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Variation of *Pythium*-induced cocoyam root rot severity in response to soil type

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Abstract

In Cameroon, andosols are suspected to be suppressive to cocoyam (*Xanthosoma sagittifolium*) root rot disease (CRRD) caused by the Oomycete pathogen *Pythium myriotylum*. To determine factors involved in disease suppressiveness, andosols were studied in comparison to ferralsols known to be disease-conducive. Soil samples were collected from six sites of which three were in andosols around Mount Cameroon (Boteva, Njonji, and Ekona) and the three others in ferralsols (Bakoa, Lapkwang, and Nko'o canane). Greenhouse plant experiments were used to assess soil suppressiveness. Soils were artificially infested with two levels of *P. myriotylum* inoculum (100 and 300 mycelia strands g^{-1} soil) prior to planting cocoyam. Disease severity was significantly higher in ferralsols than in andosols. Andosols partly lost their suppressiveness as a result of autoclaving and could recover suppressiveness following recolonisation by their original microflora. Soil microbial groups implicated in the disease suppression were investigated by assessing the effect of fungicide, bactericide, and pasteurisation on andosol suppressiveness. Andosols suppressiveness was significantly reduced following pasteurisation and treatment with fungicide and bactericide. The possible influence of microbial biomass on andosol suppressiveness was investigated by comparing microbial populations of suppressive andosols to those in andosols that had lost suppressiveness. A comparative analysis of suppressive and conducive soil properties was performed to identify soil variables, which may contribute to soil suppressiveness. Soil chemical analysis results showed that organic matter content was higher in andosols than in ferralsols. In addition, the content of mineral nutrients such as Ca, K, Mg and N, was higher in andosols than in ferralsols. These soil variables negatively correlated with disease severity. By contrast, sand and clay, which were higher in ferralsols than in andosols, were positively related to disease severity. This study has confirmed the suppressive nature of andosols from Mount Cameroon to CRRD. The results suggest that high organic matter content is likely mediating *P. myriotylum* suppression in andosols by improving soil structure, increasing soil nutrient content and microbial biomass, and sustaining microbial activity.

Keywords: Andosols; Ferralsols; *Pythium myriotylum*; Root rot disease; Suppressive soils; *Xanthosoma sagittifolium*

1. Introduction

Cocoyam (*Xanthosoma sagittifolium* (L) Schott) is an herbaceous monocotyledonous plant belonging to the Araceae family (Coursey, 1968; Purseglove, 1972). It is typically a tropical rainforest plant requiring warm weather (20 to 35 °C), high rainfall (1400–2000 mm) and adequate soil moisture for optimal growth and tuber yield. Light texture and well-drained soils are best for cocoyam growth but this crop can tolerate heavy texture soils with pH values ranging from 5.5 to 6.5 (Onwueme, 1978). The importance of cocoyam mostly relies on its edible tubers and leaves, which are staple food for more than 400 millions people in the tropics and subtropics (Onokpise et al., 1999; Reyes Castro et al., 2005). In the African continent, cocoyam is widely cultivated in West and Central Africa with Cameroon, Ghana, Nigeria, Gabon, and Equatorial Guinea as the major producing countries (Knipscheer and Wilson, 1981).

Unfortunately, this valuable crop is highly susceptible to the Oomycete pathogen *Pythium myriotylum* (Nzietchueng,

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1983; Pacumbaba et al., 1992; Tambong et al., 1999; Perneel et al., 2006). *P. myriotylum* can attack cocoyam at various growth stages. Early infection of cocoyam (at the emerging root stage) by *P. myriotylum* induces stunting, while late infection (at 5 to 6 months after planting) reduces the number of feeder roots, causing chlorosis and poor yields. In Cameroon, yield losses in some plantations due to this soil-borne disease were estimated as high as 90% (Nzietchueng, 1983).

P. myriotylum is difficult to control in cocoyam using classical control methods such as chemicals (Nzietchueng, 1983). Additionally, no resistant cocoyam variety has been developed yet. A reliable short-term disease control strategy that can reduce *Pythium*-induced cocoyam yield losses at an economically acceptable level and provide sustainable production of this vital crop is of urgent need.

Field observations seem to indicate that the two main soil types ferralsols and andosols (FAO soil classification system) used for cocoyam production in Cameroon interact differently with the cocoyam pathogen. Ferralsols (also referred to as ferallitic soils) are the predominant soil type. They are weathered soils composed mainly of kaolinite clay, sesquioxides and gibbsite. Ferralsols have a low nutrient content, and are characterized by Al and Mn toxicity, high P-fixation, and low water retention. In contrast, andosols are relatively fertile soils developed from volcanic ash. The clay fraction consists of allophane. They have a high nutrient content, Mn toxicity, high P-fixation, medium water and nutrient retention (Müller-Sämann and Kotschi, 1994). In Cameroon, cocoyam can continuously be grown on the andosols for about five years without noticeable disease outbreaks if the plot is from virgin land, whereas in all other surrounding ferralsols, replanting of cocoyam results very often in high disease severity. Andosols from Mount Cameroon area become progressively conducive as from about five years of continued cropping of cocoyam because of land use intensity.

This research was undertaken based on the hypothesis that andosol suppressiveness is due to identifiable soil variables. Knowledge of such variables may be helpful for developing a sustainable management of andosol suppressiveness, and to generate a satisfactory level of CRRD suppression in ferralsols.

The objectives of this study were to confirm suppressiveness of andosols from Mount Cameroon to CRRD and to identify essential factors that induce soil suppressiveness.

2. Materials and methods

2.1. Soil types and soil sampling

Soil samples were collected from six sites: three in andosols around Mount Cameroon (Boteva, Njonji, and Ekona) and three in ferralsols (Bakoa, Lapkwang, and Nko'o canane) (Table 1). Soil cores (20 cm depth) were taken randomly at diverse points of virgin plots at each site and were composited. A subsample of 500 g, made from composite soil sample at each site, was separately transferred into clean plastic bags and taken to the laboratory for physical and chemical analysis. Similarly, soil cores (15 cm depth) were taken at diverse points of virgin plots in Boteva and Njonji and within *Pythium*-infected cocoyam plot in Ekona, and separately composited. Then a subsample of 500 g of each composite soil sample was separately stored in sterile plastic bags and refrigerated for further microbial analysis.

2.2. Plant material

The white cocoyam type, which is highly susceptible to *P. myriotylum* attack, (Tambong et al., 1999) was micropropagated to produce enough cocoyam plantlets (Zok et al., 1997). These cocoyam plantlets were then acclimatised at 25–26 °C in the greenhouse for eight weeks before use in the various plant experiments.

2.3. Culture of the pathogen, preparation of inoculum and inoculation procedure

P. myriotylum was cultured and inoculated on cocoyam as described by Tambong et al. (1999). Briefly, *P. myriotylum*

Table 1
Origin of soils used in this study

Soil type	Agro-ecological zone[a]	Location	Altitude (m)	Geographical coordinates	
				N	E
Andosols	IV	Boteva	808	4°13′351″	9°17′047″
	IV	Njonji	50	4°10′506″	9°00′117″
	IV	Ekona	400	4°15′225″	9°20′100″
Ferralsols	V	Bakoa	458	4°33′775″	11°10′453″
	V	Lapkwang	752	4°46′445″	11°08′884″
	V	Nko'o canane	671	3°45′864″	12°13′351″

[a]Zone IV = evergreen humid forest, monomodal rainfall pattern, 3000 mm average annual rainfall; Zone V = semi-deciduous forest and transitional savannah, bimodal rainfall pattern and an annual rainfall of 1600 mm.