# *Polymyxa graminis* on New *Sorghum* Species in Africa

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**ABSTRACT**

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*Polymyxa graminis* (Plasmodiophoraceae), a fungus parasitic on the roots of a few species of Gramineae, was found in the roots of great millet (*Sorghum arundinaceum*) in Upper Volta. This is the first report of this fungus in Africa. In inoculated pot tests, six *Sorghum* spp. became infected with *P. graminis* in addition to the previously established hosts, wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), and oats (*Avena sativa*).

*Polymyxa graminis* Ledingh. is an intracellular root fungus that parasitizes Gramineae and does not produce any external symptom in the host. It may transmit soilborne wheat mosaic (2), oat mosaic (7), and barley yellow mosaic (8). *P. graminis* has been observed in Canada, the United States, New Zealand (9), Japan (8), Italy (4), England and Wales (11), and Brazil (15).

Peanut clump virus is a soilborne pathogen found on peanut (*Arachis hypogaea* L.) (14) and great millet (*Sorghum arundinaceum* (Desv.) Stapf) (6) in Upper Volta and Senegal. During experimental tests for transmission of peanut clump virus in Upper Volta, resting spores similar to those of *P. graminis* were observed in the roots of *S. arundinaceum*. Because *P. graminis* has not been described on *Sorghum* spp. nor reported in Africa, we investigated its importance in Africa.

## MATERIALS AND METHODS

A great millet plant and its roots were collected from a field near Saria in Upper Volta. Soil samples were collected from the same area, around peanut seedlings with symptoms of peanut clump virus infection (14). Soil samples were placed in window boxes and seeded to 12 graminaceous species. Seedlings were grown in a greenhouse at 23–30 C.

In some experiments, plants were grown in an artificial medium, vermiculite with KNOP solution (12.5 g each of $KNO_3$, $MgSO_4 \cdot 7H_2O$, and $KH_2PO_4$, and 50.0 g of $Ca(NO_3)_2$ per liter of solution; diluted 60 times), so that the entire root system could be sampled easily. Roots of *S. arundinaceum* infected with *P. graminis* were used for inoculum and incorporated into the soil or vermiculite.

To stain resting spores, infected roots were boiled for 1 min in lactophenol containing 1 mg/ml of acid fuchsin and then destained and mounted in clear lactophenol (3). Zoospores released from infected roots into water in 1 hr were collected by a low-speed centrifugation and fixed over vapors of osmium and stained with crystal violet (5). Other stages of development of the fungus were examined after staining by Mazia's method (12).

## RESULTS

Clusters of resting spores, characteristic of a fungus in the Plasmodiophoraceae, were observed in the roots of *S. arundinaceum* seedlings collected in the field. The different stages of development of the fungus were observed in roots of *S. arundinaceum* grown in vermiculite. The fungus did not produce external symptoms in the host and was detectable only by microscopic observation of root cells. The fungus occurred in all cortical cells of the roots and rootlets. Immature stages can develop, but cystosori have never been seen in root hairs.

Uni- and multinucleate plasmodia were the first signs of fungus development and were noticed 3–4 days after infection (Fig. 1). A plasmodium could be differentiated into zoosporangia in 5–6 days or evolve into resting spores in 10–12 days (Figs. 2–4). Zoosporangia formed exit tubes and emitted characteristic biflagellate zoospores. Clusters of resting spores differed considerably in size and shape (Fig. 4). Resting spores were 4–6 $\mu$m in diameter, and zoospores were approximately the same size.

**Factors that influence development.** Experiments were made over 3 yr, and the best months for propagation of the fungus were December and January. In the Ivory Coast during this time, special climatic conditions are caused by a dry wind, the Harmatan. The temperature remains the same throughout the year, but relative humidity is reduced to 40%, whereas it is 80–90% the rest of the year. Growth and development of the fungus were very slow except during December and January.

The best results in propagating the fungus were near pH 7 in the artificial medium. Addition of soil from termite nests with basic pH to the loam used for transmission tests stimulated development of the fungus. Zoospores from cystosori in dried roots stored for 2 yr could still infect young seedlings of great millet.

**Host plants.** One or more stages of the fungus in soil with infected *S. arundinaceum* roots were observed on the following plant species: *S. arundinaceum*, *S. cernuum* Host., *S. dochna* (Forsk.) Snowden var. *technicum* (Koern.) Snowden, *S. sudanense* Hitchc., *S. verticilliflorum* (Steud.) Stapf, *S. vulgare* Pers., *Avena sativa* L. 'Maris'

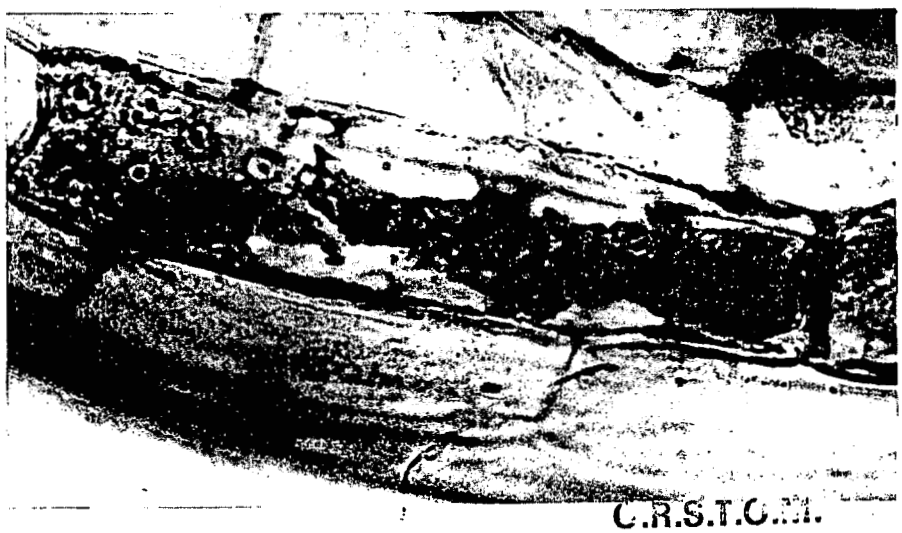

**Fig. 1.** Multinucleate plasmodium of *Polymyxa graminis* in a root cell of great millet (*Sorghum arundinaceum*).

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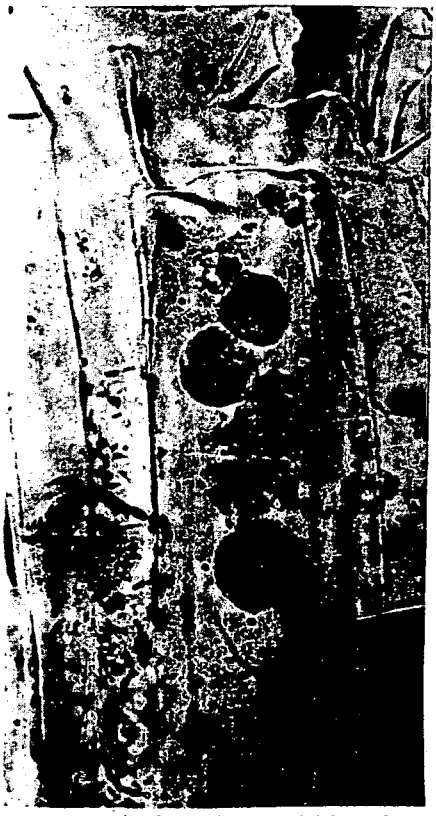

Fig. 2. Meront formation by division of the plasmodium of *Polymyxa graminis*.

Tabard, *Hordeum vulgare* L. 'Alpha' and 'Cape barley,' *Triticum aestivum* L. 'Michigan Amber,' and *T. durum* Desf. 'Agathe' and 3467-7.

## DISCUSSION

*Polymyxa* spp. are characterized especially by resting spores of indefinite size and shape and zoosporangia with one or more discharge tubes. The entire life cycle of the fungus in great millet roots is similar to that of *P. graminis* on wheat (10, 13). Cystosori resting spores and zoospores are the same size. Moreover, the fungus in *S. arundinaceum* can infect wheat and barley, which are the main hosts for *P. graminis*. Oats also are infected (7). We conclude that *P. graminis* is also parasitic and can reproduce on the six *Sorghum* spp. tested. The life cycle of the fungus is completed faster than described by Rao (13). Resting spores could be seen in *Sorghum* in 10–12 days instead of 21–28 days. High ambient temperatures apparently accelerate the growth development processes.

Fig. 3. Resting spores of *Polymyxa graminis* in a rootlet of *Sorghum arundinaceum*.

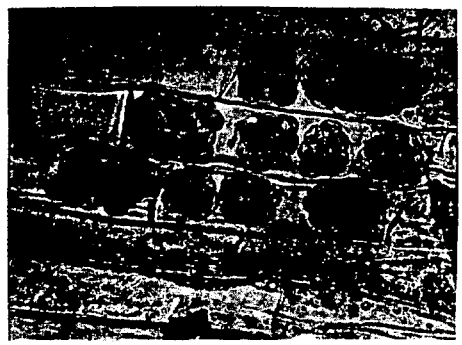

Fig. 4. Variations in size and shape of cystosori from *Polymyxa graminis* in root cells of *Sorghum arundinaceum*.

To our knowledge this is the first report of *P. graminis* in Upper Volta and on the African continent. Our results support Karling's suggestion (9) that *P. graminis* might be worldwide in distribution.

Experiments were made near Abidjan in the Ivory Coast, which has a humid, tropical climate. The best season for propagation of the fungus was during the period of lowest relative humidity, when climatic conditions are similar to those in Upper Volta.

The importance of pH that we observed for *P. graminis* was also reported for *P. betae* (1). *P. betae* produced little disease at pH 6 and below, but it was abundant at pH 7 and above.

*P. graminis* is a vector for several plant viruses. This fungus was found at Saria, a city in Upper Volta. This region (the western African continent) is in the known distribution area of peanut clump, which is incited by a soilborne virus transmitted by an unknown fungus. Experiments are under way to demonstrate the role of *P. graminis* in the transmission of the peanut clump virus and to identify fungal vectors in other areas where peanut clump virus occurs in Ivory Coast, Senegal, and Upper Volta.


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