RESPECTIVE ROLES OF ROOTS AND EARTHWORMS IN THE RESTORATION OF C STOCKS AND PHYSICAL PROPERTIES UNDER PASTURES (VERTISOL, MARTINIQUE)

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ABSTRACT

Introduction

Chemical and physical properties of Vertisols in Martinique have been degraded through intensive market gardening over a period of fifteen years, resulting in low soil organic matter contents, low biological activity (roots, earthworms, mesofauna, microorganisms) and high soil losses due to erosion. In comparison, old irrigated pastures (*Digitaria decumbens*, Pangola grass) have high C and N contents, high biological activity and a good physical structure (developed structural porosity, high aggregate stability and low erodibility). A research programme was set out in 1991 in the South-Eastern part of Martinique. It is aimed at studying the respective effects of roots and earthworms in the restoration of the properties of a degraded Vertisol.

Materials and methods

The experiment was located in the southeastern part of Martinique, French West Indies (14°25'N / 60°53'W) (humid tropical climate, mean annual rainfall of 1400 mm). The soil is classified as a smectitic Leptic Hapludert (USDA classification) or Eutric Vertisol (FAO-UNESCO classification) and characterized by a high Exchangeable Sodium Percentage (up to 15% in the upper 10 cm of soil).

The experimental design consisted of three plots, which had been under continuous sugarcane production until 1970, followed by fallow (native pasture) until 1978. At that time, the first plot, MG, (0.3 ha) was used for intensive market gardening ; the second plot, P, (0.3 ha), was converted to pasture and planted with a tropical grass *Digitaria decumbens* (Pangola grass) ;

and the third plot, Pr (0.4 ha), was used for intensive market gardening until 1991. At the end of 1991, Pr was converted into a *D. decumbens* pasture. In 1992, three sub-plots were installed in the Pr plot to distinguish between the effects of roots and earthworms (*Polypheretima elongata*) on the dynamics of C storage and physical properties : (i) Treatment P_0E_0 (no plants, no earthworms), (ii) Treatment P_+E_0 (with plants only), (iii) Treatment P_+E_+ (with plants and earthworms introduced at a density of 90 ind/m^2).

In these plots, during 5 years and for the upper 30 cm of soil, we studied root biomass, earthworm biomass and density, soil carbon content (C, N analyser), porosity, aggregate stability (desaggregation kinetics) and soil erodibility (by using a rainfall simulator).

Results

Earthworm biomasses and densities showed great differences between MG (old market gardening plot) and P (old pasture) (Table 1). In the experimental sub-plots, the eradication of earthworms in P_0E_0 and P_+E_0 was successful as no *P. elongata* were collected in these plots. In P_+E_+, earthworm density decreased after the introduction, to reach a constant density of about 50 ind/m^2.

Root biomasses were also different between the plots (Table 1). MG and sub-plot P_0E_0 presented low biomasses whereas the biomasses in plots where *D. decumbens* was not killed were high (around 20 g/kg soil).

Soil carbon content (0-10 cm) in MG and P were 14.2 and 39.1 mgC/g soil, respectively. At the beginning of the experiment, the soil carbon contents in the sub-plots were not significantly different (between 16 and 18 mgC/g soil). After 5 years, significant differences in the soil carbon content occur : 14.1 mgC/g in P_0E_0, 24 mgC/g in P_+E_0 and 23 mgC/g in P_+E_+ (Chevallier et al., 2000).

The percentage of water-stable aggregates WSA (in the absence of mechanical shaking) in the different plots varied from 29% in MG to 70% in P (0-10 cm). After 5 years of experiment, it was equal to 55% in P_0E_0, and 70% in P_+E_0 and P_+E_+.

Rainfall simulation and erodibility measurements also showed great differences between the plots. Under a 30 min rainfall with an intensity of 55 mm/h and for a gently hoed surface, soil losses were as high as 544 g/m^2 in MG and 507 g/m^2 in P_0E_0. Lowest values of soil losses were observed for P : 205 g/m^2. In P_+E_0 and P_+E_+, soil losses were 310 and 304 g/m^2 respectively.

The installation of a pasture after many years of market gardening induced an increase in the structural porosity. Under MG, the structural porosity was very low (0.020 cm^3/g) whereas it was much higher under an old pasture P (0.045 cm^3/g). Five years after the installation of the sub-plots, structural porosity did not evolve in the P_0E_0 plot ; it increased in the other sub-plots (0.030 in P_+E_0 and 0.035 in P_+E_+).

Discussion and conclusion

The installation of a *D. decumbens* pasture after many years of intensive cropping induces high increases in biomass (roots and earthworms), structural porosity and percentage of water-stable aggregates and a strong decrease in soil losses by splash effect and run-off. Then irrigated, fertilized and grazed pastures appear to be a good way to sustain agriculture on this type of soil.

The mechanisms which control these modifications are linked to the presence of grasses and especially of their roots (Chevallier et al., 2000). Actually differences appeared only between treatments without grasses and treatments with grasses. After 5 years of experiment treatments with grasses (P_+E_0 and P_+E_+) presented great differences with treatment without grasses (P_0E_0) in terms of carbon content, aggregate stability, erodibility and porosity.

Nevertheless, there was no difference between P_+E_0 and P_+E_+. We can thus infer that large earthworms like *P. elongata* do not play a major role in the control of physical properties in Vertisols whereas their role on the structure of kaolinitic soils has often been demonstrated (Blanchart et al., 1997).

References

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Tables

Plot	*P. elongata* biomass (g/m^2)	*P. elongata* density (ind/m^2)	Root biomass (g/kg soil)
MG	7.27	5.6	1.0
P_0E_0 (after 5 years)	0	0	5.6
P_+E_0 (after 5 years)	0	0	20.9
P_+E_+ (after 5 years)	32.8	48.1	19.9
P	58.7	120.0	20.2

Table I : Mean earthworm biomass and density, mean root biomass in the different treatments. See text for legend.