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0261-2194(95)00125-5

Crop Protection Vol. 15, No. 2, pp. 187–195, 1996

0261-2194/96 $15.00 + 0.00

Use of nematicides to produce yam planting material free of *Scutellonema bradys* in Martinique (French West Indies)

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Coating of yam seed tubers with liquid ethoprophos and cadusafos controlled a root population of *Scutellonema bradys* but did not produce a significant increase in yield. During storage, the yield loss was 10% with healthy tubers but reached 40% with infested tubers; the volume of necrotic tissues being proportional to the rate of infestation. When nematodes were controlled with cadusafos, only 23% of tuber yield was lost compared to 68% in untreated and nematode infested tubers. Seventy per cent of the tubers harvested from the plot treated with cadusafos were free of nematode. When these were cut into 200–230 g pieces, corresponding to seed tubers, 80% of them were healthy whereas only 30% were nematode-free, when pieces of tubers harvested in the non-treated plot were used.

Keywords: Yam; *Scutellonema bradys*; nematicides; West Indies

In the tropical countries where yams are grown, the plant is attacked by phytoparasitic nematodes, most of which belong to the genera *Scutellonema*, *Pratylenchus* and *Meloidogyne*. The growing technique, using pieces of tubers from the previous crop (usually the proximal part), favours the dissemination of pathogens which may infest the new tuber, as well as these nematodes.

Various techniques have been used to remove these parasites, or to reduce their impact on crops:

(i) Nematicide treatments applied at harvest time or during the cycle to improve the yam yield (Adesiyan and Badra, 1982). However, chemicals need to be applied at each cycle, as the nematodes are not eliminated. This situation is hardly compatible with ecological-requirements.

(ii) Heat therapy to kill the nematodes in the planting material (Kermarrec *et al.*, 1991). Although environmentally satisfactory, this method is difficult to implement.

(iii) The use of healthy material obtained either from bulblets or *in vitro* cultures (Degras, 1986). This technique should become accepted in the near future. For the moment, it is handicapped by the cost of producing seed tubers and the existence of many yam 'clones', which are often used for their specific agronomic qualities and taste by small communities reluctant to plant 'artificial' plant material from 'foreign parts'.

To counter the rapid spread of *Scutellonema bradys* on Martinique, it was necessary to develop a transitional method which could be implemented immediately and was compatible with the principles of sustainable, low-input agriculture. To develop this new technique, we based our work on studies in Nigeria and the Antilles (Bridge, 1982; Cadet & Quénéhervé, 1994) and on the behaviour of *S. bradys*, the main yam parasite, which showed that the infection was caused by females of *S. bradys* which moved from the infested seed tubers to the new tubers and other underground parts of the plant via the soil. In other words, it appeared that it was not necessary to destroy physically the nematodes in the seed tuber in order to prevent infestation; one only had to prevent them from coming out and attacking the roots or neo-tuber. To do this, we adapted the coating technique commonly used in banana cultivation (Mateille, Quénéhervé and Topart, 1988), which enables pesticides to be directly applied to plant material.

Materials and methods

The trial was set up on andosol on pumice (25% clay), on a plot of land in northern Martinique, previously used for banana growing over several years. No *Scutellonema* were found in the soil. This species is not endemic and it has so far not been found on plants other than yams. The crop cycle lasted 8 months (January–September). During this period, the rainfall was 1550 mm and the average temperature was 26.4°C. Observations continued after the harvest on tubers stored in a well-aired loft for 4.5 months (average temperature 25.8°C).

The planting material (*Dioscorea alata*, c.v. Belep),

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Table 1. Nematicide and fungicide treatments applied to yam seed tubers (ST = seed tuber)

Code	Nematicides	Formulation	Dose/ST	Fungicides	Dose*	Bentonite
E1	Ethoprophos	Liquid	0.88 g	Benomyl	1 g/l	yes
E4	Ethoprophos	Granules	0.26 g	Benomyl	1 g/l	yes
E3	Ethoprophos	Granules	0.46 g	Benomyl	1 g/l	yes
E2	Ethoprophos	Granules	0.72 g	Benomyl	1 g/l	yes
E1	Ethoprophos	Granules	0.94 g	Benomyl	1 g/l	yes
Ca	Cadusafos	Granules	0.45 g	Cryptonol	3 g/ST	yes
T	Control			Benomyl	0.1 g/l	no

The ethoprophos used was from the commercial product 'Mocap'; the cadusafos from 'Rugby'
*Of product

supplied by a farmer, was infested with *S. bradys* only. The material consisted of tubers from the previous crop which, immediately prior to planting, were cut into pieces weighing between 200 and 230 g. The average nematode infestation of the seed tubers was estimated from 16 tuber pieces selected at random.

The trial plot was planted in Fisher blocks repeated six times with six treatments and one untreated control plot. A single plot had 50 seed tubers planted at 30 cm intervals, distributed over 2 ridges 1.4 m apart. Weeding was by hand during cultivation. The crop was harvested mechanically.

The nematicide and fungicide treatments applied by coating are listed in *Table 1*. The basic coating solution was prepared by mixing 310 g of bentonite in 15 l of water for approximately 1 h. The nematicide granules were then added to the bentonite solution in a dose calculated on the basis of the quantity of suspension adhering to seed tubers (value determined by dipping 20 seed tubers). The concentration was then adjusted by means of successive dilutions so that the dose on the seed tubers was adequate.

The fungicides were also added to the bentonite suspension, except for the control seed tubers, which were dipped in a solution of 0.1 g of benomyl per litre of water, without bentonite (method customarily used by producers). The seed tubers were individually dipped in an adequate pesticide suspension (*Table 1*) immediately before being planted in the ridges at a depth of approximately 10 cm. During the first 2 months after planting, the germination was assessed by sampling six plants in each of the 42 plots.

Nematode sampling was performed approximately every 2 weeks. On each date, a yam plant was dug up in each plot, with as much root as possible and 300 cm^3 of surrounding soil. A composite sample was constituted from each replicate of the same treatment, by assembling the six soils, root systems, seed tubers, and later the six neo-tubers, according to the method used by Quénéhervé and Cadet (1986). The nematodes were extracted using the Seinhorst methods (1950, 1962). The roots were finely chopped before being placed in the mist chamber. The females, males, juveniles and second-stage juveniles, which are morphologically recognizable, were counted separately, and their number referred to the volume of soil, in dm^3 or weight of dry plant tissue in grams.

At the time of the harvest, the tubers were weighed from each elementary plot before being stored. For each treatment and the untreated control plot, ten were numbered and weighed individually every 3 weeks for 18 weeks. At the same dates, ten other tubers were cut up to evaluate the density of nematode infestation. For this purpose, approximately 100 g of surface skin were taken at random from the proximal and distal parts of five tubers for global nematological analyses by treatment, using the method previously quoted, while five others were analyzed individually to estimate the percentage of lateral contamination in the field. The infestation of the tubers reserved for weighing was measured individually and only after 18 weeks, i.e. at the end of the experiment.

Results

Seed tuber infestation

Thirty-one per cent of the seed tubers were free of nematodes. Twenty-five percent contained as few as 10 *Scutellonema* and 44% were heavily infested, with 916–18,300 *Scutellonema* per seed tuber, consisting of 49% female, 26% male and 25% juvenile.

Germination rate

During the first month after planting, the number of seed tubers which had germinated varied between 1/6 for seed tubers treated with liquid ethoprophos to 6/6 for seed tubers treated with the average dose of granulate ethoprophos, and 2/6 for seed tubers treated with cadusafos. The seed tubers not treated with nematicide nearly all germinated (5/6). At the end of the second month, all the sample seed tubers had germinated, except for those treated with liquid ethoprophos treatment, of which only 5/6 seed tubers germinated.

Effects of treatments on *Scutellonema* population

Seed tubers. For all the treatments using granular nematicide, the *Scutellonema* populations were generally higher than on the control seed tubers (*Figure 1*). The accumulated nematode population was highest on the seed tubers coated with cadusafos. However, it was lower than in the control seed tubers when liquid ethoprophos had been used. The males and juveniles (all stages) were most affected by the treatment (*Figure 2*). Most treatments significantly altered the structure of the population compared to that on the control seed tubers (Chi square test, $P < 0.05$; *Figure 2*).

Soil. As in the above case, the populations in the soil

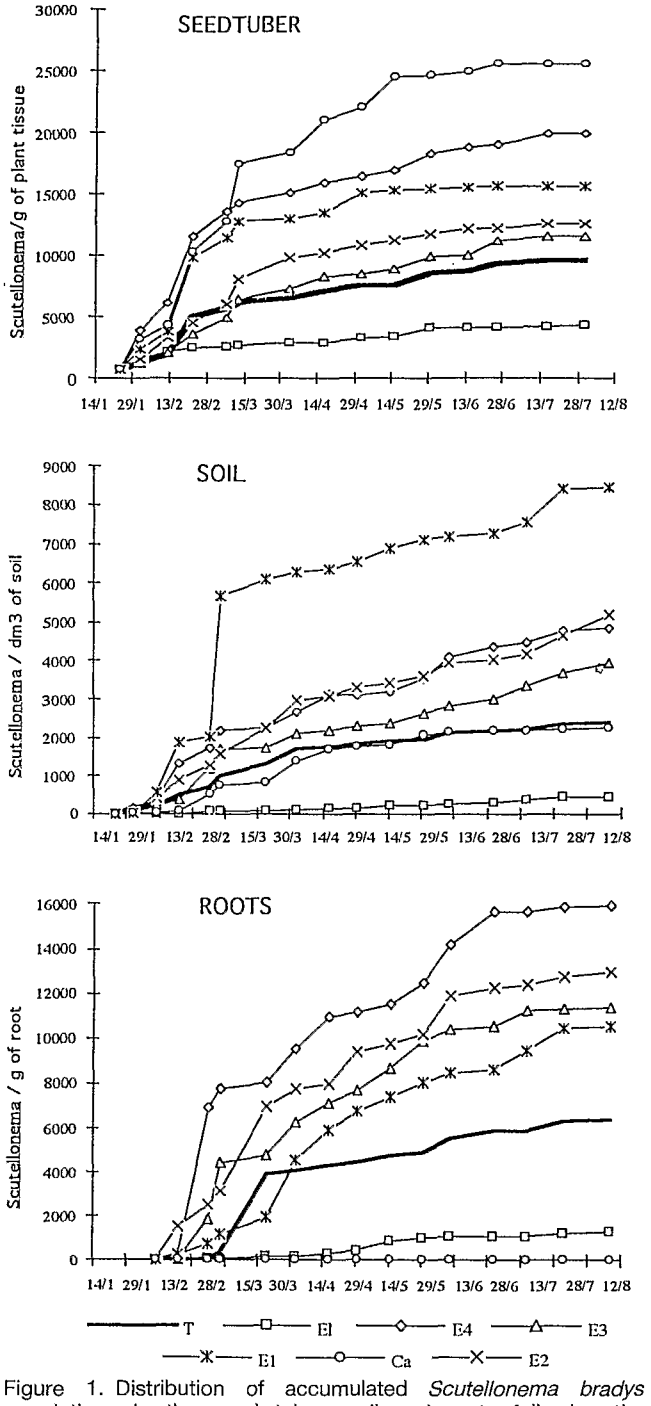

Figure 1. Distribution of accumulated *Scutellonema bradys* populations in the seed tuber, soil and roots following the various treatments and in the control plots (see *Table 1*)

around the seed tubers coated with granular ethoprophos were higher than those observed around the control seed tubers (*Figure 1*). With liquid ethoprophos, there were hardly any *Scutellonema* in the soil. All stages were affected, and the females and juveniles were significantly less numerous than around the control seed tubers (*Figure 2*). In the case of the cadusafos treatment, the nematode population was more or less the same as that observed around the control seed tubers. The proportions of adults and juveniles were different from those around the control seed tubers after treatment with liquid ethoprophos and with large doses of granular ethoprophos.

Roots. Compared with the untreated control plants, the distribution of the accumulated nematode populations observed in the roots following treatment with ethoprophos was approximately the same as in the two cases mentioned above (*Figure 1*). Only the use of the liquid formula considerably decreased root infestation. The roots of the seed tubers treated with cadusafos contained almost no nematodes. In both cases, all stages were significantly less abundant than in the control plants (*Figure 2*). The population structure was also different from that on the control plant, as there were proportionally fewer second-stage juveniles. On the other hand, this proportion was more important after the large dose of granular ethoprophos.

Neo-tubers and tubers. With the exception of the cadusafos and liquid ethoprophos treatments, the profile of the development of the *Scutellonema* populations in the tubers was comparable with that observed in the untreated control tubers (*Figure 3*). Using the slope of the curves alone as a base, three phases could be distinguished (harvesting takes place during the second stage):

(i) During the first phase, which lasted approximately 3 months and was entirely subterranean, the population increased little. After all treatments, the population structure was different from that observed on the control plants. Following cadusafos treatment, there were hardly any second-stage juveniles.

(ii) This heterogeneity disappeared during the second stage, which lasted approximately 5 months and was divided by the harvest. The population developed appreciably, in particular before the harvest. There were few *Scutellonema* in the tubers from plants treated with cadusafos and liquid ethoprophos; but the numbers began to increase in the latter case. These treatments were the only ones to significantly affect the population structure, the proportion of second-stage juveniles being lower than in the control tubers.

(iii) During the third stage, which began approximately 2 months after the harvest, the *Scutellonema* population increased notably in all cases, but remained lower after the cadusafos treatment. The treatments no longer affected population structure.

For the plants treated with ethoprophos and the control plants, an average of 17% of tubers were healthy, whereas in the case of the cadusafos-treated plants, 70% were free of nematodes (*Table 2*). After 18 weeks, the final individual infestation analysis of the tubers weighed every 3 weeks (see material and methods) showed that some of them contained none or hardly any nematodes (*Table 3*).

The influence of the treatments on yield

Yield at time of harvest. The increase in the weight of the neo-tubers during the first 2 months of growth was slower in the case of the cadusafos and liquid ethoprophos treatments than with other treatments. This handicap only persisted in the case of ethoprophos (*Figure 3*). Although higher by 14–15%, the yields achieved after the application of cadusafos and high doses of granular ethoprophos were not statistically different from those achieved on the control plots

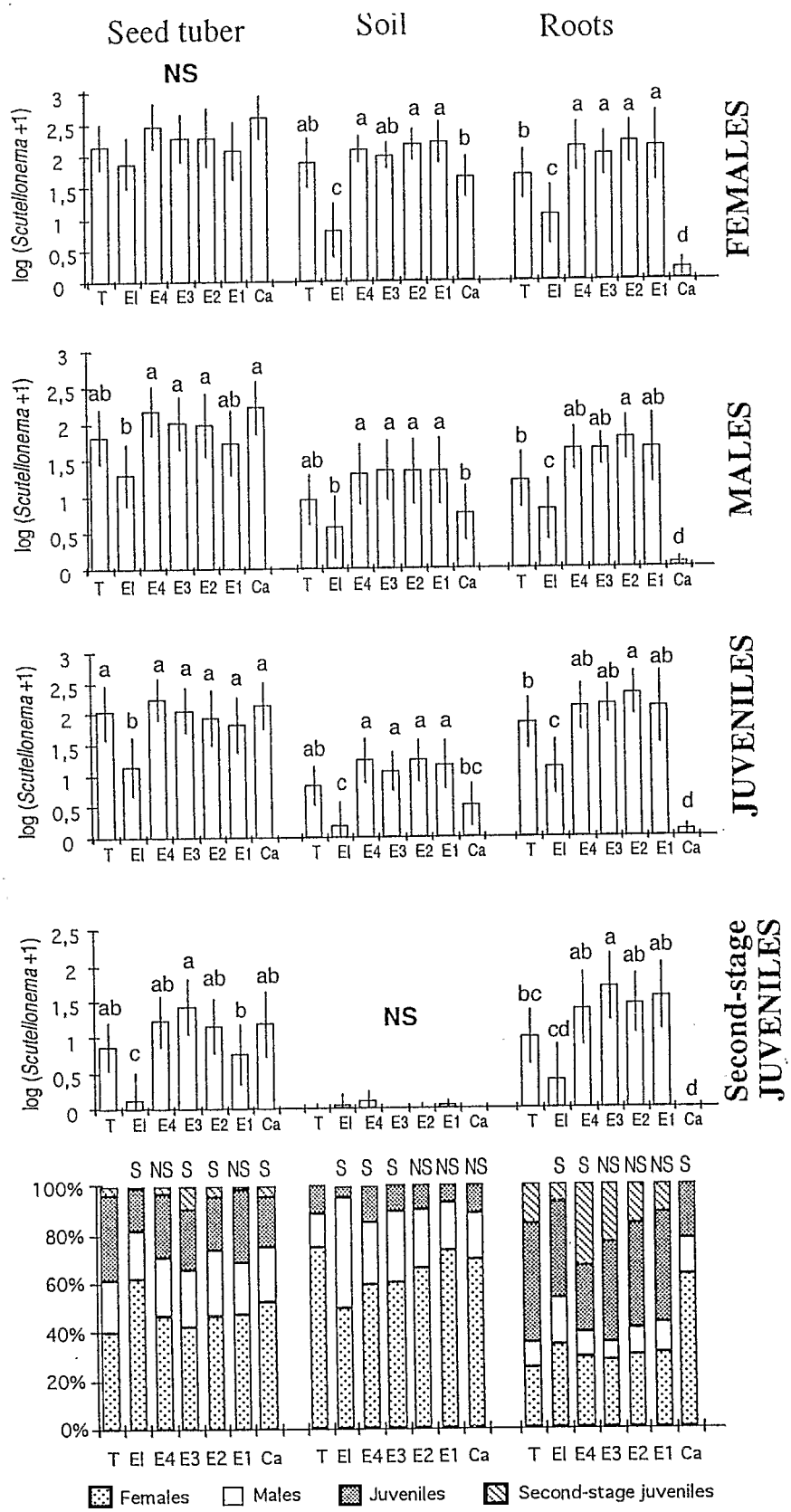

Figure 2. A comparison between average infestations with females, males, juveniles and second-stage juveniles of the seed tuber, soil, and roots during the life of the plant parts or observation period (soil). The line shows the confidence interval for the average; histograms bearing the same letter are not significantly different (see *Table 1* for treatments) (Analysis of variance, $P < 0.05$). Comparison of the average relative proportions of adults and juveniles for the different treatments and the control (Chi square test, $P < 0.05$)

Table 2. Average percentage of healthy tubers in control plots and in plots subjected to the various treatments applied to the crop, and total infestation of the five tubers analyzed at the end of 18 weeks by the composite method (*Scutellonema*/g of plant tissue)

Code	Nematicides	Number of tubers analyzed	Healthy tubers	Number of *S. bradys* per g of plant tissue
E1	Ethoprophos (liquid)	10	20%	5211
E4	Ethoprophos (granules)	10	20%	7902
E3	Ethoprophos (granules)	9	22%	5822
E2	Ethoprophos (granules)	10	30%	20,428
E1	Ethoprophos (granules)	10	0%	49,865
T	Control	10	10%	11,629
Average			17%	
Ca	Cadusafos (granules)	10	70%	4569

Table 3. Distribution of the total infestation of the 10 tubers (kept for periodic weight) from the plants treated with cadusafos after 18 weeks in storage (F, female; M, male; L, third- and fourth-stage juveniles; L2, second-stage juveniles) (*Scutellonema*/g of plant tissue)

No.	F	M	L	L2	Total
1	8250	5320	5220	1830	20,620
2	3187	3241	7163	3429	17,020
3	3	0	2	0	5
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0

(*Table 4*). Coating with liquid ethoprophos (E1; 1 g/seed tuber) significantly reduced the tonnage of tubers per hectare by 41%.

Yield following storage period. The tubers from cadusafos-treated plants lost the least weight during the 18 weeks of storage, followed by those treated with liquid ethoprophos and 0.72 g/seed tuber of granular ethoprophos (*Table 4*). In the case of the other treatments and the control tubers, losses ranged from 30 to 38% of the weight at the time of the harvest. In these cases, the slope of the lines representing weight loss were steeper than in the previous case (*Figure 4*). The average weight of the neo-tubers 2 weeks before the harvest was higher than that of the tubers at the time of the harvest probably because they had passed their best point of maturity and had begun to dry.

Loss at time of consumption. The elimination of necrotic tissue led to a loss of 13% of the weight of tubers from the plots treated with cadusafos, compared to 34% for tubers from untreated plots (*Table 4*). In all, approximately one-quarter of the yams from plots treated with cadusafos disappeared between the harvest and time of consumption. In the case of the other treatments, this proportion ranged from 33 to 56%. The accumulated total of all three levels of loss, expressed in relation to the highest yield, i.e. that which would, in theory, have been achieved were there no nematode infestation, was 68% on the control plots, of which 44% was caused by the presence of *Scutellonema*.

Relationship between nematode population and damage

There was no correlation between the *Scutellonema* population on the seed tuber and that in the soil, although there was an inverse correlation between the population and total accumulated loss. There was a correlation between soil or root population and neo-tuber and tuber population, which themselves were in proportion to losses during storage and at the time of consumption (*Table 5*).

Discussion

In most rhizomes, as in the case of banana (Quénéhervé & Cadet, 1985), the distribution of nematodes in yam tubers is heterogeneous (Blake, 1972). Even if all tubers were infested, it was possible to obtain three nematode-free seed tubers out of 10 when they had been cut into pieces weighing approximately 250 g. After the harvest, in the control plots, only 1 in 10 tubers from such seed tubers was nematode-free. In other words, as the plot contained no *Scutellonema* before planting, many were contaminated by neighbouring plants during their development in the field.

A study of germination rates has showed that the nematodes did not notably affect the germination of yam seed tubers. However, on the basis of this information, three treatments appeared to have a phytotoxic effect: liquid ethoprophos, cadusafos and the treatment with 0.26 g of granular ethoprophos. In the first two cases, the slower weight gain of the neo-tubers has confirmed this diagnosis. However, although this phytotoxic effect soon had disappeared in the case of cadusafos and granular ethoprophos, it was worse with liquid ethoprophos, following which the yield was 40% lower than in the untreated plots. In addition, liquid ethoprophos was the only nematicide to reduce the number of nematodes in the seed tuber tissues. The liquid formulation probably enabled the active substance to infiltrate the spongy nectrotic tissue and thus came into contact with the nematodes, which had concentrated at the edge of necroses (Adesiyan, Odihirin & Adeniji, 1975a). In all other situations, as shown by the visual examination of sample plants, the active substance fixed in the granules was not able to penetrate the necrotic areas and the nematodes were often more abundant than in the control seed tubers, especially after cadusafos treatment.

It is generally accepted that the size of nematode

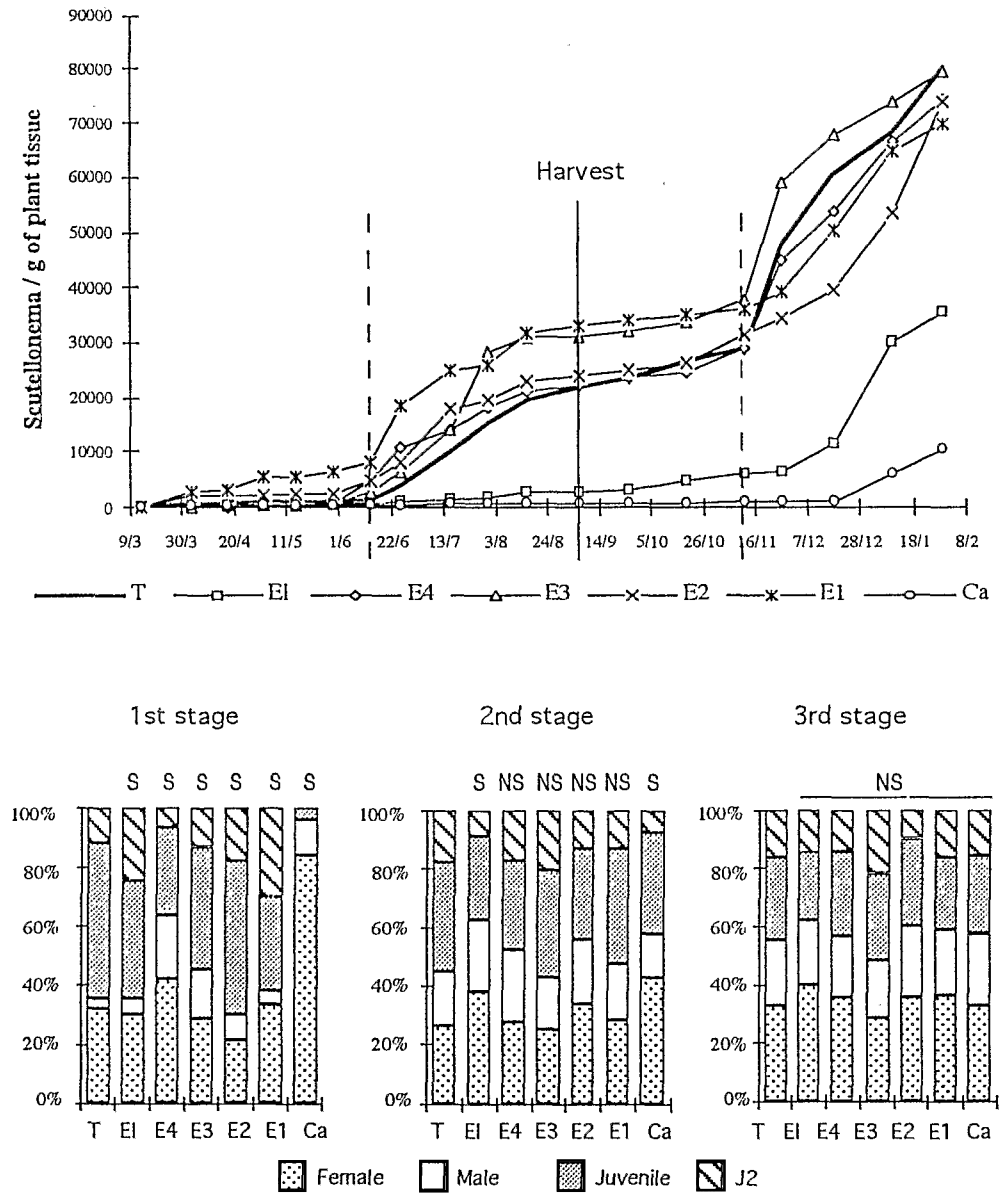

Figure 3. Distribution of the accumulated *Scutellonema bradys* population in the tuber from the time of its appearance in the field to the end of the storage period, following the various nematicide treatments and in the control plants (see *Table 1*). Comparison of the average relative proportions of adults and juveniles during the three stages of the growth of the nematode population (Chi square test, $P < 0.05$)

populations is in proportion to that of the plant mass the parasites can feed on. According to the previously mentioned results, this would show that more tissue was available for nematodes in the nematicide-coated seed tubers than in the control seed tubers. In the latter case, the tissues were probably destroyed by fungi or bacteria, the swift development of which deprived the nematodes of the food resources required for them to multiply. According to this hypothesis, the activity of the fungicide was enhanced when the product was mixed with bentonite rather than simply dissolved in water prior to its application, as was the case for the control seed tubers. The particularly heavy infestation in seed tubers treated with cadusafos could, therefore, be explained if this substance also had a fungicidal or bacterial effect, or if quinotozene were more effective than benomyl. In any case, the high clay content of the soil certainly helped reduce the fungicidal activity of the benomyl (Wauchope and Butler, 1994).

According to this hypothesis, by preventing the swift decay of the seed tuber, the fungicidal treatment has encouraged a centre of infestation to persist well beyond the active period of nematicides. Indeed, the fact that a number of tubers from the plots trated with cadusafos were contaminated at the end of the storage period has confirmed this hypothesis. By encouraging the decomposition of the seed tuber tissues by inoculating it with fungi harmless to the crop, it may be possible to considerably reduce the infesting *Scutellonema* population. Indeed, it may be for that reason that the infestation of the seed tubers was in reverse proportion to the total accumulated losses.

The results given above have demonstrated that the active substance of the nematicides in granular form, which were stuck to the seed tuber skin by the bentonite, did not penetrate the seed tuber. Under this coating, *Scutellonema* develop normally, protected by the plant tissue. It was when they pierced the skin to

Table 4. Yields at time of harvesting and weight loss (%) of tubers during storage period and at the time of consumption after the various nematicide and fungicide treatments; figures for control tubers

Code	Nematicides	Crop (t/ha)	Variation/Ca (Ca = no nematode)	% Lost in storage	% Lost at time of consumption	Accumulated losses/Ca (Ca = no nematode)
Ca	Cadusafos Gr.	36.1 b	0	12%a	13%a	23%
E2	Ethoprophos Gr.	35.9 b	−1%	27%abc	21%b	43%
E1	Ethoprophos Gr.	36.0 b	−1%	36%bc	24%bc	52%
E3	Ethoprophos Gr.	34.9 b	−5%	38%c	28%bc	60%
E4	Ethoprophos Gr.	30.6 b	−10%	36%c	31%c	66%
T	Control	31.6 b	−15%	29%bc	34%c	68%
E1	Ethoprophos liquid	18.6 a	−46%	15%ab	21%b	79%

Figures with the same letter are not significantly different ($P < 0.05$); Krugshall and Wallis test) (Gr: granules)

Table 5. Relation between the various nematological and agronomical parameters

	Correlated parameters	*p*	*r*	Regression
Scutellonema soil	*Scutellonema* neo-tuber	0.0379	0.78	+
Scutellonema seed tuber	Accumulated losses	0.041	0.77	−
Scutellonema root	Losses during storage	0.0088	0.88	+
Scutellonema root	*Scutellonema* neo-tuber & tuber	0.0173	0.84	+
Scutellonema neo-tuber	Losses during storage	0.0007	0.96	+
Scutellonema neo-tuber	*Scutellonema* tuber	0.006	0.90	+
Losses during storage	Losses at time of consumption	0.0433	0.77	+
Losses during storage	*Scutellonema* neo-tuber & tuber	0.0008	0.96	+
Losses at time of cons.	*Scutellonema* neo-tuber & tuber	0.0299	0.80	+

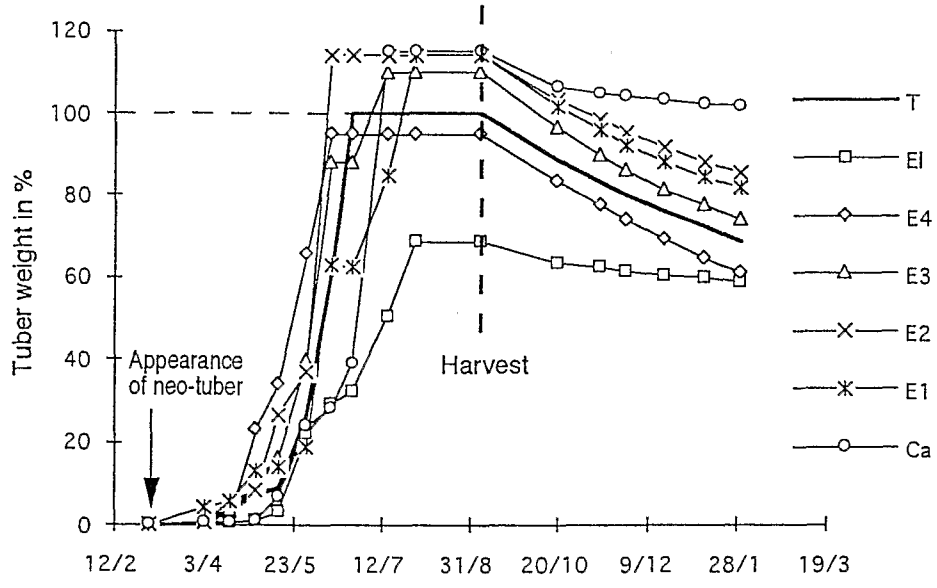

Figure 4. Percentage increase in weight of the neo-tubers following the nematicidal treatments (see *Table 1*), in relation to the control plants (measured on the neo-tubers taken at each date), and evolution of the weight loss of the tubers during the storage period, in percentage of the weight at the time of the harvest (measured on the same tubers on each date)

reach the roots that the nematodes came in contact with the active substances.

The fact that in the soil, the proportion of females was higher than in the seed tuber has confirmed that it was mainly females which were able to migrate to the roots (Cadet and Quénéhervé, 1994). No treatment has changed the structure of the soil population, but there were major differences as far as quantity was concerned. Relatively few *Scutellonema* have survived contact with liquid ethoprophos, while they did not appear to be affected by the granular product. This result could be explained if it is accepted that the distribution of the active substance fixed on a solid base does not enable a lethal concentration to be achieved in the coating, contrary to what occurs with the liquid product, which is uniformly distributed and immediately active.

Except in the case of seed tubers treated with a high dose of ethoprophos (0.94 g/seed tuber) and cadusafos, the size of the endoparasitic population was proportional to the size of the population in the soil. In the first case, the presence in the soil of an abnormally high number of *Scutellonema* could be due to poor coating adhesion caused by the excessive quantity of grains of nematicide the coating contained, in order to reach that dose. In the second case, only the elimination of part of the *Scutellonema* by the cadusafos during their migra-

tion to the soil could explain the fact that the poulation in the soil was proportionally lower than that of the tuber from which it had issued.

In the roots, the condition of the seed tubers treated with ethoprophos was more or less the same as that previously described for the soil from where the nematodes originated. That is, the roots of seed tubers treated with liquid ethoprophos were appreciably less infested than those of the control seed tubers; while the reverse was true of the seed tubers treated with the granular product. In these cases, root infestation was generally inversely proportional to the dose of ethoprophos applied. On the other hand, there were hardly any *Scutellonema* in the roots of the seed tubers treated with cadusafos. This result has proved that the females in the soil, even when active, have mostly lost their ability to penetrate the roots. Unlike ethoprophos, cadusafos has altered the relative proportions of adults and juveniles in the population, which included almost no second-stage juveniles. There has, therefore, been little egg-laying in the roots.

The infestation of the tubers harvested from the plots treated with granular ethoprophos was identical to that of tubers from the control plots, both in quality and quantity. For the two treatments in which the root populations were lower than in the control sed tubers, it was noted that there were also fewer *Scutellonema* in the tubers, in particular, when treated with cadusafos. This substance was also the only one to affect the structure of the population during the initial neo-tuber volume increase stage. The few *Scutellonema* in the roots were mainly females; however, there were too few of them to produce significant quantitites of second-stage juveniles. In the case of liquid ethoprophos, the growth of the nematode population beyond the 3 months after the tuber had emerged confirmed that the tuber colonization process had simply been delayed, owing to the presence of a very small population. The nematicides used mainly acted by limiting the number of nematodes which could attack the subterranean parts of the plant, in accordance with their characteristic as 'contact' nematicides.

These results have confirmed that in Martinique, as in some other yam-producing countries, but unlike Nigeria (Adesiyan & Badra, 1982), *Scutellonema* did not have a major impact on the yield at harvest time (Bridge, 1973). The damage mainly became apparent during the storage period, which, indeed, also corresponded to the period during which the nematodes multiplied most actively (Bridge, 1973; Adesiyan, 1977). The weight loss was then all the swifter when the tubers were more heavily infested (Adesiyan, Odihirin and Adeniji, 1975b). The fall in yield caused by the phytotoxicity of liquid ethoprophos was partially offset by the fact that the product had also controlled the nematodes fairly well and that the tubers therefore lost less weight during the storage period and at the time of consumption (few necrotic areas). Although *S. bradys* was only introduced into Martinique a short time ago (Kermarrec *et al.*, 1987), it has already caused major damage. Each time enough seed tubers to produce one tonne of yams are planted, approximately half is lost in the presence of *S. bradys*, against only a quarter where there is none (drying and peeling).

The alterations caused by the nematodes encouraged the infestation of the tuber tissues by fungi and bacteria, which increased necrosis at the end of the storage period (Adeniji, 1970). In this case, 'wet' necroses appeared alongside the 'dry' necroses caused by the nematodes (Adesiyan, Odihirin and Adeniji, 1975a). However, the significant correlation between the loss percentages during the storage period, or before consumption, and the number of nematodes in the roots and/or tuber, appeared to demonstrate that *Scutellonema* was probably responsible for most of the damage noted. It was, therefore, possible to predict yield losses by measuring root infestation.

Cadusafos has enabled a high proportion of totally *Scutellonema*-free tubers to be obtained (70%). The late re-infestation of the tubers, probably from the seed tuber prevented from rotting by the associated fungicidal treatment, could probably be prevented by not performing that particular operation. This plant material could then be used for seed tubers, in which case approximately 80% of the seed tubers would be healthy.

Conclusion

The production of a high proportion of nematode-free seed tubers using a cadusafos coating has the advantage of self-limiting the use of this nematicide and preventing the repeated use of nematicide by yam producers. However, like all pesticide-based techniques, it should only be used to counter an economically serious situation and when there is no other way of producing healthy plant material. The monitoring of population dynamics has shown that a number of techniques or treatments carried out before the emergence of the nematode problem, such as the fungicidal treatment of seed tubers, could limit the impact of measures taken to eliminate nematodes. Complementary work on the antagonism between nematodes and fungi could perhaps make it possible to develop new methods for biologically countering *S. bradys*. As a first approach, the elimination of fungicide seed tuber treatments could be studied.

Acknowledgements

The authors wish to thank M. Aubery, who supplied the plant material, the land and the staff needed to carry out the trial and M.B. Anastasiadis (FMC Europe) who translated into English and J. Bridge for scientific advice.

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Received 3 February 1995
Accepted 26 September 1995