodium* spores on plane surfaces. Ann. Appl. Biol. 40:651-674.
12. Haddow, W. R., and Newman, F. S. 1942. A disease of the Scots pine (*Pinus sylvestris* L.) caused by the fungus *Diplodia pinea* Kickx associated with the pine spittlebug (*Aphrophora paralella* Say.). Trans. R. Can. Inst. 24:1-18.
13. Laughton, E. M. 1937. The incidence of fungal disease on timber trees in South Africa. S. Afr. J. Sci. 33:377-382.
14. Laughton, F. S. 1937. The effects of soil and climate on the growth of *P. radiata* D. Don in South Africa. S. Afr. J. Sci. 33:589-604.
15. Ostry, M. E., and Nicholls, T. H. 1982. A technique for trapping fungal spores. U.S. Dep. Agric. For. Serv. Res. Note NC-283.
16. Palmer, M. A. 1985. Biology and forest tree nursery management of *Sphaeropsis sapinea* in the North Central United States. Ph.D. thesis. University of Minnesota, St. Paul.
17. Peterson, G. W. 1981. Control of *Diplodia* and *Dothistroma* blights of pines in the urban environments. J. Arboric. 7:1-5.
18. Poynton, R. J. 1979. Tree planting in South Africa. Vol. 1. The Pines. South African Department of Forestry. 576 pp.
19. Punithalingam, E., and Waterston, J. M. 1970. *Diplodia pinea*. No. 273. Descriptions of pathogenic fungi and bacteria. Commonw. Mycol. Inst./Assoc. Appl. Biol., Kew, Surrey, England.
20. Swart, W. J., Knox-Davies, P. S., and Wingfield, M. J. 1985. *Sphaeropsis sapinea*, with special reference to its occurrence on *Pinus* spp. in South Africa. S. Afr. For. J. 35:1-8.
21. Waterman, A. M. 1943. *Diplodia pinea*, the cause of disease of hard pines. Phytopathology 33:1018-1031.
22. Wingfield, M. J., and Palmer, M. A. 1983. *Diplodia pinea* associated with insect damage on pines in Minnesota and Wisconsin. (Abstr.) Page 249 in: Proc. Int. Congr. Plant Pathol. 4th. Melbourne, Australia.