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Nematoides da cana-de-açúcar: perspectiva global

Nematodes of sugarcane: global perspective

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Sugarcane production globally

Sugarcane (*Saccharum* species hybrid) is a tall, perennial grass crop grown for food, fibre and fuel. Sugarcane is predominantly grown for the extraction and production of sugar, but other useful by-products (such as molasses, ethanol, filtercake, bagasse, fly-ash) are also produced during the sugar extraction process. Globally, 130 countries produce either sugarcane or sugar beet, with ten countries producing sugar from both sugarcane and sugar beet (1). However, in terms of production, sugarcane, accounts for approximately 80% of global sugar production (1). The majority of sugarcane is grown in tropical and subtropical countries with high average temperatures, lots of sunlight and good annual rainfall. Brazil is the top sugarcane growing country in the world, growing sugarcane on ~10 million hectares, followed by India, China, Thailand and Pakistan (Top 5 countries) accounting for ~75% of total world production (2). Other sugarcane growing countries include: Mexico, Colombia, Indonesia, Philippines, USA, Australia, South Africa (3).

Nematodes associated with sugarcane

The first record of the presence of nematodes on sugarcane was in 1885 by Treub in Java. In 1906, Cobb showed that root-knot (*Meloidogyne*) and burrowing (*Radopholus*) nematodes caused injury to sugarcane roots (4). Later, species of *Pratylenchus sacchari* and *Helicotylenchus dihystera* were found associated with sugarcane roots. In 1953, species of *Meloidogyne* and *Pratylenchus* were associated with root rot in Lousiana. Studies in Hawaii found eight genera of plant-parasitic nematodes: *Helicotylenchus* sp., *Melodoigyne* sp., *Pratylenchus* sp., *Paratrichodorus* sp., *Xiphinema* sp., *Radopholus* sp., *Paratylenchus* sp. and *Criconema* sp. (5). In Southern Africa, approximately 77 species of Tylenchida and Dorylaimida have been found associated with sugarcane (6). The frequency and occurrrence of different plant-parasitic nematodes associated with sugarcane can be found in more detail in Cadet and

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Spaull (7). Ramouthar and Bhuiyan (8) talk about the nematode diversity in sugarcane being greater than in most other cultivated crops. They mention more than 317 species of 48 genera found in the roots and rhizosphere around sugarcane. These authors also propose nematode threshold values above which sugarcane growth is reduced. Globally, the three main nematode species affecting the majority of sugarcane growing regions are *Pratylenchus zeae, Meloidogyne javanica* and *Meloidogyne incognita*. Other genera do occur but their occurrence is more erratic and less likely to result in as much yield loss as these three species.

Effect of nematodes on sugarcane growth and yield

The yield of sugarcane is a function of the number, length and diameter of stalks which all affect the sucrose (sugar) yield. To understand the effects of nematodes on sugarcane growth and yield, it is important to understand the root system of this crop. Sugarcane being a grass species does not form a tap root, but rather fibrous and lateral roots which differ depending on the crop stage. In the plant (first) crop, the initial roots that emerge from the planted sett (stalk) are called 'sett roots' which support the newly emerging shoots with nutrients and moisture. These are later replaced by thicker, fleshier and less branched 'shoot roots' which eventually replace the sett roots and become the dominant root system. After sugarcane is harvested, the next crop produces a new set of 'shoot roots' that replace that of the plant crop. Plant-parasitic nematodes can infect both types of root systems at different times of the crop and affect plant growth in different ways (9, 15).

Estimates of yield loss due to nematodes varies. Globally, Sasser and Freckman (10) estimated a few years back that the yield loss in sugarcane was 15.3%, although this can vary by country where, for example, the USA estimates yield loss to be 4%, South Africa 8% (11), Australia 9%, Cote d'Ivoire 11% (9). This has recently been updated for ratoon crops with an average of 8% for Burkina Faso and Cote d'Ivoire, 12% for South Africa and 14% for Australia and Brazil, depending on the number and type of ratoon crop (8). Yield loss in sugarcane can be seen as reduced yield in each crop grown, but also as a reduction in the number of subsqeuent high-yielding ratoon crops. These yield losses are most likely very conservative (economical) values as repeated applications of nematicides on a monthly basis has shown that crop loss is substantially greater than previously thought (12).

Above-ground symptoms of nematode damage can include: chlorosis, stunting of internodes, wilting (particularly during periods of high transpiration and/or water stress), patchy growth, spiky leaves, reduced tillering thin stalks (13). Below-ground symptoms are a bit more diagnostic and can include sparse root system and root stunting (typically by species of *Xiphinema* and *Paratrichodorus*) and galls (typically produced by species of *Meloidogyne*) (14), red/reddish-purple/brown lesions (associated with *Pratylenchus* species) (8).

Management Practices

Once nematodes are present, it is nearly impossible to eradicate them. The next best solution is to manage the nematode problem. A variety of recommended solutions for sugarcane farmers include: use of fumigant and non-fumigant chemical nematicides; biological control agents; planting tolerant/resistant cultivars; planting during the cooler periods (when nematode activity is reduced); applying various types of organic amendments in the furrow at planting, or over the field during ratoon crops; planting nematode resistant and/or trap crops in-between sugarcane cycles or as intercrops during sugarcane crops; and use of various physical control measures (7, 8, 9, 14, 15 to name just a few references). This is further complicated by the two different cropping systems (plant crop and ratoon crops) that the sugarcane crop has which affects placement, proximity to the roots and nematode species present and the associated damage they cause (15).

However, more recent research instead of focusing on individual nematode genera and species has focused more on the nematode communities and managing the composition and interactions within these communities. Cadet and Spaull (7) show survey data from eight sugarcane-growing countries that show that the minimum number of genera in soil samples range from 1 (lowest) to 12 (highest) with average number of genera per sample ranging from 3.2 in Papua New Guinea to 7.9 in Chad. They hypothesize that the pathogenecity of the community depends not on the total number of PPNs, but rather on the number of pathogenic individuals. Additionally, the pathogenecity of the community is inversely proportional to the diversity of the PPNs and the balance between species making up that community.

Sugarcane research

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A Google Scholar search for publications mentioning "nematodes of sugarcane" found 39 publications (from 1981-1990), 29 (from 1991-2000), 55 (from 2001-2010) and 31 (from 2011-2019) equating to ~154 publications on nematodes of this crop in the last 38 years. This is approximately half of the total 277 publications that Google Scholar could find for the last 100 years (from 1919-2019). Admitedly, this many not be an entirely comprehensive collection of all possible papers ever published, but it does give an indication of the amount of work published on this topic. In comparison to Nematology research on other crops (see Table below), sugarcane research is in the middle range, with higher research output than crops such as citrus, coffee, cotton, pineapple, tea and lower output than crops such as rice, soybeans, vegetables, banana/plantains and potatoes.

Crop	Potato	Banana/plantains	Vegetables	Soybeans	Rice	Sugarcane	Maize/Corn	Tobacco	Citrus	Coffee	Cotton	Pineapple	Tea
No. papers	1050	485	408	310	305	277	275	256	187	153	84	68	61

Although much has been discovered relating to nematodes of sugarcane in the last 100 years, still more work needs to be done to better understood the complex interactions between this crop and the many nematodes that are associated with it.

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