SOIL PHYSICAL ATTRIBUTES AFFECTING COTTON PRODUCTIVITY AND NEMATODE POPULATION IN MATO GROSSO STATE, BRAZIL

Carlos M.P. Vaz[1], Rafel Galbieri[2], Sílvio Crestana[1], João F.V. Silva[3], Júnio M. Resende[1], Anésia L. Andrade[1]*

[1]EMBRAPA Agricultural Instrumentation, São Carlos, Brazil; [2]Mato Grosso Cotton Institute, Brazil; [3]EMBRAPA, Brasília, Brazil; *carlos.vaz@embrapa.br

INTRODUCTION

- Cotton is an important cash crop to Brazil, which is the fifth world cotton producer with an annual lint yield of about 1.4 million tons in 1 million hectares planted. Most of the cotton is cultivated in the savannah-like cerrado in an intensive and high-input production system. The State of Mato Grosso is the largest cotton producing State, representing 70% of the Brazilian cotton cultivated after the harvest of soybean.

- The use of state-of-art technologies in soil management, pest control, mechanization and high yielding varieties contributed to this highest world rain fed cotton productivity, reaching up to two tons of lint per hectare.

- However, despite the increasing use of cotton technology, that leads to high production costs, productivity has reaching a plateau at the last years. Therefore, understanding key factors affecting cotton yield is important to adjust or propose new approaches in cotton production technologies.

- Plant parasitic nematodes are important soil pests, causing yield loss at damage population thresholds that varies among different species. In Brazil, the most deleterious nematode species for cotton are *Meloidogyne incognita* (root-knot nematode), *Rotylenchulus reniformes* (reniform nematode) and *Pratylenchus brachyurus* (lesion nematode). Spread of nematode in agricultural fields are potentialized by inadequate soil practices and management, and soil attributes as texture, water content, organic matter, pH and others directly affects the behavior and dynamics of parasitic nematodes in the soil root zones.

- The objective of this study was to evaluate in a State scale the relationships between soil physical parameters and nematode population and their effects on cotton yield.

MATERIAL AND METHODS

- The study was conducted during 4 consecutive cotton crop seasons (2012 to 2015) in 1,779 commercial production planting fields in the Cerrado of Mato Grosso State, Brazil (Figure 1). The soil physical attributes were determined directly in field or in laboratory with soil samples collected at the rainy season, mostly from February to April each year.

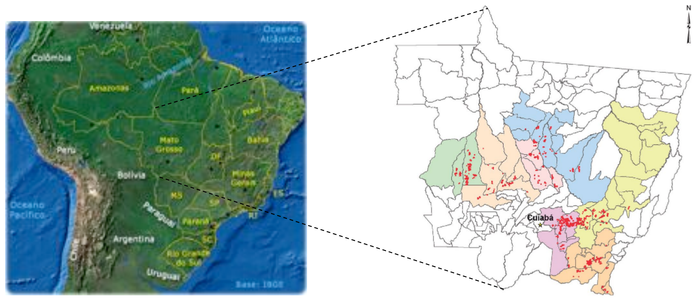

Figure 1. Map of Brazil (left) and Mato Grosso State (right) indicating the 1,779 sampled fields (red points).

- The soil physical attributes measured for each field were:
  - Clay, silt and sand contents (Naime et al. 2001)
  - Bulk density (ρ_b) and volumetric water content (θ) (undisturbed soil samples)
  - Particle density (ρ_p) and total porosity ($f=1-\rho_b/\rho_p$) (Vaz et al. 1999)
  - Electrical conductivity (EC) (saturation extract-conductivimeter)
  - Soil penetration resistance (PR) (dynamic penetrometer: Vaz et al. 2011)

- Nematode species evaluated were *Meloidogyne incognita*, *Rotylenchulus reniformes* and *Pratylenchus brachyurus*. Soil samples (0-25cm, 800 grams) and cotton roots (100 grams) were collected in about 10 ha (12 subsamples for a good representation of each individual field) for nematode population determination in all the 1,779 fields monitored. Soil chemical parameters as pH, CEC, plant macro and micronutrients were also determined.

- Cotton yield of each field was provided by the farm managers at the end of the crop season. Additional information including the geographic coordinates, planting and harvesting date, cotton variety used, plants spacing and density was also provided.

RESULTS

- Average values of the soil physical and chemical properties, yield and nematode populations are presented in Table 1. In general these soils under cotton production have good physical and chemical quality, presenting high clay content, penetration resistance lower than 3 MPa, low electrical conductivity and good fertility.

- The most frequent nematode was *Pratylenchulus brachyurus*, (97.4% of the fields inspected) although in relatively low population levels. *Meloidogyne Incognita* was present only in 24.7% of the fields sampled, but in larger population density than *Pratylenchulus*. *Rotylenchus* was less frequent than *Pratylenchus* and *Meloidogine* (Table 2)

Soil physical parameters		**Soil chemical parameters**	
ρ_b (g cm^3)	1.25	pH water	5.9
ρ_p (g cm^3)	2.72	P resin (mg dm^{-3})	39
θ (cm^3 cm^{-3})	0.267	K (mg dm^{-3})	75
clay (%)	51	Ca (cmolc dm^{-3})	3,0
silt (%)	8	Mg (cmolc dm^{-3})	1.1
sand (%)	41	Al (cmolc dm^{-3})	0.03
EC (dS m^{-1})	0.55	OM (g dm^{-3})	35
$PR_{0\text{-}10cm}$ (MPa)	0.84	Sum of bases	4.3
$PR_{10\text{-}30cm}$ (MPa)	2.11	CEC (cmolc dm^{-3})	8.3
$PR_{30\text{-}50cm}$ (MPa)	1.84	Zn (mg dm^{-3})	6.3
Productivity & nematodes		Cu (mg dm^{-3})	1,7
cotton yield (ton ha^{-1})	3.88	Fe (mg dm^{-3})	81
M. incognita#	495	Mn (mg dm^{-3})	16
R. reniformis#	155	S (mg dm^{-3})	14
P. brachyurus#	235	B (mg dm^{-3})	0.48

Table 1. Average values of measured soil physical and chemical attributes, nematode population (# specimens measured in 200 cm^3 of soil and 5 g of cotton roots) and cotton productivity:

ρ_b: soil bulk density
ρ_p: soil particle density
θ: volumetric soil water content
EC: soil electrical conductivity
PR: soil penetration resistance

Parameter	*Pratylenchulus*			*Meloidogyne*			*Rotylenchus*		
	S	R	S+R	S	R	S+R	S	R	S+R
average population	58	236	294	1598	427	2025	1264	26	1290
maximum population	2130	2870	2990	23600	10880	34480	13080	920	13100
number of fields with		1732			439			231	
% of fields with		97%			25%			13%	

- Table 2. Occurrence of nematode in the 1,779 sampled cotton fields (S: soil; R: root). Population is given in number of specimens found in 200 cm^3 of soil and 5 g of cotton root.

- Relationships between the soil physical parameters, nematode population densities and cotton yield are presented in Figure 2 and Figure 3, respectively.

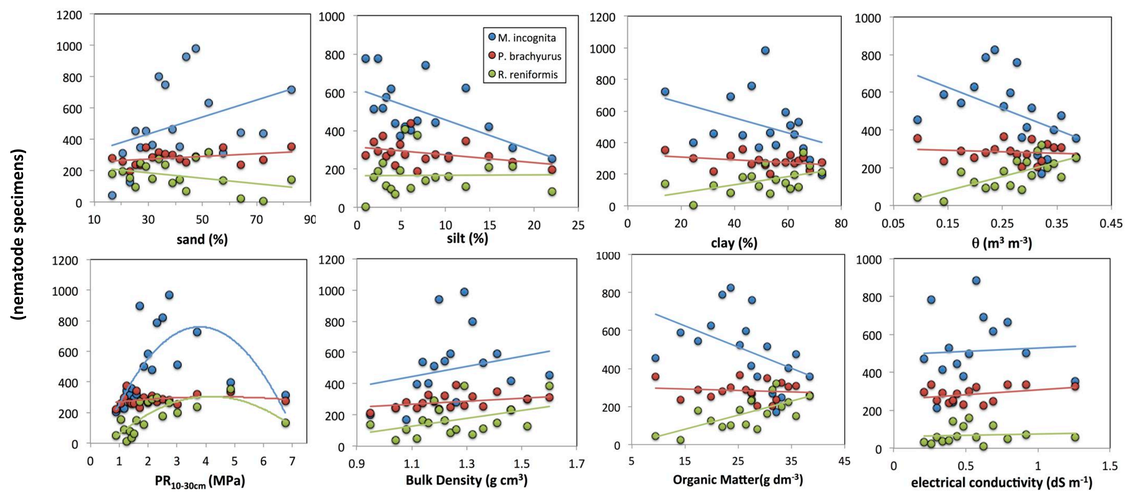

Figure 2. Relationships between some soil physical parameters and nematode population in 200 cm^3 of soil + 5 g of root (Pi). Each point represents an average of 100 sampled fields.

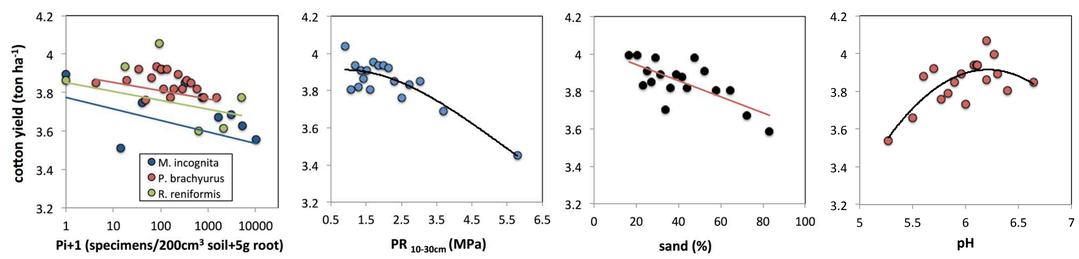

Figure 3. Relationships between some soil physical parameters and cotton yield.

DISCUSSION AND CONCLUSIONS

- Soil physical properties highly affects the behavior of cotton parasitic nematodes and cotton productivity. *Meloidogyne* population was higher for sandy soils and soils with low amount of silt. This can be due to the close relation between soil texture, organic matter (OM) and water retention, since clay content, water content (θ) and OM correlated with nematode population in a very similar way (Fig. 2).

- Increasing soil penetration resistance (PR) up to about 4 MPa increased *Meloidogyne* and *Rotylenchus* populations, but decreased populations for higher PR, probably due to the negative effect of soil compaction on the root system.

- Soil electrical conductivity does not seem to affect nematode population at the evaluated ranges (1.5 dS m^{-1}).

- *Pratylenchulus* and *Rotylenchus* populations increased as soil pH decreased (more acidic soils), whereas for Meloidogyne it was the opposite (data not presented).

- In general, *Meloidogyne* and *Rotylenchus* species were sensitive to the soil physical properties, but not Partylenchulus.

- Cotton productivity decreased with soil penetration resistance increasing and as sand content increases.

REFERENCES

NAIME, J.M., C.M.P. VAZ, A. MACEDO, 2001. Automated soil particle analyzer based on gamma ray attenuation. Computers and Electronics in Agriculture, 31:295-304
VAZ, C.M.P., J.M. NAIME, A. MACEDO, 1999. Soil particle size fractions determined by gamma-ray attenuation. Soil Science, 164(6):403-410
VAZ, C.M.P., J.M. MANIEIRI, I.C. de MARIA, M. TULLER, 2011. Modeling and correction of soil penetration resistance for varying soil water content. Geoderma, 166(1):92-101