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Aerobiology of Two Species of *Cercospora* Pathogenic to Groundnut

K V MALLAIAH and A S RAO
Department of Botany, Nagarjuna University, Guntur 522 510 AP

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Aerial dissemination of conidia of *Cercospora personata* and *C. arachidicola*, which cause tikka leaf spot disease of groundnut (*Arachis hypogaea* L.) was studied using a 'Hirst spore trap' and 'glassrod samplers' for a period of three years from 1974 to '76, covering nine crop periods. The incidence of *C. personata* spots in the field and its conidia in the air were always higher than those of *C. arachidicola*. Conidia of both the species showed a clear diurnal periodicity pattern with peaks occurring at 10.00 hrs for *C. arachidicola* and at 12.00 hrs for *C. personata*. Air-borne conidial concentrations were high when temperature was 29°–31°C and relative humidity levels 75–85%. Mechanical disturbances temporarily increased air-borne conidia steeply. There was a steep decrease of *C. personata* conidia as height increased above the ground level up to 3 m. Numbers of conidia deposited on leaflet surfaces showed a positive correlation with air-borne conidial concentrations.

Key Words: Ground nuts, *Cercospora spots*, **Air-borne conidia, Periodicity**

Introduction

The tikka leaf spot disease of groundnut (*Arachis hypogaea* L.) caused by *Cercospora personata* (Berk. and Curt.) Ellis and Everh. and *C. arachidicola* Hori are very prevalent wherever the crop is grown and lossess amount up to 50% (Jackson & Bell 1969). Feakin (1973) classified this as the most important air-borne fungal disease of the crop. However, work on aerial dispersal of the pathogens involved is very limited. Sreeramulu (1970) studied aerial dispersal of conidia of the two pathogenic species for a single crop season, while Smith and Crosby (1973) studied only *C. arachidicola* in three rainy season crops. Hence air sampling studies were conducted in groundnut fields over three years (1974-'76), covering nine crop periods and the results are presented in this paper.

Materials and Methods

The crop was raised in winter (December–March) and in summer (April–July) under irrigation and as a rainy season crop (July–October) without irrigation. Air spora were estimated by employing a Casella model of 'Hirst volumetric spore trap' and glassrod samplers, as detailed in our earlier paper (Mallaiah & Rao 1980). The diurnal variation in spore counts and effect of mechanical disturbance on spore concentrations were determined by using rotorod samplers, as also described in the above paper.

Results

Seasonal periodicity

The conidia of *Cercospora* spp. were observed on spore trap slides during winter and rainy season crops but not in summer. Day to day changes in air-borne concentrations of these conidial types recorded from 1974 to '76 together with relevant weather data are presented in figure 1.

The conidia of *C. personata* were caught in low numbers in January and up to the middle of February in winter season crops and then the concentrations rose steeply reaching the peak towards the end of February (1974 and '75) or in the first week of March (1976). The spore concentrations decreased steeply after the peak was reached. In the rainy season crops, spore numbers were very low (1974) or completely absent in August (1975 and '76), slowly increased in September and peaks were observed in the first week (1975) or third week of October (1974 and '76). Spore concentrations were very low in the 1976 rainy season and appeared discontinuously, coinciding with dry conditions that persisted in September and October due to scanty rains and high temperatures.

The conidia of *C. arachidicola* were caught in very low numbers and that too in rainy season crops of 1974 and 1975 and in winter season crop of 1974–'75 only. The disease was observed when the crop was about 30 days old but incidence and spread were very low. The air-borne conidia were observed discontinuously and in very low numbers in August. The concentrations slowly increased in September and the peak was reached either in the first week (1975) or in the last week of October (1974). In winter season crop of 1974–'75 they were caught in low concentrations from December to February with very little increase in concentrations.

Spore numbers

The peak concentrations of *C. personata* were observed when the crop was around 100 days old (table 1). The peak was reached

Table 1 *Highest daily mean concentrations of the conidia of* Cercospora spp. *in different crop seasons*

Year	Crop season	Spore Nos. estimated per	*C. personata*			*C. arachidicola*		
			Highest daily mean	Date	Age of the crop	Highest daily mean	Date	Age of the crop
1974	Winter	sq. cm*	270	27.02.74	89	Nil	—	—
1974	Rainy	m^3 of air**	1911	19.10.74	106	29	26.10.74	113
1975	Winter	,,	732	23.02.75	95	15	20.02.75	92
1975	Rainy	sq. cm	1376	2.10.75	95	262	2.10.75	95
1976	Winter	,,	573	4.03.76	81	Nil	—	—
1976	Rainy	,,	52	16.10.76	100	Nil	—	—

*glassrod sampling
**Hirst spore trap estimates

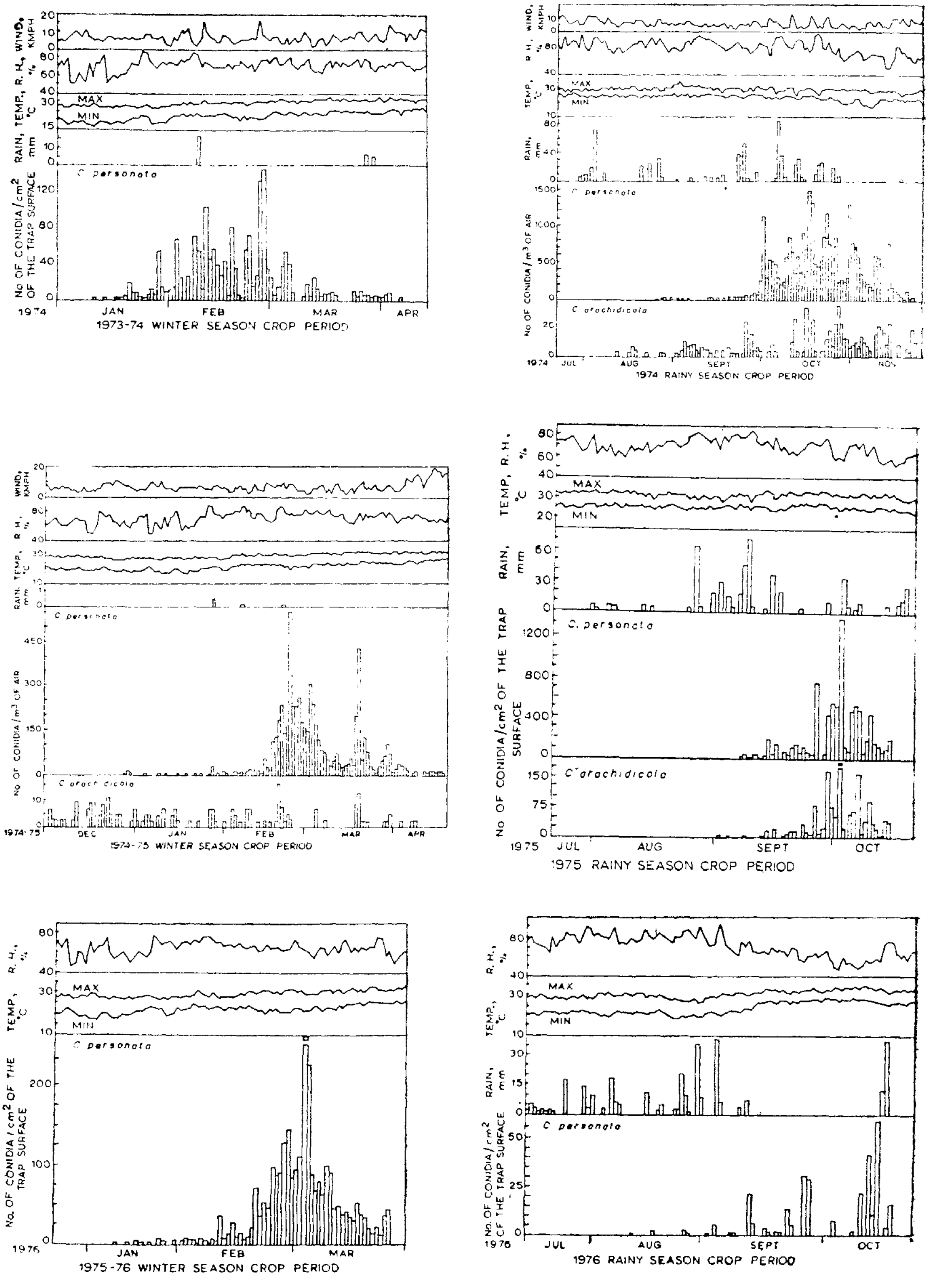

Figure 1 Day-to-day changes in the concentration of air-borne conidia of *Cercospora* spp. together with weather data during winter and rainy season crops of 1974-76

Table 2 *Highest hourly concentration of spores recorded on Hirst trap slides*

Spore type	Crop season		Highest hourly conc.	Hour	Date
C. personata	1974	Rainy crop	12,258	16.00	3.10.74
	1974–75	Winter crop	8,986	12.00	23.02.75
C. arachidicola	1974	Rainy crop	216	10.00	27.10.74
	1974–75	Winter crop	61	10.00	20.02.75

a little earlier in winter than rainy season (except in 1975). Highest daily mean observed in October 1975 was 1911 m^{-3} of air (in Hirst trap sampling) and it was 1376 cm^{-2} from glassrod sampling in rainy season crop of 1975. The highest concentration of *C. arachidicola* was only 262 cm^{-2} during the rainy season crop of 1975, when the plants were 95 days old. Thc highest hourly concentrations were observed during rainy season (table 2).

Diurnal periodicity

The conidia of *C. personata* exhibited a distinct diurnal rhythm with peaks occurring at noon, both in winter and in rainy season (figures 2A, B). The minimum numbers were recorded either at 02.00 hrs (rainy season) or 06.00 hrs (winter season) and the concentrations showed a steep increase after daybreak. Hourly changes in air-borne conidial concentrations recorded with rotorod samplers during 1976 crop seasons showed that the rise and fall of concentrations was gradual during day time (figure 2C). Deviations from normal periodicity pattern were however observed on many days of rain or humid cloudy weather. In rainy season, the day to night catch ratio was 4.7:1 while in winter it was 3.97:1.

The conidia of *C. arachidicola*, though occurring in very low concentrations, exhibited a diurnal rhythm with peak at 10.00 hrs during both rainy and winter season crops (figure 3). The day to night catch

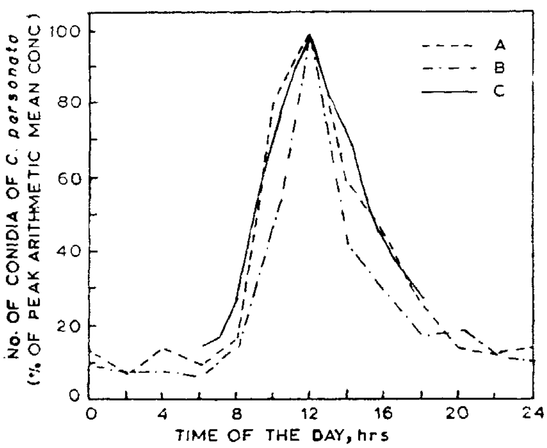

Figure 2 Diurnal periodicity patterns exhibited by air-borne conidia of *C. personata* during rainy season crop of 1974 (*A*) and winter season crop of 1974-75 (*B*) Hourly changes during day time observed with rotorod samplers in winter and rainy crop periods of 1976 are shown in 'C'

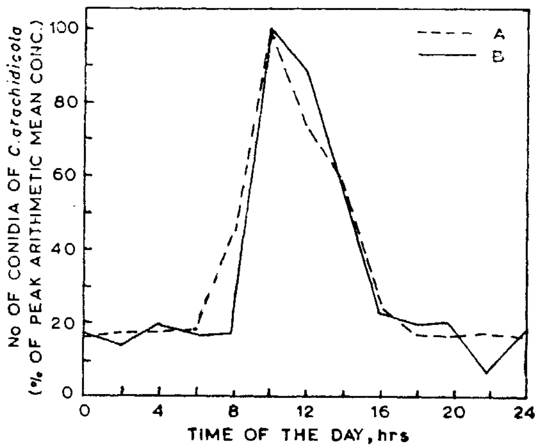

Figure 3 Diurnal periodicity patterns exhibited by air-borne conidia of *C. arachidicola* during rainy season (*A*) and winter season (*B*) crop periods

ratio was 3:1 during rainy season and in winter it was 3.2:1. Variations from normal periodicity pattern were observed on a few days in rainy season and they were much less in winter season crop.

Effect of weather

An analysis of spore concentrations in relation to temperature showed that highest concentrations occurred when maximum day temperatures were 29°–30°C (figure 4A) and minimum night temperatures were 18.4°–25.8°C. Relative humidity range of 65–75% was optimum for the incidence of these conidial types (figure 4B). Fairly high concentrations were observed at higher relative humidities but below the optimum range the concentrations were very low.

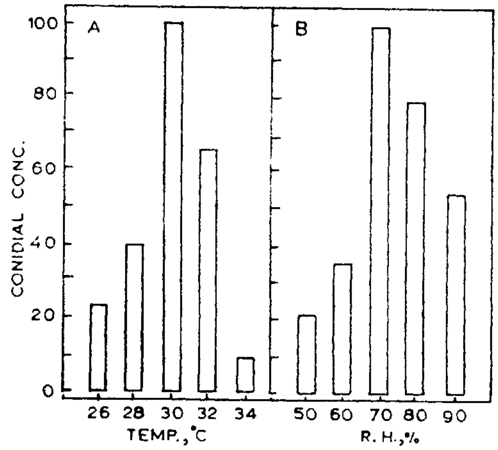

Figure 4 Effect of temperature (*A*) and relative humidity (*B*) on the incidence of air-borne conidia of *C. personata*. The values are presented as percentages to the maximum recorded at a point in the range observed

Rain is a very important factor that affects conidial concentrations in air. Lower than normal concentrations were observed during rainy days. However, concentrations increased before the start of rainfall on many occasions and this coincided with the prevalence of high wind speeds. Higher concentrations were observed even at low wind speeds of 2–4 kmph and increase in wind speeds always resulted in an increase in spore numbers.

Mechanical disturbance

Unusually high concentrations of *C. personata* conidia occurred on certain days or at certain times of the day which could not be related to changes in weather conditions but coincided with field operations like watering, weeding etc. Rotorod samplers were operated in the field continuously for 70 min and the rotating units were changed at 10 min intervals. Infected plants around the trap were shaken gently for 1 min after the first 10 min period. The concentration of *C. personata* conidia rose steeply during the disturbed state but predisturbance concentrations were restored in the third 10 min period. The ratio of concentrations between predisturbed and disturbed states were 1:19 on average. The conidia of *C. arachidicola* were not observed during the undisturbed periods but occurred soon after the mechanical disturbance. *C. arachidicola* spots were very few near the trapping area and the conidia liberated due to disturbance were perhaps diffused or settled and they were not trapped further.

Vertical profiles

Spore concentrations at different heights up to three meters above the ground level in the field was determined by exposing glass-rods with cellophane strips coated with an adhesive, at 0.5 m intervals. The conidia of *C. personata* were observed at all heights of exposure but the concentrations decreased with increasing height.

Horizontal gradients

The conidia of *C. personata* were deposited on 'gravity slides' exposed at different distances up to 100 m from one end of the field in windward direction. They decreased with increasing distance and, from 40 m onwards, their appearance was discontinuous.

Spore deposition on leaflet surfaces

The number of conidia deposited on leaflet surfaces were observed by the 'Sticky cellotape method'. The numbers on upper (adaxial) surface were always higher than those deposited on lower surface. The ratio of conidia deposited on upper to lower surfaces was in the range of 1:0.200-0.860 and the average was 1:0.500. The number of conidia deposited on leaf surfaces showed a positive correlation with the number of conidia trapped on glassrod samplers on those days (table 3). The ratio between spores trapped from air to that deposited on leaflet surface was 1 : 0.265 on average and the range was 1:0.1660-0.522.

Discussion

The conidia of *C. personata* were observed in all the winter and rainy season crops while those of *C. arachidicola* were caught on trap slides in only three crop periods. The absence of *C. arachidicola* conidia in other crop periods is attributable to its very meagre incidence in the field. Though the geographical distribution of *C. personata* and *C. arachidicola* (CMI maps 152 and 166, respectively) is similar, the incidence of infection by either pathogen differs markedly (Jackson & Bell 1969). Thus *C. arachidicola* is predominant in USA (Woodroof 1933 Jenkins 1938) while *C. personata* is predominant in India (Butler 1918, Mundkur & Chattopadhyay 1967). The absence of air-borne conidia of *C. personata* at Georgia, USA (Smith & Crosby 1973) may be due to the same reason.

In all the crop periods the conidia were caught on spore trap slides only after the disease appears in the field indicating that the primary inoculum was too small to be detected by the spore trap used. Hirst (1959) pointed out that 'no trap is likely to detect spores as sensitively as an acre of susceptible crop in weather favourable to infection'. Further, soil-borne inoculum was reported to cause primary infection by *Cercospora* spp. (Hemingway 1954, Shanta 1960, Jackson & Bell 1969).

The tikka leaf spots appeared when the crop was 30-40 days which agrees with earlier observation of Ramakrishna and

Table 3 *Deposition of conidia of* C. personata *on leaflet surfaces*

Date	No. of spores deposited* on		Ratio of upper to lower	Average No. of spores deposited cm^{-2}	No. of spores trapped on trap surface on the day	Ratio between air-borne spores to deposited spores
	Upper surface cm^{-2}	Lower surface cm^{-2}				
2.03.76	22	9	1 : 0.408	16	93	1 : 0.172
8.03.76	31	22	1 : 0.709	27	127	1 : 0.220
12.03.76	43	37	1 : 0.860	40	135	1 : 0.298
27.09.76	5	1	1 : 0.200	3	15	1 : 0.200
29.09.76	7	3	1 : 0.428	5	21	1 : 0.238
5.10.76	3	1	1 : 0.330	2	12	1 : 0.166
8.10.76	5	2	1 : 0.400	35	18	1 : 0:522
10.10.76	12	8	1 : 0.666	10	33	1 : 0.303

*Each number is average of ten observations

Apparao (1968). The air-borne conidia of *C. personata* increased as the crop reached maturity, while those of *C. arachidicola* remained low till the harvest time. In Tanzania, Hemingway (1955) observed more than ten-fold increase of *C. personata* over *C. arachidicola* in the field in a given period and this higher rate of spread was attributed to greater spore-producing ability of the former. Sreeramulu (1970) observed that air-borne conidia of *C. personata* outnumber those of *C. arachidicola*. Seasonal changes of conidial concentrations of *C. personata* showing a prolonged lag phase leading to a short exponential phase towards the end of the crop is a characteristic feature of secondarily air-borne diseases that multiply at compound interest rate (Van der Plank 1963). Such a pattern of incidence was also observed by Lawrence and Meredith (1970) for *C. beticola* and by Smith and Crosby (1973) for *C. arachidicola*.

The difference in peak hours of two species of *Cercospora*, *C. personata* showing the peak at 10.00 hrs and *C. arachidicola* at 12.00 hrs, may be explained on the basis of abundance of spore production. Under normal conditions the increase of concentrations start after daybreak and in the case of a smaller source (for *C. arachidicola*), spore production may exhaust sooner, but with a larger source (for *C. personata*) the concentrations may build up for a longer time. The peak hours of 10 to 12 were reported for other species of *Cercospora* (Meredith 1967, Sreeramulu et al. 1971, Berger 1973). However, Pathak and Pady (1965) did not observe a clear periodicity for *Cercospora* group, while Smith and Crosby (1973) observed delayed peaks between 11.00 and 15.00 hrs for *C. arachidicola*.

The diurnal rhythm for both the species is related to changes in temperature and atmospheric turbulence during daytime. The conidial concentrations were high even at low wind speeds of 2–4 kmph and this indicates that conidial attachment to conidiophore gives little resistence for their take-off. Meredith (1967) observed that conidia and conidiophores of *C. beticola* underwent violent hygroscopic movements when transferred from saturated to drier atmosphere and conidia were detached from conidiophores. Easy release of conidia of *C. personata* and *C. arachidicola* even at low wind speeds in the morning with decreasing relative humidity and increasing temperature suggests similar hygroscopic movements for these species also.

The effect of rain was to decrease the air-borne conidial concentrations temporarily. Prolonged rain washes down air-borne spores as well as spores from leaf spots. Field observations showed that on normal days a bloom of conidial mass is present at the centre of *C. personata* leafspots but when observed after rains the spots did not show such spore mass. Washing down of conidial mass due to rain was reported for *C. apii* also (Berger 1973). Increase of spore concentrations preceeding the rains may be due to violent shaking of the spore-bearing structures by the increased wind speeds preceeding the rain and most of the variations from normal diurnal periodicity pattern were observed on rainy days.

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