Influence of Cropping Systems on *Macrophomina phaseolina* Populations in Soil

S. K. SINGH, Post-doctoral Fellow, Y. L. NENE, Deputy Director General, and M. V. REDDY, Senior Plant Pathologist, Legumes Pathology, ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India

ABSTRACT

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Cumulative effects of 15 crop combinations and rotations on populations of sclerotia of *Macrophomina phaseolina* in soil were studied during the fifth year of a Vertisol cropping system experiment at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Center in Patancheru, India. Higher counts of sclerotia were recorded in the intercropping systems of sorghum (*Sorghum bicolor*) or cowpea (*Vigna sinensis*) with pigeon pea (*Cajanus cajan*) than in single-cropping systems. The highest counts of sclerotia were recorded in plots where sorghum was intercropped continuously with pigeon pea in both the rainy and postrainy seasons. An increase in the populations of sclerotia was also recorded when rainy season sorghum was followed by either safflower (*Carthamus tinctorius*) or chickpea (*Cicer arietinum*). Cropping systems with fallow in the rainy season, followed by sorghum or chickpea in the postrainy season, stabilized the inoculum density of *M. phaseolina*.

Macrophomina phaseolina (Tassi) Goid. (*Rhizoctonia bataticola* [Taub.] Butler) is one of the most destructive plant pathogens in the tropics and subtropics, inciting diseases in a wide range of hosts (7,25). High temperature and moisture stress conditions often prevailing in these areas favor the diseases caused by *R. bataticola* (5). The most common diseases caused by this pathogen are charcoal rot, dry root rot, wilt, leaf blight, stem blight, and damping-off (both pre- and postemergence).

The pathogen survives in the form of sclerotia free in soil or as sclerotia embedded in diseased plant tissues (4,10,21). Sclerotia are produced in large numbers in host tissues and subsequently dispersed in soil during tillage or decaying of the plant residues. Infected seeds also contribute to the primary source of inoculum (1,12,20). Mycelium in the soil is generally not considered a major source of inoculum (14,19,23). Survival of sclerotia has been reported for up to 10 mo under dry soil conditions (6), 18 mo in corn residues in soil, and 16 mo in sorghum residues in soil (4). The severity of the disease caused by this fungus is directly related to the population of viable sclerotia in soils (3,22). Inoculum levels in the soil are greatly influenced by cropping history (17), intermediate cropping (two cropping seasons of the main crop sandwiching one nonhost crop) (2), and crop rotation (24). Populations of sclerotia increase annually where susceptible crops are grown continuously (8,9,14,21).

Because *M. phaseolina* has a very wide host range, obtaining host resistance or tolerance is not easy. Chemical management is often uneconomical or infeasible because the pathogen is both seed- and soilborne. Management of the diseases through cropping systems that reduce the population of *M. phaseolina* in the soil appears to be the most practical method.

We report the influence of some common cropping systems used in the semi-arid tropics to control populations of sclerotia of *M. phaseolina*.

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MATERIALS AND METHODS

Cropping systems and rotations. The population of sclerotia of *M. phaseolina* was estimated in an agronomy experiment of ICRISAT's Resource Management Program in which the long-term effects of different cropping systems on soil fertility in a Vertisol field were studied. The experiment investigated 15 cropping systems composed of various crop combinations and rotations, including fallow systems (Table 1). The crops included in the cropping systems were cowpea (*Vigna sinensis* L. Savi ex Hassk.), chickpea (*Cicer arietinum* L.), mung bean (*Phaseolus aureus* Roxb.), pigeon pea (*Cajanus cajan* [L.] Huth.), sorghum (*Sorghum bicolor* [L.] Moench), and safflower (*Carthamus tinctorius* L.). The cropping systems were rotated in 2-yr cycles. The experiment was carried out in a randomized block design with allocated plots in three replications.

Soil sampling. Soil samples were collected during the fifth year of the experiment (after completion of two cycles of each cropping system and eight seasons). These were collected from 0 to 15 cm in depth before rainy season planting (June), at rainy season harvest (September-October), and at postrainy season harvest (February). Soil samples were not collected at the start of the experiment. Each sample contained three cores from each of three replications. Samples were oven-dried for 48 hr at 30 C, crushed, and sieved through a 2-mm mesh for quantitative assay of sclerotia.

Selective isolation of sclerotia from soil. Estimation of *M. phaseolina* sclerotia from the soil was carried out with a modified Mihail and Alcorn selective culture medium (15). A blender was used to mix a 1-g soil sample in 250 ml of 0.525% NaOCl. The blender was operated three times for 30 sec each at 3-min intervals. The NaOCl was used to exclude soil bacteria and fungi present as hyphae. This mixture was washed with running tap water through a 45-μm-opening sieve, and the residue was backwashed with distilled water into a 250-ml beaker for a final volume of 5–10 ml. To this soil slurry was added 100 ml of cooled (45–50 C) molten selective medium containing Difco potato-dextrose agar (PDA) (39 g/L), Difco Bacto agar (10 g/L), chloroneb (Demosan 65WP, 200 μg a.i./ml), and streptomycin sulphate (250 μg a.i./ml). Although Mihail and Alcorn used chloroneb at 100 μg a.i./ml (15), we used double that amount to reduce the contamination. Chloroneb and streptomycin sulphate were added after autoclaving of the culture medium and just before mixing with the soil slurry. The mixture was then plated in five to six petri dishes and incubated in darkness for 4–5 days at 30 C. *M. phaseolina* colonies were identified within 4–5 days as rings of fluffy white colonies of mycelium surrounding a central area with black sclerotia. Some fungi such as *Aspergillus* and *Penicillium* also grew in this medium but did not interfere with the growth and identification of *M. phaseolina* colonies.

Two 1-g soil samples from each of the three replications of the 15 cropping systems were analyzed for estimation of sclerotia. The average of the six samples, two from each replication, represented populations of sclerotia of the soil drawn from each cropping system.

RESULTS

The cumulative effect of different crop combinations and rotations spread over eight seasons in 4 yr on *M. phaseolina* populations of sclerotia is given in Table

1. The populations of sclerotia in the soil was higher at the end of the postrainy season crops compared with the population at sowing time. The rainy season crops had a differential effect on population of sclerotia, which was also affected by the cropping systems and rotations. Compared with the single-cropping systems, higher counts of sclerotia were recorded in the intercropping systems of sorghum or cowpea with pigeon pea. Highest counts (38 sclerotia per gram of soil) were recorded in plots where sorghum was continuously intercropped with pigeon pea in both the rainy and postrainy seasons every year. Even in systems where sorghum and pigeon pea intercropping occurred in alternate years, the population of sclerotia was high. The second highest population of sclerotia (31 sclerotia per gram of soil) was recorded in the cropping system in which sorghum and pigeon pea intercropping in the first year and sorghum and chickpea sequential cropping in the second year were recycled. The population of sclerotia was generally low in systems where land was kept fallow during the rainy season. The population of sclerotia was also lower in rotations where sorghum and chickpea sequential cropping and cowpea and pigeon pea intercropping in the first year were followed by sorghum and safflower sequential cropping in the second year.

Table 1. Density of viable sclerotia of *Macrophomina phaseolina* in soil during the fifth year of the Vertisol cropping-system experiment, ICRISAT Center, Patancheru, 1987

Crop combination[a]				Sclerotia/g of dry soil		
Year 1[b]		Year 2		Rainy season		Postrainy season
Rainy season	Postrainy season	Rainy season	Postrainy season	Before sowing	At harvest	At harvest
S/PP	S/PP	S	SF	1.8	9.3	21.2
S	SF	S	SF	ND[c]	1.5	12.0
S/PP	S/PP	S	CP	6.0	14.5	31.3
S	SF	S	CP	10.8	3.8	17.8
S	SF	C/PP	C/PP	7.0	4.2	23.5
S	CP	S/CP	S/CP	9.7	4.2	12.8
F	S	F	CP	12.7	2.5	9.2
F	S	F	S	9.2	5.5	11.8
S	CP	S/PP	S/PP	9.8	2.8	26.0
M	S	M	S	8.8	6.0	13.7
F	CP	F	S	9.5	3.5	14.0
S/PP	S/PP	S/PP	S/PP	6.7	21.0	38.2
S	CP	S	SF	3.2	1.8	7.5
C/PP	C/PP	S	SF	0.3	10.7	9.2
S	SF	S/PP	S/PP	6.3	4.7	26.2
Least significant difference				3.3	3.6	8.9
Coefficient of variation				27.8	33.7	28.4

[a] C = cowpea, CP = chickpea, F = fallow, M = mung bean, PP = pigeon pea, S = sorghum, SF = safflower.
[b] Repeated in 2-yr cycles.
[c] Excluded from SE calculation. ND = not detected.

DISCUSSION

M. phaseolina isolates from different crops are cross-pathogenic (16) and have a wide host range (6,25). Because it is a seed- and soilborne pathogen (1,11,14), cultivation of susceptible crops results in an increase of soilborne inoculum (5,8,24). Cropping of susceptible crops such as sorghum and pigeon pea in most of the cropping systems investigated caused an increase in the population of sclerotia in the soil. Although the incidence and severity of diseases caused by *M. phaseolina* in different crops was not recorded in this experiment, it is expected that higher densities of sclerotia will induce higher disease levels. In addition to population of sclerotia in soil, prevailing temperature and moisture regimes also influence development of diseases caused by *M. phaseolina*. Similarly, increases in population of sclerotia were reported after continuous cropping of susceptible cultivars of maize and soybean for 3 yr in the same field (5). Cropping of susceptible crops such as soybean, pine, and jute have also been reported to increase the soilborne inoculum density of *M. phaseolina* (8,9,13,24). Intercropping of sorghum and pigeon pea has been found to be a highly remunerative cropping system in the semi-arid tropics (11). This system was also beneficial in reducing wilt (*Fusarium udum* Butler) incidence in pigeon pea. The incidence of pigeon pea wilt in sorghum-intercropped pigeon pea was 55%, compared with 86% wilt incidence in the single pigeon pea crop (18). Unfortunately, since both crops are susceptible to *M. phaseolina*, the soilborne inoculum of the fungus was increased, and continuous intercropping resulted in a rapid increase in the population of sclerotia in the soil.

M. phaseolina was isolated from the sorghum stalks collected from the field after harvest on PDA. Leftover sorghum stalks may support the multiplication of *M. phaseolina* in the saprophytic phase. Pigeon pea stalks, on the other hand, are usually removed from the fields and used as kindling. Sorghum and corn stalks are known to assist the rapid multiplication of the fungus in natural soils (4). Intercropping of susceptible legumes such as *Cyamopsis tetragonoloba* L. Taub or *Vigna aconitifolius* (Jacq.) Maréchal with *Cenchrus ciliaris* L. have also been reported to increase the inoculum of the fungus in the soil (13). Cropping systems with fallow in the rainy season resulted in a stable population of sclerotia. This may be caused by a break in the crop cycle of the susceptible host.

Intermediate cropping of resistant crops such as field pea and rice between two seasons was reported to reduce the soilborne inoculum of *M. phaseolina* (2). Development of resistant or tolerant cultivars for *M. phaseolina* is the best option for management of the pathogen. However, in the absence of such cultivars, either keeping fields fallow or utilizing intermediate cropping with nonhost crops in crop rotation is helpful in reducing the population of *M. phaseolina* sclerotia in the soil. Removal of diseased plant stubble may reduce further multiplication of *M. phaseolina* in its saprophytic phase and should also help reduce the inoculum levels in soil.

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