

## Epidemiology of Sorghum Downy Mildew. IV.\* Incidence of Local Lesion Infection

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Two types of local lesions, extending and restricted types were identified in sorghum downy mildew disease. Maximum local lesion infection was observed at 11-leaf stage and this growth stage is recommended for disease scoring. The maximum leaf area infected on any crop by local lesions did not exceed 10.9%, and most of it is recorded on leaves 6-9 which were most susceptible. The last four leaves were relatively free from local lesions and thus had no substantial direct effect on the filling of grains. Local lesions were present throughout the crop period and contributed to a major share of air-borne conidial inoculum. The maximum sporulation index is found to be at 9-12 leaf stages. The disease cycle with reference to local lesions took a minimum of 8 days and in the course of 24 days almost all the plants in the field developed local lesions, even when the source was a single systemically infected plant.

**Key Words:** Epidemiology, Aerobiology, Local lesions, Downy mildew

### Introduction

Recent investigations on Sorghum downy mildew (SDM), caused by *Peronosclerospora sorghi* (Weston & Uppal) Shaw, have resulted in several new findings. The aerial dissemination of SDM conidia has been brought to light by Shenoj and Ramalingam (1979) and their role in the development of local lesions and systemic infection (SI) is established by Cohen and Sherman (1977), Jones (1978) and Rajasab et al. (1980). This

communication presents information, collected since 1971, on the incidence of local lesion infection on sorghum.

### Materials and Methods

A local variety, 'Bili jola', grown over vast areas in semi-arid tracts of Mysore district, was used for cultivation throughout the course of our investigation. The crop was

\*This is 4th paper in the series. \*\*Paper III is...."Dispersal and deposition of inoculum" (*Kavaka* 7: 63-67)

cultivated in Manasa gangotri, the Post-graduate campus of the University of Mysore, isolated by 1 km from the nearest farmers fields and about 200 m from the downy mildew nursery plots of Dr Safeeulla. An experimental plot measuring half an acre was used to raise sorghum crops during *kharif* (from May to August) and *rabi* (from September to December). Sorghum rows were sown at weekly intervals between 5 April 1977 and 6 June 1978, and 15 January 1979 onwards, in the botanical garden approx. 300 m away from the experimental plot. Each row had 150 plants approx. Data on the infection were collected at 5-day intervals in 1971 and 1972 and at 7-day intervals since 1977, as per scales given by Shenoi and Ramalingam (1976).

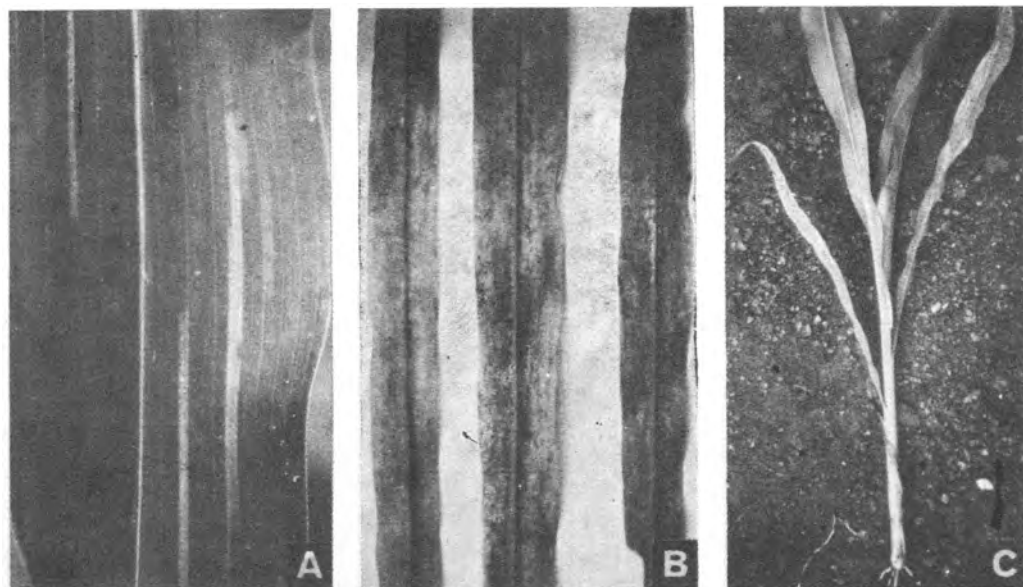
**Results**

*Types of local lesions*

Two kinds of local lesions were identified:

(i) extending type and (ii) restricted type (figure 1). The first type expresses only on leaves 1-5, spreads fast to the entire surface of the leaf, in many cases extends to the meristem and develops into systemic infection. In a number of plants, upper leaves were free from systemic infection but lower leaves exhibited extending lesions. The second type lesions are clearly delimited, rectangular spots, measuring 4-45 x 1-2 mm in size. These could be clearly identified from 6-leaf stage onwards only.

In order to confirm these field observations, sorghum seedlings raised in oospore-free plots (in a secluded place far off from any source) were inoculated with conidia by spore fall and whorl inoculation methods. Data gathered on the incidence of SDM are presented in table 1. In plants inoculated with spore fall method, lesions developed a day earlier than those inoculated by spore suspensions into the whorl. When the last score was taken on 18th day after emergence, 100% of the inoculated plants developed



**Figure 1** Local lesions. *A*, restricted type; *B*, extending type; *C*, extending lesions on leaves 3 and 4 on a plant at 5-leaf stage. 1 and 2 leaves dried up

**Table 1** Incidence of extending and restricted lesions on artificially inoculated plants and their relation to development of systemic infection and death

No. of days after emergence	% of plants				Killed by infection
	With extending lesions only	With extending lesions & systemic infection	With restricted lesions only		
1	0	0	0	0	0
4	19	0	0	—	—
5	53	0	0	1.0	1.0
10	100	34	0	12	12
18	100	45	1.0	15	15

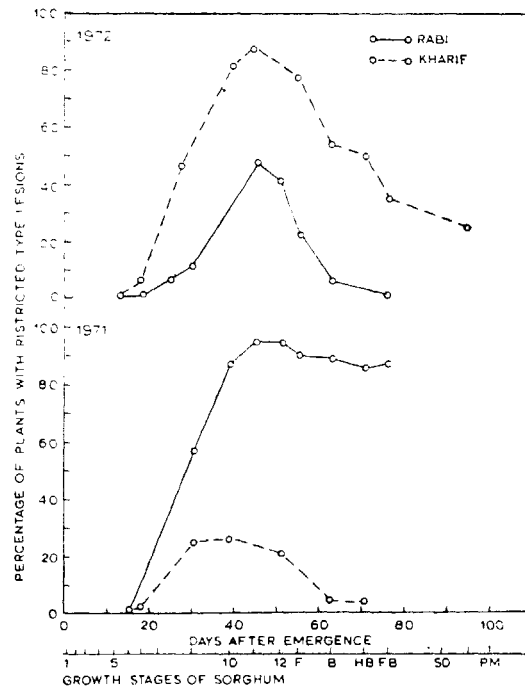
extending lesions, about 45% of the plants developed systemic symptoms and only 1% exhibited local lesions of restricted type. On 5th day when plants were in 2-leaf stage, only 15% plants were bearing extending lesions on 1-leaf, 22% on both 1 and 2 leaf and 16% only on 2nd leaf. On 18th day when last score was taken plants were in 6 leaf stage, 1 leaf is fully dried up, 2nd leaf three-fourths dried, 3rd leaf half dried, and 4th leaf partly dried, a major share of this drying being caused by extending lesion infections, in addition to maturation of tissues. Since the occurrence of extending lesions was recognised by us only recently, the data presented are only on the restricted type lesions.

#### *Incidence of local lesions on crops and weekly sowings*

In *kharif* and *rabi* crops of 1971 and 1972, four in all, restricted lesions were noticed from 6 or 7-leaf stage. They spread very fast reaching a maximum percentage of infection by 11-leaf stage (figure 2). Thereafter, a sharp decrease was observed in the

count as the infected leaves dried up and fresh lesions were not formed in dry weather periods. However, in the *kharif* crop of 1971 the percentage of infected plants remained high until maturity as the weather was humid, crop was healthy and infected leaves had not dried up early.

In weekly sowings made during the dry season, January to April fresh local lesions were not recorded on plants in any row at any growth stage. The first local lesions appeared, in such rows, only after a heavy summer shower as in February 1979 or after regular onset of monsoon rains as in May 1977 and 1978. The source of inoculum was either conidia coming from a systemically infected plant as in May 1977 and March 1979, or an external source as in May 1978. The mean data for the above mentioned three periods is given in table 2. It reveals that



**Figure 2** Incidence of restricted type local lesions on sorghum plants in relation to growth stages in 4 crops

**Table 2** Incidence of local lesions on weekly sowings after summer showers \*

Growth stage	% of plants infected
Emergence	0
2-leaf	0
3-leaf	0
4-leaf	1.0
5-leaf	0
6-leaf	2.0
7-leaf	14.0
8-leaf	16.0
9-leaf	20.5
10-leaf	16.0
11-leaf	2.0
12-leaf	2.5
Flag leaf	0
Booting	0
Half bloom	0
Full bloom	0

\*Data mean for 3 periods

sorghum plants are highly susceptible to local lesion infection at 7–10 leaf stages.

#### Amount of leaf area infected

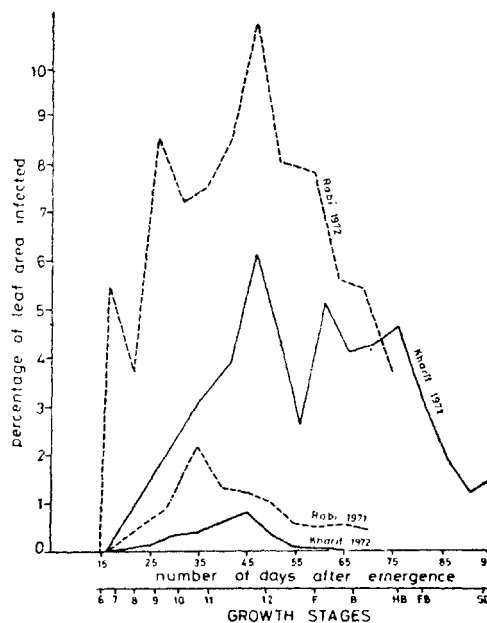
The maximum area occupied by restricted lesions ranged from 1 to 10.9% at any given growth stage (figure 3) in the four crops studied. The percentage of infected area began to increase from 6-leaf stage, reached a maximum at 10 to 12-leaf stages and declined thereafter to minimum. The rate of development of infection also differed from crop to crop, fastest rates being noticed in *kharif* crop of 1971 and *rabi* 1972, and lowest in other two crops. A close relationship was noticed between the rates of infection development, weather as well as healthiness of the crop. *Rabi* crop of 1971 and *kharif* crop of 1972 in which fast rates of infection were scored, were healthy, while the other two crops were very weak.

In the *rabi* crop of 1971 detailed data were gathered on the occurrence of different

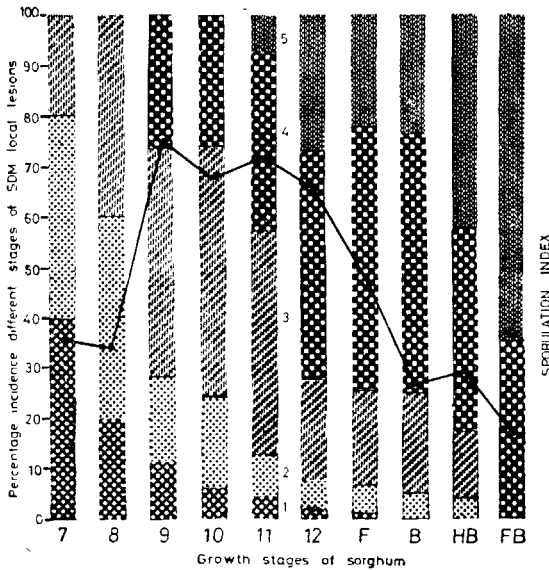
stages of leaf spots on foliage at 5-day intervals. Infection spots of stage-1 were seen in maximum number at 7-leaf stage and declined to a minimum by flag-leaf stage. Fresh local lesions were not seen on any leaves from booting to physiological maturity (figure 4). Acute spots, stage-5, appeared only at 11-leaf stage and contributed to more than 50% infected leaf area in mature stages of crop.

#### Susceptibility of different leaves of sorghum plant to local lesions

In the *rabi* crop of 1972 detailed data were also gathered on the area occupied by restricted type local lesion on different leaves of sorghum plants, at each growth stage, and presented in figure 5. The leaves 6, 7, 8, and 9 recorded maximum incidence of local lesions when the plants were 30 to 60 days old. The topmost four leaves recorded a very low incidence, of the diseased area



**Figure 3** Percentage of leaf area occupied by sorghum downy mildew restricted lesion in 4 crops related to growth stages of crop



**Figure 4** Relative occurrence of different stages of sorghum downy mildew restricted type lesions (1—5), related to growth stage of the crop. The curve indicates the sporulation potential of the infected crop

decreasing with increasing number of leaf, the least being on the flag-leaf. On each leaf, more lesions were formed at tip portion, the spots often coalescing with each other resulting in the drying of lamina, whereas, their number as well as area was least in the basal and middle portions. The decrease in the percentage of leaf area (after 11-leaf stage) as represented in figure 5, is due to the early drying of the infected leaves as compared to the healthy ones, which were excluded from the sources.

*Spread of local lesion infection in weekly rows from a point source*

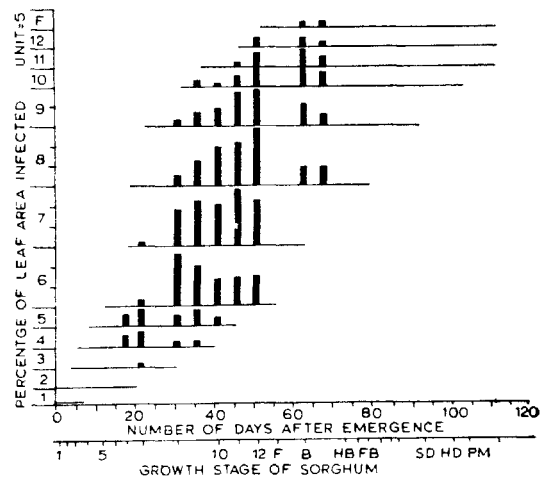
In the summer season of 1979, weekly sowings were commenced on 15 January 1979 and by the end of February 1979, 7 rows were in different growth stages, free from downy mildew infection. One systemically infected

plant was noticed in the middle portion of row 5, on 27th February 1979 and by 7th March local lesions were observed on leaves of plants in rows 2, 3, 4 and 5. The first score for the mapping on the spread of local lesions was made on that day followed by 3 more scores as shown in figure 6. It could be observed that the disease had spread from the single systemic to almost all the susceptible plants in 24 days.

When the source of conidia is a standing crop or row, and if the conidial inoculum fell on plants from emergence itself, extending lesions were formed on the first 5 leaves of almost all the plants. However, in a crop when the source is a systemic, arising probably from oospore infection, the plants are aged by the time the conidia are produced and disseminated from the systemic, and mostly restricted type of lesions were formed on plants.

*Conidial inoculum from local lesions*

Extending lesions could be recognized on leaves of sorghum plants from 2-leaf stage



**Figure 5** Percentage of leaf area occupied by sorghum downy mildew lesions on different leaves of sorghum plant at different growth stages of the crop

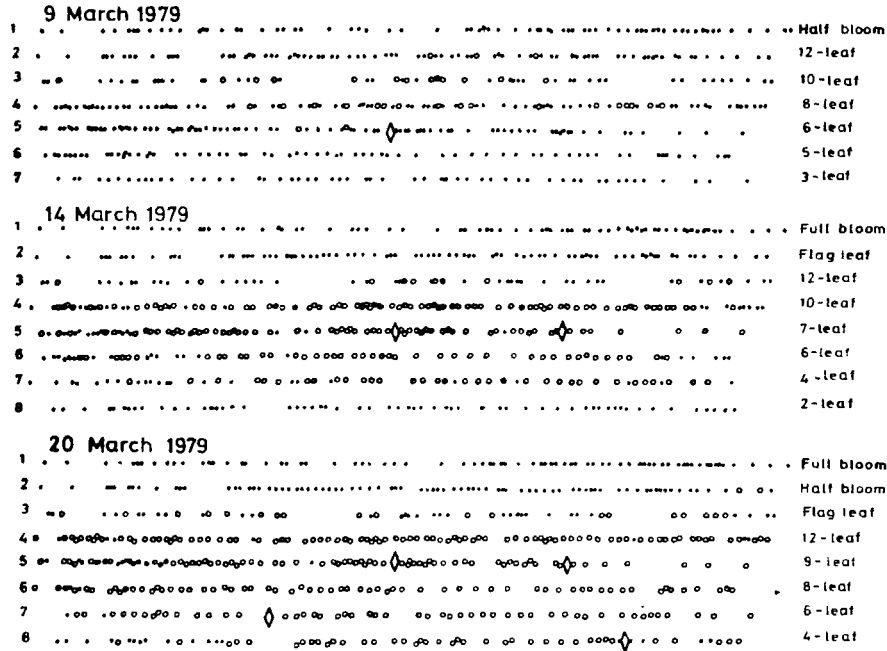


Figure 6 Maps showing the spread of sorghum downy mildew by conidia from a systemically infected plant in weekly rows

•=healthy plant, 0=plant with local lesions and <math>\diamond</math>=systemically infected plant

and restricted type from 6-leaf stage onwards. The latter which could be scored with certainty from 6-leaf stage onwards are found to produce conidia on leaves until harvest. On the basis of available data on conidial production (Shenoi & Ramalingam 1976), amounts of leaf area occupied by local lesions; the conidial production from the crop at each growth stage was estimated from the *rabi* crop of 1971 (figure 4). An infected crop with local lesions is a source for conidial inoculum almost throughout its life period particularly from 7-leaf to full bloom stage, with maximum sporulation at 9 to 12-leaf stages.

**Discussion**

Soil-borne oospores infect roots and produce systemics as shown by Suryanarayana (1954)

using artificial inoculation method with oospores, but the oosporic infections do not produce local lesions. On the other hand, conidial infections, depending upon the growth stage, age and state of tissue infected, produce either local or systemic infection (Fredericksen et al. 1973, Cohen & Sherman 1977). Our observations on the development of local lesions both on the leaves of the healthy plants as well as on healthy leaves and portions of systemically infected plants further substantiate the above statement.

SDM infections are scored by plant pathologists at their choice, at any growth stage. Our study reveals a definite pattern of host-parasite interactions in relation to the growth stages as well as the number of leaf. While the leaves 1 to 5 develop extending lesions on conidial infection, leaves 6 and above produced restricted type of

lesions. Maximum expression of restricted lesion infections were observed at 11-leaf stage and it is suggested to take scores at this growth stage for accurate determination of restricted lesion infections. Further the scales already given by Sheno and Ramalingam (1976) could be utilized for the estimation of local lesion infection in the crop.

The data presented here clearly indicates that inoculum required for initiating the foci of infections in a crop would come from the following sources :

- (1) Soil-borne oospores infecting young seedlings and developing systemic infection
- (2) The conidial inoculum coming from seedling systemics
- (3) Conidia coming from local lesions—within the crop or from external sources

The local lesions seem to be an important source of conidial inoculum and could be cited as an important factor in initiating epidemics on young plants in the vicinity of infected crops as revealed by Cohen and Sherman (1977), Jones (1978).

An analysis of the data on the initiation and spread of downy mildew infections in weekly sowing (table 3) further substantiates the above conclusion. In row 5, a single plant expressed systemic infection 8 days after receipt of a heavy shower of rain, probably arising from soil-borne oospore infection. Local lesions appeared on plant leaves in rows 2-5 after a further period of 8 days. A second small shower on 28 February contributed to heavy sporulation and spread of conidia leading to 90% of plants in susceptible growth stages developing local lesions, in another 8 days period. No increase was noticed in the percentage of plants infected in rows 2 and 3 as they reached mature stages and their leaves became resistant to conidial infection. Thus 8 days seem to be

**Table 3** Events in the appearance and spread of *Sorghum downy mildew* in weekly sowings during the summer of 1979

Date	No. of days after sowing	Event
12-2-79	0	Row No. 5 sown
20-2-79	8	Heavy shower of rain 43.5 mm.
27-2-79	15	A small shower of rain 1.6 mm
28-2-79	16	One plant in Row 5 expressed systemic symptoms, conidial spread commenced
8-3-79	24	Local lesions recorded in rows
9-3-79	25	First score taken. 6.9% plants showing local lesions
14-3-79	30	Second score taken 36.6% plants showing local lesions
20-3-79	36	Third score taken 59.3% plants showing local lesions

the period required for the expression of disease after inoculation. This is in agreement with the reports of Cohen and Sherman (1977), Jones (1978) and Rajasab et al. (1980). The disease cycle taking only 8 days, under optimum conditions, the pathogen is capable of spreading in the crop many times during the susceptible growth stages of sorghum plant. The capacity of local lesions to produce successive crops of conidia could further enhance the epidemic potentiality of the fungus.

While extending lesions occupied a greater portion of the leaf area on young plants and caused death in some (up to 15%) the restricted type lesions did not occupy more than 10.9% of leaf area on leaves 6-9 and resulted only in partial drying of leaves. However 10, 11, 12 and flag leaves were relatively less affected. The top four leaves

being the most important structures in supplying photosynthates for filling up of sorghum grains (Fisher & Wilson 1971), thus in well grown canes bearing local lesions mostly on lower leaves the grain yields would not be affected significantly. Cohen and Sherman (1977) also arrived at a similar conclusion.

#### Acknowledgements

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