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Thio Bouma, Bazongo Pascal, Wonni Issa & Kiemdé Salam

Abdoulaye TOGUYENI University

INTRODUCTION

Agriculture employs more than 80% of the population of Burkina Faso and contributes nearly 40% to the Gross Domestic Product (GDP). rainfed agriculture and occupy an important place because the crop employs nearly 4 million people and contributes more than 4% to GDP and about 14% of export earnings in recent years (AICB (2023a). The area sown in 2016-2017 are estimated at nearly 740,000 ha, and the production was estimated at nearly 683,000 tons of seed cotton with relatively low yields of less than one ton per hectare (AICB (2023b). The cotton sector has experienced a significant decline in recent years producing 407,308 tons with yields of 655 kg/ha during the 2022-2023 agricultural season (AICB (2008). This situation can be explained, among other things, by uncertain climatic conditions (rainfall and temperature) and damage due to crop pests (AICB (2008). Finally, the intensification of agricultural production in the cotton-growing area has favored the development of pests and diseases and the destruction of the many beneficial auxiliary organisms present in the soil (Berimey (2012). Indeed, the cotton plant is attacked by many pests, including plant-parasitic nematodes, which is observed at high population levels in the country's main Cotton-growing areas.

Keywords: NA

Classification: LCC Code: SB608.N4, SB608.C8, QL391.N4

Language: English

Great Britain Journals Press

LJP Copyright ID: 925617
Print ISSN: 2631-8490
Online ISSN: 2631-8504

London Journal of Research in Science: Natural & Formal

Volume 25 | Issue 13 | Compilation 1.0

Survey of Parasitic Nematodes Associated with Cotton in Burkina Faso

Thio Bouma[α], Bazongo Pascal,[σ] Wonni Issa[ρ] & Kiemdé Salam[ω]

Author α ρ ω: Institute of Environment and Agricultural Research (INERA), Farako-Ba Station. BP 910, Bobo-Dioulasso, Burkina Faso.
σ: Yembila Abdoulaye TOGUYENI University (University of Fada N'Gourma), High Institute for Sustainable Development, BP: 54. Fada N'Gourma, Burkina Faso.

I. INTRODUCTION

Agriculture employs more than 80% of the population of Burkina Faso and contributes nearly 40% to the Gross Domestic Product (GDP). rainfed agriculture and occupy an important place because the crop employs nearly 4 million people and contributes more than 4% to GDP and about 14% of export earnings in recent years (AICB (2023a). The area sown in 2016-2017 are estimated at nearly 740,000 ha, and the production was estimated at nearly 683,000 tons of seed cotton with relatively low yields of less than one ton per hectare (AICB (2023b). The cotton sector has experienced a significant decline in recent years producing 407,308 tons with yields of 655 kg/ha during the 2022-2023 agricultural season (AICB (2008). This situation can be explained, among other things, by uncertain climatic conditions (rainfall and temperature) and damage due to crop pests (AICB (2008). Finally, the intensification of agricultural production in the cotton-growing area has favored the development of pests and diseases and the destruction of the many beneficial auxiliary organisms present in the soil (Berimey (2012). Indeed, the cotton plant is attacked by many pests, including plant-parasitic nematodes, which is observed at high population levels in the country's main Cotton-growing areas. However, significant losses due to this group of pests, and particularly to the root-knot nematodes *Meloidogyne incognita*, is reported on cotton throughout the world (Taylor et al. (1982), Pages (1983), Sawadogo et al. (1998-1999) have noted that the genera *Helicotylenchus, Pratylenchus, Hoplolaimus* and *Rotylenchulus* are considered as the most important and likely to cause yield losses on Cotton. *Meloidogyne incognita* and *Rotylenchulus reniformis* are considered to be the major pests limiting Cotton yield in the United States of America (Lawrence (2022). Cotton is known to be heavily attacked by the root-knot nematodes *Meloidogyne* spp. with yield losses of up to 60% for population densities of 1,000 nematodes/100 cm^3 of soil estimated as a threshold of harmfulness (Blasingame et al. (2002), Doshi et al. (2010), Moore and Lawrence (2012). *M. incognita* is one of the world's most loss nematodes, with estimated annual losses of US$100 billion on crops (Wram and Zasada (2019) and US$283 million on Cotton in the United States of America (Forghani and Hajihassani (2020), Lawrence (2022). The aim of the inventory is to identify parasitic nematodes associated with cotton in order to develop appropriate control methods with a view to improving productivity and production of Cotton.

II. MATERIALS AND METHODS

The inventory of cotton parasitic nematodes concerns the three cotton-growing areas represented by the Société des Fibres Textiles (SOFITEX), the Société Cotonnière du Gourma (SOCOMA) and Faso Coton, during the 2017-2018 agricultural campaign (Map 1).

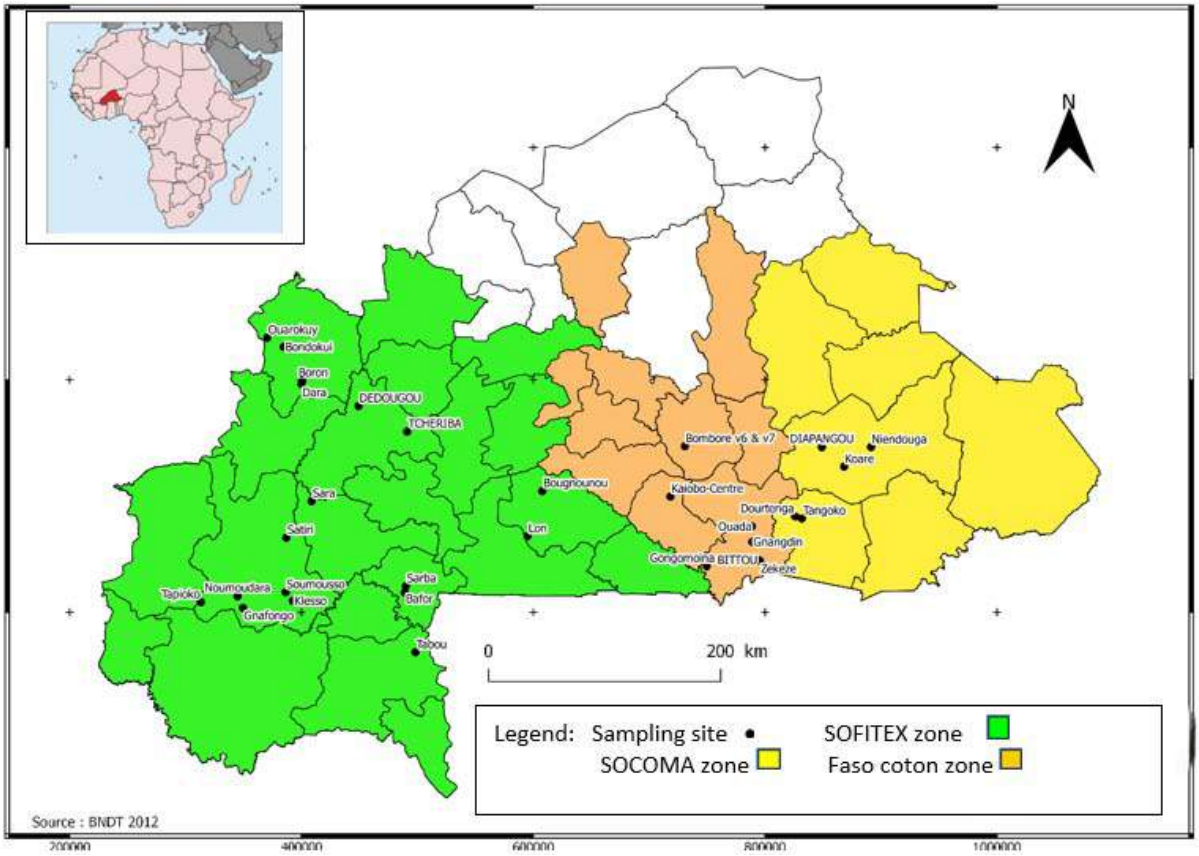

Fig. 1: Cotton-growing areas of Burkina Faso

The composite sample consisted of 10 samples of roots and adjoining soils in 0 - 20 cm horizon is collected for seed production fields at the capsulation-early maturity stage. 94 samples of roots and adjoining soils is taken and nematological analyses is carried out at the Nematology Laboratory of the Institute of Environment and Agricultural Research (INERA), Farako-Bâ/Bobo-Dioulasso Station. Nematodes is extracted from 250 cubic centimeters (cc) of soil using the (Seinhorst (1962) elutriator method. The nematodes present in the roots is extracted by the sprinkler method (Seinhorst (1950). Population densities is expressed in terms of number of nematodes/dm3 of soil and number of nematodes/g of roots. The morpho-biometric identification of the nematodes was done according to the identification key of (Mai and Lyon (1975). The data analysis focused on the frequency and abundance of parasitic nematode populations recorded. Frequency is calculated as the total Number of samples where the nematode is present divided by the total Number of samples collected multiplied by 100.

$$\textbf{Frequency F} = \frac{e}{n} \times 100$$

e = Number of samples where the nematode considered is present

n = Total Number of samples

Abundance is calculated by the sum of the samples where the nematode divide by the number of samples.

$$\textbf{Abundance A} = \frac{\sum Xi}{n}$$

Xi = Number of individuals of the nematode per dm3 of soil or per gram of roots

n = Number of samples where the nematode under consideration is present

The importance of the main genera of nematodes parasitic on Cotton is determined according to the method of (Fortuner and Merny (1973), which proposed that a nematode is said to be abundant in the soil, if the abundance is ≥ 200 individuals/dm3 of soil and in the roots if the abundance is ≥ 20 individuals/g of roots. A nematode is said to be share in soil or roots, if it is observing in at least 30% of the samples. Statistical analyses is performed with the XLSTAT 2016 software and the separation of the means according to the Newman Keuls test.

III. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Frequency and abundance of observed nematodes

About ten genera of parasitic nematodes are associated with the cotton plant and represented by *Meloidogyne, Pratylenchus, Helicotylenchus, Scutellonema, Tylenchorhynchus, Telotylenchus, Rotylenchulus, Xiphinema, Criconemella* and *Paratrichodorus* (Table 1).

3.1.2 Nematodes extracted from soil samples

Helicotylenchus, Scutellonema, Tylenchorhynchus, Pratylenchus and *Telotylenchus* are frequent and abundant with frequencies between 100% and 36% for densities varying between 7,328 and 1,360 nematodes/dm³ of soil. According to the method of (Fortuner and Merny (1973), this group of nematodes can be capitalized as the most important on Cotton and likely to cause significant damage (Frequency >30% and Abundance <200 nematodes/dm³ of soil). *Xiphinema, Rotylenchulus* and *Meloidogyne* are infrequent (<30%) but abundant (<200 nematodes/soil dm³) and their presence may be associated with particular environmental conditions (soil texture, humidity, etc.). *Paratrichodorus Minor* and *Criconemella onoensis* are uncommon (<30%) and not very abundant (<200 nematodes/dm³ of soil) and can be considered as little damage to Cotton.

3.1.3 Nematodes extracted from the roots

Pratylenchus is observed in 73% of the samples with root population densities of 30 nematodes/g of roots; This nematode is viewed to be frequent and abundant (frequency >30 and abundance >30%) and can be considered as a parasite of Cotton according to the method of (Mai and Lyon (1975). The nematodes *Scutellonema* and *Helicotylenchus* are infrequent (>30%) and scarce (<20 nematodes/g of roots). This group of nematodes is considered mainly as ectoparasites and therefore little observed in the roots.

3.1.4 Nematode community densities by cotton-growing areas and prospecting localities

The nematode samples is taken in the 3 cotton-growing areas represented by the cotton companies SOFITEX (18 sites), SOCOMA (7 sites) and Faso Coton (7 sites).

The high population densities of *Pratylenchus* is observed in the SOFITEX zone with 1,029 nematodes/dm³ of soil with the highest densities observed on the Sarba site with 2,960 nematodes/dm³ of soil (P<0.05). Respective population densities of 350 and 187 individuals/dm³ of soil are observed, respectively in the SOCOMA and Faso Coton zones. The cotton-growing area of SOCOMA appears to be more infested with Helicotylenchus (1,0408 individuals/dm3 soil), *Scutellonema* (1,546/dm³ soil), *Tylenchorhynchus* (243/dm³ soil) and Telotylenchus (264/dm³ soil) (P<0.05), representing, with *Pratylenchus*, the group of nematodes likely to cause significant damage to cotton. The SOFITEX zone appears to be less infested for these nematodes, compared to the Faso Coton zone, except for *Helicotylenchus,* with an average density of 7,239 individuals/dm³ of soil. The highest population

densities of Helicotylenchus were observed at the Dedougou site with 29,600 individuals/dm³ of soil in the SOFITEX zone and at the Gongongwana/Pama site with 25,280 individuals/dm³ of soil in the Faso cotton zone. The total population densities of all parasitic nematodes observed in soil samples are higher in the SOCOMA zone, with 12,911 individuals/dm³ of soil ($P<0.05$). In the SOFITEX zone, the total soil populations are estimated at 9,583 nematodes/dm3 of soil and 6,624/dm³ of soil in the Faso Coton zone. Total populations of root-extracted nematodes are relatively low across cotton-growing areas with less than 10 nematodes/g of roots.

Table 1: Frequency and densities of nematode communities observed on cotton

Nematode genera	Frequency	Minimum	Maximum	Average	standard error
Extracted from soils	(%)	Nber N/dm³	Nber N/dm³	Nber N/dm³	Nber N/dm³
Helicotylenchus	100	40	37,040	7,328	± 781
Scutellonema	100	60	4,800	1,133	± 107
Tylenchorhynchus	75	0	7,560	464	± 117
Pratylenchus	71	0	4,940	584	± 93
Telotylenchus	36	0	1,360	121	± 27
Xiphinema	26	0	380	25	± 781
Rotylenchulus	19	0	1,460	41	± 18
Meloidogyne	13	0	200	7	± 3
Paratrichodorus	9	0	120	6	± 2
Criconemella	3	0	20	1	± 0
Extracted from roots	(%)	Nber N/g	Nber N/g	Nber N/g	Nber N/g
Pratylenchus	73	0	30	3	± 1
Scutellonema	14	0	7	1	± 0
Helicotylenchus	27	0	14	1	± 0

Legend: Nber/dm³: number of nematodes/dm³ of soil; Nber/g: number of nematodes/g of roots

Table 2: Population densities of the leading parasitic nematodes according to cotton-growing areas and sampling sites

Cotton-Zone	Location	Pray/dm³	Heli/dm³	Scute/dm³	Tyle/dm³	Telo/dm³	Tot/dm³	Tot/grac.
SOFITEX	Satiri	4,680	3,360	680	560	0	9,280	12
	Sara	1,160	10,030	650	180	0	12,070	5
	Bondokuy	1,180	3,755	1,030	55	0	6,140	7
	Ouarkoye	1,193	4,267	587	67	0	6,307	5
	Dédougou	0	29,600	800	80	0	30,560	1
	Dara	847	3,167	733	207	0	4,960	1
	Boron	700	10,640	1,180	180	0	12,940	1
	Tcheriba	900	6,040	340	340	0	7,640	2
	Bognounou	380	3,180	880	100	0	4,620	3
	Lon	1,345	4,250	915	90	25	6,675	7
	Tabou	1,090	3,390	1,273	170	203	6,243	2
	Sarba	2,960	10,920	1,720	40	280	16,600	4
	Bafor	45	6,290	1,280	170	0	7,810	4
	Klesso	1,320	3,140	420	0	120	5,160	4
	Soumousso	260	5,380	1,820	180	260	7,940	7
	Gnafogo	150	8,720	1,030	60	110	10,110	1

	Noumoudara	193	5,527	733	53	20	6,600	3
	Tapoko	120	8,640	1,860	20	0	10,840	1
Average		1,029	7,239	996	142	57	9,583	4
SOCOMA	Kouaré	749	7,832	335	886	349	10,194	7
	Niendouga	270	7,410	590	80	460	8,830	26
	Gongongwana	25	25,280	2,205	45	435	28,560	1
	Diapangou	80	17,100	1,330	260	20	18,830	4
	Dourtenga	327	1,660	1,393	147	60	3,593	2
	Tangonko	7	973	3,800	173	433	5,400	9
	Koghin	990	12,600	1,170	110	90	14,970	3
Average		350	10,408	1,546	243	264	12,911	7
Faso coton	Gonbloré V6	67	1,567	247	4,793	0	6,680	1
	Gonbloré V7	0	1,560	100	4,640	0	6,300	0
	Gnangdin	0	7,707	2,107	7	0	9,820	1
	Bittou	100	3,090	870	150	70	4,280	1
	Zekeze	900	5,967	1,740	20	0	8,647	2
	Ouadav1	200	260	3,560	0	0	4,020	1
	Kaïbo Sud	45	4835	1,085	648	8	6,620	1
Everage		187	3,569	1,387	1,465	11	6,624	1

Legend: Praty: Pratylenchus; Heli: Helicotylenchus; Scute: Scutellonema

Tyle: Tylenchorhynchus; Telo: Telotylenchus; Tot: Total in soil and roots

3.2 Discussion

The results of this study, which covered all major areas of Burkina Faso, are in line with the work of (Sawadogo et al. (1998-1999) which had identified *Helicotylenchus, Pratylenchus, Hoplolaimus, Tylenchorhynchus, Rotylenchulus* and *Meloidogyne* as the main nematodes associated with the cotton-maize-sorghum cropping system in the cotton basin of the Houndé zone in western Burkina Faso. This study did not make it possible to rule on the pathogenicity of the root-knot nematodes *Meloidogyne* spp. on cotton, unlike several studies conducted in the primary production areas of the United States and South Africa where *Meloidogyne incognita* race 3, is known to cause significant damage (Starr et al. (2005). *M. incognita* (Cophoid and white), Chitwood, and *Rotylenchulus reniformis* (Linford and Oliveira) are identified as major yield-limiting pests of upland cotton (Moore and Lawrence (2013). *M. incognita* is considered to be the nematode causing yield losses on a global scale on crop plants Wram and Zasada (2019). Our research in the main cotton-growing areas of Burkina Faso shows that the root-knot nematodes *Meloidogyne* spp. do not constitute a significant problem because they are observed at low frequencies (13%) and at average densities of 7 nematodes/dm^3 of soil. Studies on the pathovars of *Meloidogyne incognita*, recognized as the dominant species, would make it possible to decide on its pathogenicity. However, *M. acronea*, known to be a parasite on cotton and, present in South Africa and Malawi, is not present in Burkina Faso CABI (2019). The present study showed a predominance of the lesion nematode *Pratylenchus brachyurus* in the SOFITEX zone, a former cotton production area in western Burkina Faso ($P<0.05$) where cotton is generally in rotation with maize, the preferred host plant of this group of nematodes. Its abundance in this area confirms its adaptation to this culture. The lesion nematode *Pratylenchus* is known to cause significant damage to cotton and (Gay and Bird (1973) have shown that the presence of *P. brachyurus* would induce a decrease in *Meloidogyne incognita* populations. Similar competition has been observed between *Meloidogyne incognita* and *Rotylenchulus reniformis*. As for the kidney-shaped nematode *Rotylenchulus reniformis*, it is known as an important pest of cotton throughout the world mainly, in soils with a high silt/clay content (Starr et al. (2005), Gordon et al. (2022). This species may pose a

danger to cotton in Burkina Faso is where it is observed in high populations but limited to a few sites with 1,460 nematodes/dm3 of soil. The species has experienced a substantial expansion in the southern United States, causing significant damage and losses to cotton (Bridge (1992), Lawrence (2022). Several ectoparasitic nematodes is identified on Cotton, mainly in the Central, Cotton-producing states of the United States of America, but their pathogenicity has not been demonstrated. These are mostly *Helicotylenchus, Paratrichodorus minor, Tylenchorhynchus* spp. but with very low population levels (less than 100 nematodes/100cm^3 of soil or less than 10/dm^3 of soil) (Bridge (1992), Wrather et al. (1992). On the other hand, other studies have shown high densities of these groups of nematodes, which are often considered secondary but likely to cause yield losses on cotton (Singh and Mishra (2016), Schumacher et al. (2020). The high populations of the nematodes H*elicotylenchus, Scutellonema, Tylenchorhynchus* and *Telotylenchus annulatus* observed on cotton can cause significant damage to this crop under the conditions of Burkina Faso (McLean and Lawrence (2003).

IV. CONCLUSION

About ten genera of parasitic nematodes are associated with cotton in Burkina Faso, seven (7) of which are likely to cause yield losses on cotton in Burkina Faso. *Meloidogyne, Pratylenchus, Helicotylenchus, Scutellonema, Rotylenchulus, Tylenchorhynchus* and *Telotylenchus*. The nematodes *Meloidogyne* and *Rotylenchulus*, known as major cotton pests throughout the world, have been observed at low frequencies but often at high population levels, suggesting their development in particular soil and soil moisture conditions. In perspective, it will be a question of identifying the existence of races of nematodes belonging to the species *Meloidogyne javanica* and *M. incognita* by molecular characterization that can attack cotton in Burkina Faso.

Competing Interests

Authors have declared that no competing interests exist.

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