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Epidemiology of Sorghum Downy Mildew VI. Relative Importance of Oospores and Conidia in Epidemics of Systemic Infection

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Incidence of systemic downy mildew in sorghum variety 'Bili jola', inoculated separately with oospores and conidia of *Peronosclerospora sorghi* was estimated on plants effectively isolated from non-applied inoculum and air-borne conidia. The oospore inoculum gave only 1.2% infection, whereas a conidial suspension applied to young seedlings produced systemic infection in just over half the crop. The relative importance of the two inocula is discussed.

Key Words: Epidemiology, Sorghum downy mildew, Systemic infection

Introduction

Sorghum downy mildew (SDM) systemic infection (SI) caused by *Peronosclerospora sorghi* (Weston & Uppal) C. G. Shaw is responsible for considerable losses in grain, fodder and investment (Jones 1970, Jones & Frederiksen 1971, Cohen & Sherman 1976, Rajasab et al. 1980b). For a long time oospores of *P. sorghi* were considered to be solely responsible for the production of SDM epidemics and the role of conidia was not recognized. Even though, Safeeulla and Thirumalachar (1955) had successfully induced systemic infection on seedlings by bringing conidial inoculum on leaves in contact with seedlings in Petridishes in the laboratory, their aerial dispersal as well as their role in the development of SI under field conditions was not recognized until recently. Only in the past few years the researches of Jones and Frederiksen (1971), Cohen and Sherman (1976), Jones (1978), Shenoi and Ramalingam (1979) and Rajasab et al. (1980a, b) have brought to light the aerial dispersal of SDM conidia and their role in the development of systemic and local lesion infection.

Because the role of air-borne conidial inoculum was recognized only recently, one of the chief defects in the previous experiments was, that the plants were not kept in isolation from inoculum sources in the plot and nearby fields. Hence conclusions drawn about the role of oospores were inaccurate. Unless experiments are conducted using conidial and oospore inoculum separately with a suitable arrangement to isolate plants from other air-borne conidial sources, it is not possible to evaluate the relative importance of the two inocula in the production of epidemics. Hence isolated experiments were made in November, 1979, a period identified as most suitable season for the development of SDM at Mysore (Rajasab et al. 1980b), and the results are reported here.

Materials and Methods

Healthy sorghum seed of 'Bili jola', a local variety which is grown over extensive semi-arid areas of Mysore district, was used for the experiments. The seed was not treated with any chemicals.

Oospore inoculation studies were conducted in a small plot in the Botany garden, where sorghum was cultivated for many seasons. Small holes were made in the ground and a pinch of oospore inoculum collected from the previous year crop was added to it and a seed was placed. Five such rows were sown giving a total of 167 plants at emergence. From the fourth day onwards (a day before emergence) the plot was covered overnight with a polyethylene cover between 1800 and 1000 hr. Emerging plants were carefully examined for SDM symptoms and any diseased plant was isolated from the others by covering it with a separate polyethylene cover during the night hours. The procedure was continued for 23 days.

Another plot in the residence of the senior author was used for conidial inoculation. This plot was 1 km upwind from the nearest source. The soil of the plot was tested and found to be free from SDM inoculum. On the 1 and 3 day after emergence the seedlings were sprayed with conidial inoculum at 1200 hr. The conidia for inoculation were obtained from infected sorghum leaves incubated in moist chambers. They were washed into distilled water past 0100 hr, their concentration adjusted to 80,000/ml and were sprayed to plants using an automizer. The plants were not covered, as any possibility of external contamination by air-borne conidia was slight and in any case would not have interfered with the experiment.

The plants in the two plots were observed daily and any plant that expressed disease was tagged.

Results

In the plot inoculated with oospore inoculum, only two plants out of a total of 167 expressed SI, one on the 15 and another on the 16 day after sowing (table 1). The healthy plants were isolated from these two as well as outside sources up to the 22 day. In this time no plant developed either extending or restricted type local lesions as classified by Rajasab et al. (1980a) on any leaf. Local lesions of both types were noticed on the plants on the 31 day i.e. 8 days after the exposure of plants.

In the plot inoculated with *P. sorghi* conidia, extending type local lesions appeared on the 1 and 2 leaves on the 5 day after inoculation and systemic symptoms were apparent 2 days later. The percentage of plants systemically infected was 47 and 51 respectively on 7 and 11 days after inoculation. Thereafter only one more plant showed SI (table 1). Local lesions of restricted type were noticed on leaf 5 and above only after the plants had reached the 6-leaf stage, 31 days after sowing. Some plants which expressed local lesions of the extensive type developed SI.

Discussion

SDM SI is initiated from three sources: (1) oospores in soil (McRae 1924), on seed and inside the glume and pericarp (Suryanarayana 1954, Frederiksen et al. 1973, Safeeulla 1976), (2) mycelium in seed (Jones et al. 1972,

Table 1 *Production of sorghum downy mildew infection by the oospore and conidial inoculum of* Peronosclerospora sorghi

Date	No. of days after sowing	Crop growth stage	Inoculated with oospores			Inoculated with conidia		
			Percentage of plants showing			Percentage of plants showing		
			EL	RL	SI	EL	RL	SI
12 Nov 79	0	sown	—	—	—	—	—	—
18 Nov 79	6	1-leaf	—	—	—	Conidia sprayed		
20 Nov 79	8	—do—	0	0	0	Conidia sprayed		
21 Nov 79	9	2-leaf	0	0	0	0	0	0
23 Nov 79	11	3-leaf	0	0	0	24	0	0
25 Nov 79	13	4-leaf	0	0	0	85	0	31
27 Nov 79	15	—do—	0	0	0.6	100	0	48
28 Nov 79	16	5-leaf	0	0	1.2	—	—	—
29 Nov 79	17	—do—	—	—	—	100	0	52
4 Dec 79	22	6 leaf	0	0	1.2	100	0	52
5 Dec 79	23		Covers removed and plants exposed			—	—	—
13 Dec 79	31	8-leaf	—	11.4	1.2	100	0	53
31 Dec 79	44	10-leaf	—	100.0	1.2	*	34	53

EL=Extending lesions; *RL*=Restricted lesions; *SI*=Systemic infection
* =Leaves 1 to 5 dried up due to extending lesion infection; — =Data not scored

Safeeulla & Shetty 1974, Safeeulla 1976), and (3) air-borne conidia (Jones 1970, 1971, Rajasab et al. 1980a, b).

The mycelium carried in seed is short-lived (Jones et al. 1972) and seed treated to reduce moisture below 29% level gave no SDM SI (Frederiksen 1980).

Compared with that of conidia, oospores are produced in relatively small numbers per unit area of the leaf (Shenoi & Ramalingam 1976). They are carried as inoculum to the next crop through seed or soil. Sorghum leaves bearing oospores were found to be heavily colonized by epiphytic microbes, the bacterial and fungal populations being 24,000 and 12,000 times greater than those colonizing healthy leaves (Meenakshi 1981). These microbes as well as those infections from *Phlyctochytrium lippi* (Kenneth & Shahor 1975) are supposed to decrease the viability of the oospores. The percentage of germination of the oospores is itself very small and even with Furfural treatment (French & Schmitt 1980) has not exceeded 16%. Further their germination is not simultaneous (Safeeulla & Shetty 1974). Ball et al. (1980) determined the threshold concentration for the oospores of *Sclerospora graminicola*, for the infection of bajra when applied as spore suspension on seed as 1,000–2,000/ml. The number of oospores that are likely to come in contact with the seed of sorghum and cause successful infection is meagre. Thus it can be concluded, as observed in experiments with applied inoculum, that oospore infections cannot produce epidemics of SDM by themselves as erroneously reported in earlier studies. In farmers fields, where sorghum is sown with the onset of summer showers in April–May when there is no standing crop, after a long dry spell SDM SI greater than 2% is never noticed even in ideal places for infection like low land patches and shade (Unpublised). Shetty et al. (1980) who applied oospore inoculum to bajra seed and grew each plant in isolation, had also observed only a low incidence (below 2%) of SI as observed in our experiments with sorghum.

Conidia of SDM are produced in enormous numbers from systemically infected plants as well as those bearing local lesions (Shenoi & Ramalingam 1976). They are dispersed at night (Shenoi & Ramalingam 1979) to considerable distances (Rajasab et al. 1979, Tantera 1975, Unpublished data of the authors) and when they fell on emerging plants produced SI (Cohen & Sherman 1976, Yeh & Frederiksen 1980, Jones 1978, Rajasab et al. 1980a, b) in epiphytotic scale (20–98%). Similar observations were also made on pearl millet downy mildew by Singh and Williams (1980). The results of our experiments reported in this communication, wherein for the first time the plants were isolated from inside and outside sources of inoculum in the field, conclusively prove the role of air-borne conidia in initiating epidemics. The erroneous conclusions made in several published studies of the past are due to the non-recognition of aerial spread of SDM conidia, their role in the production of SI and the scoring of SI caused by conidia as those of oospore infections.

In a crop where SDM SI was initiated from oospore infections (which is expressed at various growth stages of the plants), by the time the systemically infected plants produce conidial inoculum the seedlings which have emerged along with them would be in relatively resistant stages and SI will not exceed 10%. However, when SDM conidia fell on emerging plants of late sown crops or late germinations in the same crop, SI was produced in an epiphytotic scale. A similar conclusion was also made by Tantera (1975), Cohen and Sherman (1976) and Rajasab et al. (1980b). The data recorded on the incidence of SDM over several seasons (Rajasab et al. 1980b) adds further evidence to the above conclusions.

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