Pathogenic action of nematodes on irrigated sugar-cane

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Summary

Observations on tillering and the build-up of nematode populations on sugar-cane both in light (sandy) and heavy (clayey) soils may give information on how nematodes reduce yields. It has been shown by plant physiologists that the emergence of stems after planting is directly related to the development of the roots on the setts. The authors have observed that nematodes only multiply abundantly on the roots produced by the sett during the emergence of the stem. The attacks on these roots lead to a reduction in the number of stems, which is known to be directly correlated to yield reduction. In sandy soils, nematodes heavily attack sett-roots immediately, thus disturbing primary and secondary tillering, but in heavy clay soils nematode attacks are slower and only interfere with secondary tillering, this explains why, on heavy soils, yield reduction is generally less marked although nematode populations are often higher. These observations may also indicate what effect nematodes will have ony ields in the first weeks after planting. The authors conclude that : *i*) research concerning tolerant sugar-cane cultivars should aim at selecting those with a large, quick developing and rapidly renewed root system on setts, *ii*) nematicides should be selected for their ability to control early nematode attacks.

Résumé

Mécanisme de l'action pathogène des nématodes sur la canne à sucre en culture irriguée

Il est connu que l'effet des traitements nématicides sur canne à sucre est beaucoup plus faible en terrain lourd (argileux) qu'en terrain léger (sableux). Il a été également constaté qu'en terrain lourd les réductions de récolte causées par les nématodes étaient généralement plus faibles bien que les populations de nématodes y soient souvent plus élevées qu'en terrain léger. Enfin il a été antérieurement constaté que les pertes de récolte étaient liées à un déficit du tallage et les physiologistes ont établi que la sortie des tiges après plantation était liée directement au développement des racines de bouture.

Dans le but de mieux connaitre le mécanisme de l'action pathogène des nématodes sur la canne à sucre et plus particulièrement de comprendre l'influence du type de sol sur cette action, des observations concernant l'élaboration des populations de nématodes et le tallage de la canne à sucre ont été faites, en Côte d'Ivoire et en Haute-Volta, à la fois sur sol léger et lourd. Les auteurs ont observé que les nématodes parasites ne se multipliaient abondamment, pendant l'émission des tiges, que sur les racines issues de la bouture. Les attaques sur ces racines conduisent à une notable réduction du nombre des tiges. Dans les sols sableux, ces attaques sont précoces et perturbent à la fois les tallages primaire et secondaire. Au contraire, dans les sols lourds, ces attaques sont progressives et ne perturbent que le tallage secondaire. Ceci explique que les dégats causés par les nématodes soient généralement moins importants en sol lourd. Ces observations ont également montré que l'action pathogène des nématodes ne s'exerçait que pendant les toutes premières semaines qui suivent la plantation. Les auteurs concluent que : *i*) la recherche de cultivars tolérants aux nématodes devrait s'orienter vers ceux possèdant un système de racines de boutures abondant, à développement et à renouvellement rapides, *ii*) les nématicides à appliquer devraient être choisis non pour leur rémanence mais pour leur capacité de libérer rapidement leur matière active pour contrecarrer, surtout en sol sableux, les attaques précoces de nématodes sur les racines de boutures.

In nematicide trials against nematodes in irrigated sugar-cane cropped annually in Upper-Volta and Ivory Coast, it was observed that the most effective treatments (DBCP, aldicarb or carbofuran) lead to the same yield level, about 100 tons/ha ; yield increase compared with the control was mainly due to an increase in tillering (Cadet & Merny, 1978). However, marked differences in yield have been observed : In the Ivory Coast, tillering reduction due to the action of nematodes is less than in Upper-Volta, although nematode populations extracted from soil and roots are higher. Since in both areas climatic and farming conditions are similar and the composition of the nematode fauna is almost the same, the differences observed in the action of nematodes on sugar cane can mainly be attributed to differences in soil composition which is light and sandy in Upper-Volta and more clayey in the Ivory Coast. Moreover, in plots where maximum yield increase has been obtained by treatments with non-fumigant nematicides, nematode populations observed at the end of the cropping season are often higher than in the control plots.

The purpose of the present study was to elucidate *i*) the incidence of clay content of soils on the pathogenicity of nematodes on sugar-cane and *ii*) how do nematodes decrease sugar-cane yields.

Material and methods

Between 1975 and 1980, several nematicide trials have been done, some in the light sandy soil of Upper-Volta and others in the heavy soils of the Ivory Coast. The plots were 100 m² and contained six rows 11.11 m long and 1.5 m apart. Two trials have been made in the Ivory Coast and three in Upper-Volta. In a trial, each treatment was replicated six times. The best treatments, which, in the same time, suppressed or reduced nematode populations and increased tillering were, in Upper-Volta DBCP or aldicarb and in the Ivory Coast carbofuran. In this study, plots having received these treatments are referred to as « without nematodes » and untreated control plots as « with nematodes ». Results are presented as averages of eighteen samples in « light soils » and twelve in « heavy soils ».

Soils are classified as light or heavy according to how much of their content is in the fine fraction (< 50 µm). Soil granulometric characteristics of the plots under study are given in Table 1.

Table 1

Granulometry of light and heavy soils (%)
(organic matter content is 1.2 % in light soil and 1.6 % in heavy soil)

SOIL FRACTIONS	LIGHT SOIL 3 replications			mean	HEAVY SOIL 2 replicat.		mean
clay (0-2 µm)	3.0	4.0	2.8		20.8	20.5	
fine silt (2-20 µm)	2.5	4.8	3.8	11.3	26.3	14.8	54.0
coarse silt (20-50 µm)	3.9	5.3	3.8		14.6	11.0	
fine sand (50-200 µm)	44.9	39.0	47.0		24.8	39.0	
coarse sand (200-2 000 µm)	45.7	47.1	42.8	88.8	12.1	22.0	44.9

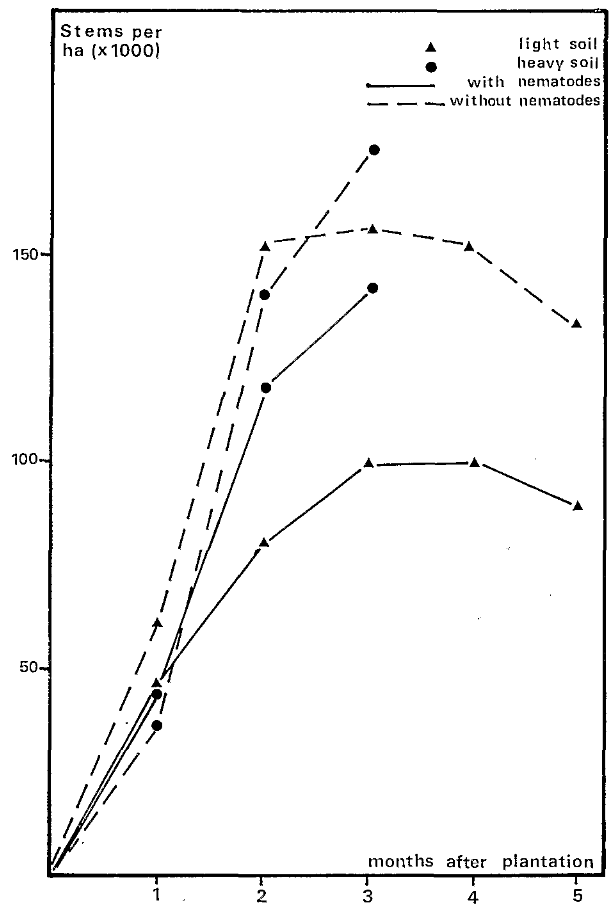

Fig. 1. Dynamics of sugar-cane tillering with or without nematodes in light or heavy soil.

Plant and soil samples were as follows : *i*) on one- to three-month-old seedlings grown from setts (sett seedlings) the whole plant was up-rooted, the maximum quantity of roots being carefully collected; *ii*) on older canes, a portion of soil was collected, near the base of the plant with roots in the sample (stem-roots).

Each sample was composed of two subsamples collected in two different rows of the same plot and mixed. Nematodes were extracted from soil by elutriation and from roots in a mist chamber (Seinhorst, 1950 ; 1962). Nematodes were counted separately in roots of sett seedlings (sett-roots) and in stem-roots. In each case, roots were separated from stems at the stem base. Tillers were counted every month in two 11.11 m rows.

In both areas, observations were made on the same cane cultivar NCO 376.

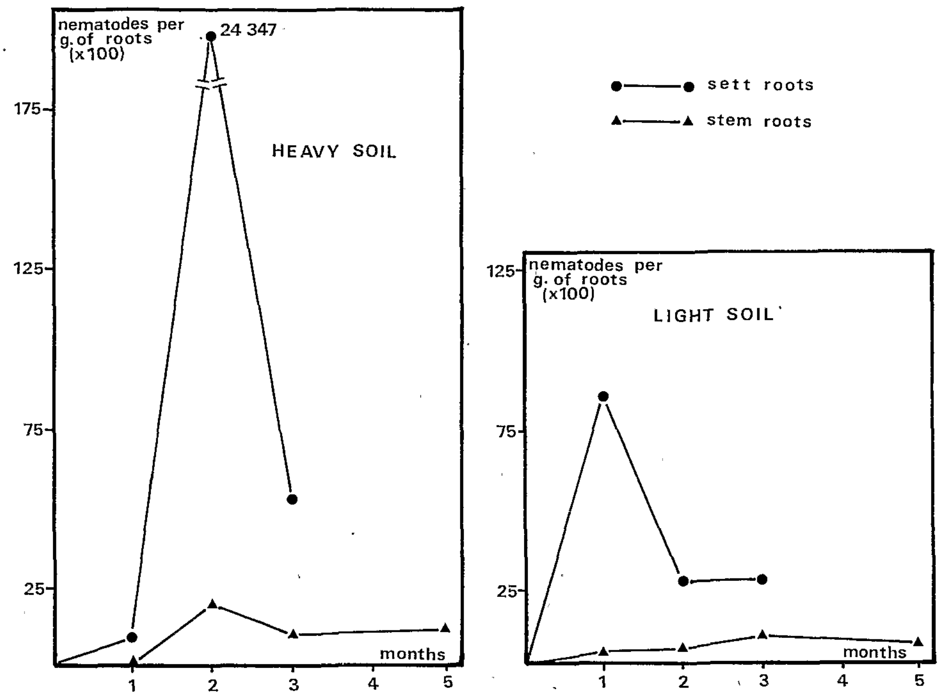

Fig. 2. Evolution of nematode populations in cutting- and stalk-roots in plots with nematodes in heavy soil (left) or light soil (right).

Results

Tillering

The evolution of tillering in light or heavy soil, with and without nematodes is given in Figure 1. Tillering was roughly the same in nematode-free plots in both types of soil. The presence of nematodes reduced tillering much more in light than in heavy soil.

Changes in nematode population on the roots

In light soil, the nematodes extracted from roots belonged mainly to four genera : *Meloidogyne*, *Pratylenchus*, *Hoplolaimus* and *Paratylenchus* and in heavy soil to only three genera : *Meloidogyne*, *Pratylenchus* and *Scutellonema*.

Figure 2 shows the results of monthly observations concerning populations extracted from roots of sett seedlings and stem-roots in plots « with nematodes ». During the first three months, populations were high to very high in roots whereas, during the whole period of the observations, they were low in stem-roots. It is noteworthy that maximum populations of nematodes per gram of root were about three times higher in heavy than in light soil, but maximum nematode numbers are reached after one month in the light soil compared to two in heavy soil.

Discussion

Cadet and Merny (1978) have observed that nematodes reduced sugar-cane yield by reducing tillering, no significant difference being observed between treated and untreated plots for other parameters such as lengths or diameters of canes.

To help understand the pathogenic action of nematodes on sugar-cane and the influence of soil type in host-parasite relationships, observations were made on the development of roots after sugar-cane plantation. They confirmed reports by Van Dillewijn (1952) that shortly after plantation roots arise from each node of the sett (sett-roots) and that these roots disappear after three months and are followed by two root-systems arising from the newly formed stems (primary and secondary stem-roots) (Fig. 3). He established that tillering is directly dependent on sett-roots developing, tillers failing to arise if sett-roots are mechanically destroyed.

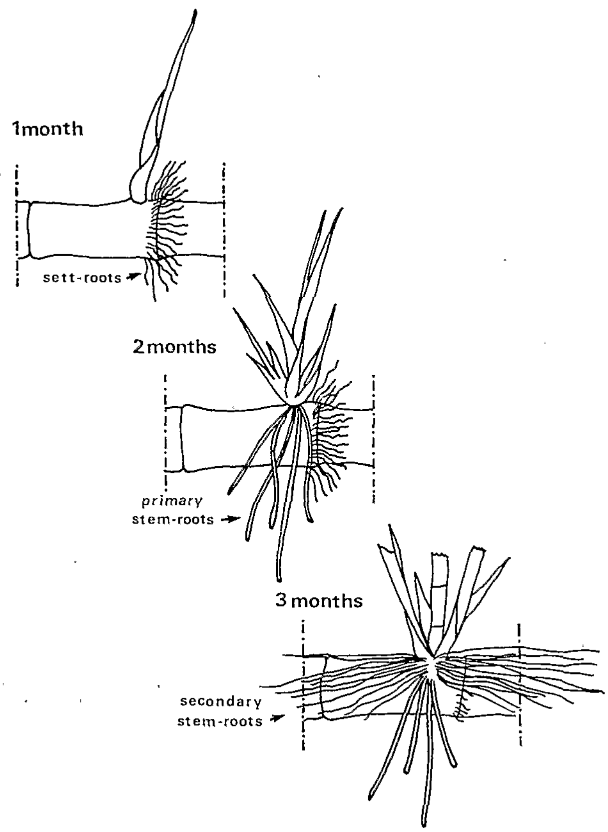

Fig. 3. Emergence of cutting-roots, primary stalk-roots and secondary stalk-roots during the first three months after planting.

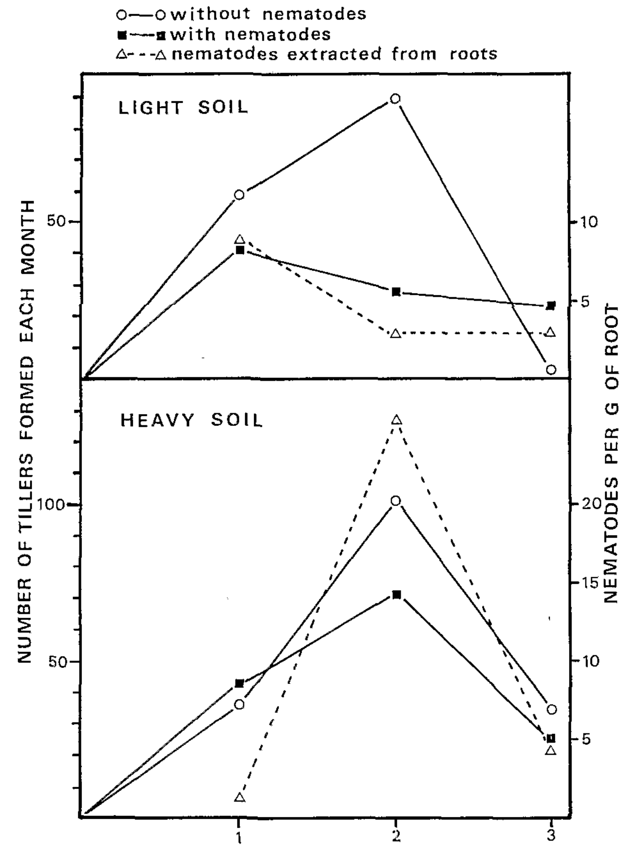

Fig. 4. Monthly emergence of tillers and nematode populations extracted from root during the three months following plantation of sugar-cane.

Figure 4 shows, for each type of soil, the number of tillers formed each month during the first three-month period and the nematode populations extracted from roots.

In light soil at the end of the first month, nematode populations were well developed and a deficit in tillering (— 17 000 stalks/ha) was already observed in untreated plots. During the second month, nematode populations decreased because the sett-root system was largely destroyed and the deficit in tillering in plots with nematodes was very large : 28 000 tillers/ha compared to 90 000 in nematode-free plots (— 62 000/ha). During the third month, nematode populations remained low and, suprisingly, more tillers were formed in untreated than in treated plots, which can be explained by the fact that development of some tillers had only been delayed in the previous month.

In the first month, in heavy soil, tillering was slightly higher in plots with nematodes but this may be due to slight phytotoxicity caused by nematicides in the « nematode free » plots as nematode populations remained very low. In the second month tillering in untreated plots decreased (— 29 000 stalks/ha) and nematode populations became very high but during the third month tillering was almost the same in treated and untreated plots and nematode populations decreased rapidly. The reduction in tillering was low because in heavy soil nematode populations increased later and by the time they attained significant levels, the sett-root system was well established and tillering had already started.

It is evident that the differences observed between light and heavy soil are due to the fact that in light soil nematode populations built up rapidly and the sett-roots were destroyed as soon as they appeared, whereas in heavy soil nematode populations built up slowly and the sett-root system had time to develop normally before being attacked and the tillering reduction remained relatively low. Hence, in light soil, due to quick destruction of the sett-roots, nematode populations decreased rapidly, whereas in heavy soil they reached a much higher level.

Conclusion

These observations indicate that in clayey soil, damages caused by nematodes to sugar-cane are lower than in sandy soil and a fairly good yield level can be maintained even in fields were nematode populations are very high.

They also explain why, in plots treated with non-fumigant nematicides, which generally have a gradual effect on nematode kill and give a limited protection to plants, yield is high and nematode populations become very high. The pathogenic action of nematodes is mainly restricted to the first month after planting so that, when normal tillering has taken place, nematodes can develop freely on stem-roots but have very little effect on the plant.

This indicates that research concerning tolerant sugar-cane cultivars should aim at selecting those with a sett-root system which is particularly abundant and likely to be renewed quickly. In addition, nematicides should not only be selected for their persistance in the soil but for their ability to control early nematode attacks on sett-roots.

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