Original Research Article

Host Efficiency of *Scutellonema Bradys* in Yam Companion Crops in Nigeria

ABSTRACT

Aim: Fourteen plants associated with the cultivation of yam in Nigeria were assessed for host suitability to *S. bradys.*

Methodology: Cowpea, cassava, eggplant, fluted pumpkin, melon, maize, hot pepper, okra, water leaf, Mexican sunflower, tridax, peuro, and siam weed were inoculated with 5000 *S. bradys* individuals in sterilized or unsterilized soil. The experiment was a 3 x 14 factorial, laid out in a randomized complete block design (RCBD). Data were analyzed using ANOVA and means were separated using Fishers Least Significant Difference (LSD) at 5 % level of probability.

Results: Based on the number of *S. bradys* recovered from the soil and root symptoms, cowpea and yam were found to be good hosts to *S. bradys* with reproductive factor ≥ 2, while fluted pumpkin, okra, melon and eggplant were moderate hosts with reproductive factor ≥ 1. Maize, puero, hot pepper, waterleaf, Mexican sunflower, siam weed were non-host to *S. bradys* with reproductive factor ≤ 1.

Conclusion: maize, puero and hot pepper are non hosts of *S. bradys* and could be intercropped with yam to reduce nematode populations and help to minimizing to the use of nematicides for *S. bradys* management in the yam cropping systems

Keywords: *Dioscorea*, Host efficiency, intercrops, *Scutellonema bradys*.

1. INTRODUCTION

The warm tropical climate and heavy rains promote the multiplication and spread of pest and diseases almost all the year round. Among such pests are the plant-parasitic nematodes. Nematode pests are of significant importance (1) among the various constraints to production of yam. In West Africa, the yam nematode, *Scutellonema bradys*, cause of the decay of yam tubers known as “dry rot disease” (2). *Scutellonema bradys* is found in the peridermal and subperidermal layers, rarely penetrating deeper than 1 or 2 cm during growth of the tuber.

Yam has the potential for meeting the hunger problems of many people in sub Saharan Africa, its production and management therefore, need to be sustainable. The management of pests threatening productivity of yams contributes to its sustainable production. *S. bradys* induce a significant reduction in the quality, marketable value and edible portions of tubers. These reductions are more severe in stored yam (3). Effective management with chemical nematicides is possible (4), however, the high cost, their non-availability at the time of need and the hazards they pose as environmental pollutants discourage most potential users in Nigeria (5). The use of rotation or intercropping of suitable crops can effectively reduce nematode population, however, the intercropping practices employed by many farmers is complicated by the presence of three to four crops growing with yam in the same season (6).

Population of *S. bradys* can build up in root of some weed host in the absence of yams and it can also survive in low populations in soil even in the absence of its hosts, which can serve as inoculum for next yam crop (7). This causes reduction in size and quality of yam produced on infected soil and may result in the destruction of the yam tubers (8). The development of complimentary strategies that are reliable, practicable, and economically justified to lower nematode damage to meet farmers’ income and nutrition needs is necessary. A suitable crop rotation scheme can contribute to effective control of *S. bradys* (dry rot), but this will require information on the host status of various plants commonly associated with yams in the field. This study was designed to assess weeds and crops commonly associated or intercropped with yams for their host status to *S. bradys*.

2. MATERIALS AND METHODS

2.1 Experimental site and treatments

The experiment was conducted in the screenhouse of the International Institute of Tropical Agriculture (IITA) main station at Ibadan (7 ˚31´N and 3˚ 54´E), south western Nigeria. The following plants were evaluated; cowpea (Ife brown) (*Vigna unguiculata* L*),* egusi melon (*Citrullus lanatus L.*), okra (*Abelmoschus esculentus* L), eggplant (*Solanum melognena* L), cassava (cv TZE 419) (*Manihot esculentus* Crantz), hot pepper (*Capiscum frutescens* L), Mexican sunflower (*Tithonia diversifolia* (Hemsl.) A. Gray), *puero* (*Pueraria phaseoloides* (Roxb.) Benth.), water leaf (*Talinium triangulare* L.) Rohrb), tridax daisy (*Tridax procumbens* L), siam weed (*Chromolaena odorata* L.) King & H.E. Robins), yam (*Dioscorea rotundata* (Poir.) J.Miège), fluted pumpkin (*Telifera occidientales* Hook. F.), maize (cv Oba super 1) (*Zea mays* L.). The seeds of maize, cowpea, *puero,* yam sett and cassava cuttings were obtained from IITA, while seeds of egg plant, hot pepper, and okra were obtained from a local seed store and weed seeds were obtained from field plots. The treatments included naturally infested *S. bradys* field soil, sterilized soil inoculated with 5000 *S. bradys*, uninoculated sterilized soil (control). Naturally infested field soil was collected from plots in which yams with high dry rot damage were recently harvested while top soil to be sterilized was collected from fallow fields. The experiment was laid out in a randomised complete block design (RCBD) with three *S. bradys* applications (naturally infested field soil, artificially infested soil and sterilized control soil) and fourteen plants, in four replicates. The plants were sown in ten-litre pots, irrigated on alternate days and kept free of weeds.

2.2 Source of inoculum and extraction of *Scutellonema bradys* from tubers

Yam tubers showing advanced symptoms of dry rot, obtained from IITA yam barn and yam stores served as source of inoculum. The *S. bradys*-infected yam tubers were peeled and the peels cut into small (1 x 0.5 cm) pieces. *S. bradys* was extracted from the infested tubers using the modified Baermann funnel method (9). The set-up consisted of plastic sieves, shallow trays and double-ply tissue paper. Plastic sieves, lined with two-ply tissue paper were placed in shallow trays (25 cm diameter) separately. Chopped tuber tissues were spread carefully and evenly over the tissue paper. Water was carefully and slowly added to each tray until the samples were submerged. The set-up was left undisturbed in the laboratory for 48 hrs. The nematode-water suspension, after removing the sieves, was poured into beakers and was concentrated after 24 hrs by decanting 70% of the supernatant.

2.3 Estimation of inoculum and inoculation

The number of nematodes per ml of the suspension was determined by counting from three aliquots of 2 ml each under a dissecting microscope. The number of *S. bradys* per ml was used to extrapolate the volume of suspension that will carry 5000 *S. bradys* required for inoculation. The suspension of inoculum was applied to the appropriate treatments 28 days after planting using a syringe into four 1–cm holes made in the soil close to the seedlings. Soil extraction was carried out to determine the quantity of nematodes in the naturally infested field soil. This was achieved by thoroughly mixing all the soil and collecting five samples of 250 cm^3 each. The modified pie-pan method was used for nematode extraction over 48 hours. The number of *S. bradys* per sample was averaged and calculated per pot as initial population (Pi = 3200) for the treatment. The experiment was terminated at twelve weeks after inoculation. A second trial was run for data verification.

2.4 Data collection and analyses

Data on plant height was measured with a meter rule from the soil level to the plant apex while counting was done to determine the number of leaves. At harvest, fresh shoot weight (g) was obtained by cutting the plant at the soil level and weighing the above ground parts of the plant using a Metler® balance. The pots were upturned and the roots were carefully separated, washed and weighted to obtain fresh root weight (g). Nematode populations were determined by counting after extraction using the modified Baermann funnel method (9). The final nematode population per plant was estimated by summing the total number of nematodes in soil and roots. Reproductive factor (RF) was calculated using the formula RF= Pf/Pi where Pf (final population) is the average total soil and root nematode populations; Pi is the initial nematode population (5,000 for the inoculated soil and 3,200 for the naturally infested soil). Host plant efficiency rating based on reproductive factor using a modification of the method of Loveys and Bird (10) was used; RF >3 = Very good host; RF 2-3 = Good host; RF 1-2 = Moderate; RF < 1= Poor host; non entry of nematode into root = Non- host.

Nematode counts were transformed using the square root (x + 0.5) transformation method to normalize the data. (11). Data were submitted to Analysis of Variance (ANOVA) using SAS statistical package (12). Means were separated using Fishers Least Significant Difference (LSD) at 5 % level of probability.

3.0 RESULTS AND DISCUSSION

3.1 Growth of yam companion crops in response to *Scutellonema bradys*

There were no significant differences in plant height among treatments for siam weed, hot pepper, water leaf, and tridax daisy (Fig. 1a). Water leaf, yam and fluted pumpkin plants growing in field soil were taller than in sterilized inoculated pots, uninoculated cowpea, eggplant, cassava and okra were significantly taller (*P* = .05) than the *S. bradys* infested plants. Mexican sunflower growing in field soil were significantly (*P* = .05) shorter that other treatments.

There were significantly more leaves (*P* = .05) in cowpea, okra, puero, maize, eggplant, melon and tridax daisy growing in pots with no *S. bradys* compared to quantity of leaves in *S. bradys*- inoculated pots (Fig. 1b). However, there was no significant difference (*P* = .05) in number of leaves between *S. bradys*-inoculated mexican sunflower and siam weed compared to the control. The number of leaves in *S. bradys*-inoculated pots were also higher in cowpea, okra, melon mexican sunflower, water leaf siam weed and tridax daisy compared to plants growing in field soil. Only in yams did the number of leaves from field soil exceed that from *S. bradys*-inoculated soil

The reduced plant height observed in inoculated cowpea, eggplant and melon in this investigation as a result of root infection by the nematode. Poor absorption of water and mineral salts leading to a decreased growth rate is a result of nematode infection on roots, this is line with other reports (13, 14), where a reduction in the photosynthetic rates of plants due to nematode infection was observed and which contributed to reduction in the plant growth rates. Another report also shows that plant invaded by nematodes cause damage at all the three regions of a root, the epidermis, cortex, and vessels. Such plant exhibit retarded growth, chlorotic leaves, delayed flowering, fruit formation and susceptibility to fungal and bacteria attack plus significant growth and yield reductions (15). Nematode attack is known to decrease the uptake of minerals of infected plant especially nitrogen, phosphorus and potassium and also do not translocate adequate water and nutrients to the vegetative organ for photosynthesis (16).

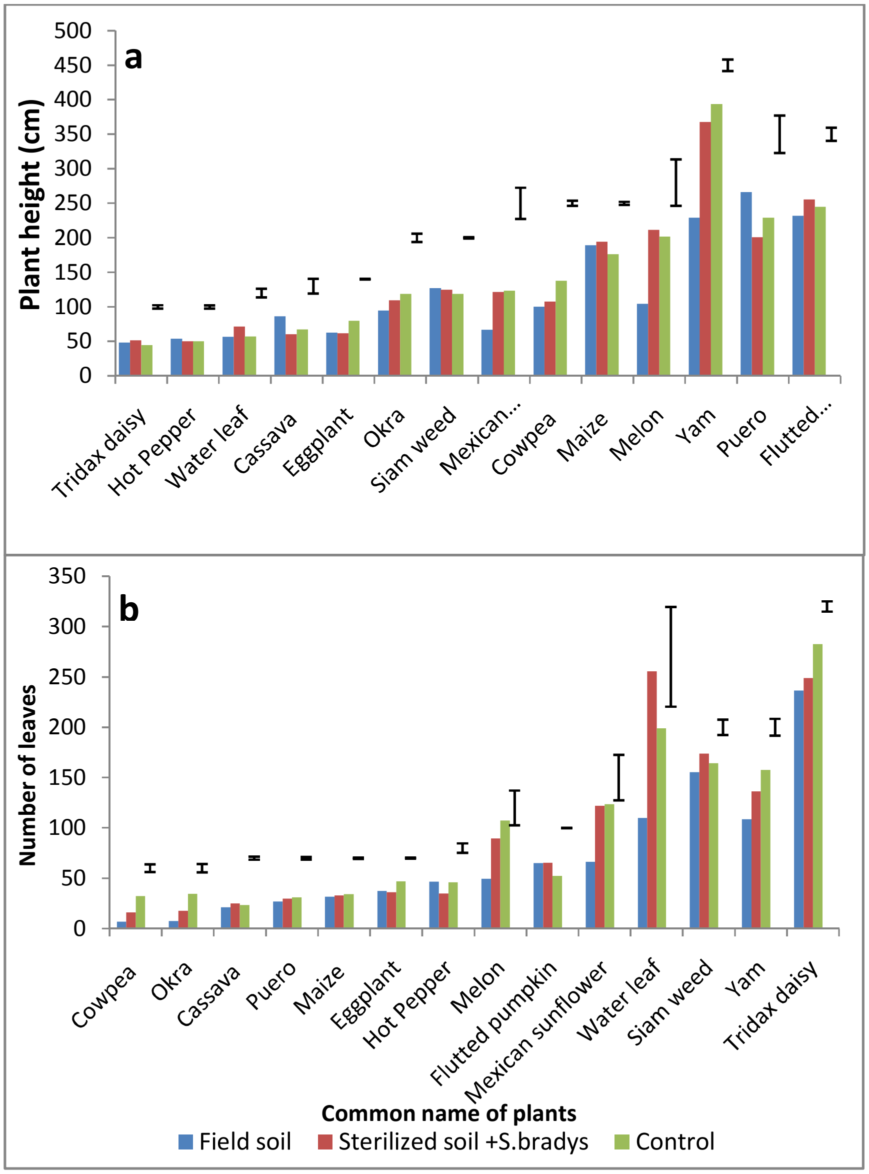

Figure 1: Plant height (a) and number of leaves (b) of yam companion crops inoculated with *S. bradys* in field, inoculated and uninoculated (control) soil at 12 WA**I.**

Bars are Standard error of means; WAI = weeks after inoculation

3.2 Effect of *Scutellonema bradys* on fresh shoot and root weight of yam component crops

There were no significant differences in the shoot weight between the control and infested pots for hot pepper, peuro, flutted pumpkin, and tridax daisy, however, uninoculated yam, cowpea, eggplants, okra, had significantly (*P* = .05) higher shoot weight than the nematode infested plants (Fig. 2a). Shoot weight of uninoculated melon, water leaf and mexican sunflower were significantly higher than weight from plants growing in field soil but not different from weights of plants growing in *S. bradys*-inoculated soil. Inoculated cassava, siam weed and maize plants had significantly (*P* = .05) higher shoot weights than the non infested plants. There were no significant differences in root weight between the control and infested tridax daisy and fluted pumpkin. Root weight of uninoculated cowpea, eggplant, okra, and yam were heavier (*P* = .05) than *S. bradys*-infested ones. Generally, plants growing in field soil had lower root weights in comparison to inoculated plants except for cassava and puero. Similar finding on reduced biomass has been observed (17). The reduction in the root weight of eggplant, melon, okra and the shoot weight of cowpea, eggplant, melon and okra observed in this work could be attributed to the feeding and burrowing activities of *S. bradys* on the root tissues. Feeding activities of nematodes can result in the extensive destruction, cavity formation and secondary infection. Reduction in the shoot, root lengths, fresh and dry weight was observed in okra plants inoculated with *Meloidogyne incognita* compared with uninoculated plants (18). Fluted pumpkin plants inoculated with *M. incognita* had significantly reduced growth compared to uninoculated plants (19). Chlorotic patches were observed on inoculated fluted pumpkin plants (though data were not taken on this), this can contribute to reduced photosynthetic ability of the leaves resulting in decreased market value of the leafy vegetable and reduced income for the farmers. This agrees with the findings of Jain (20) who reported that chlorosis of foliage lowered the quality of vegetable crops resulting to severe economic losses.

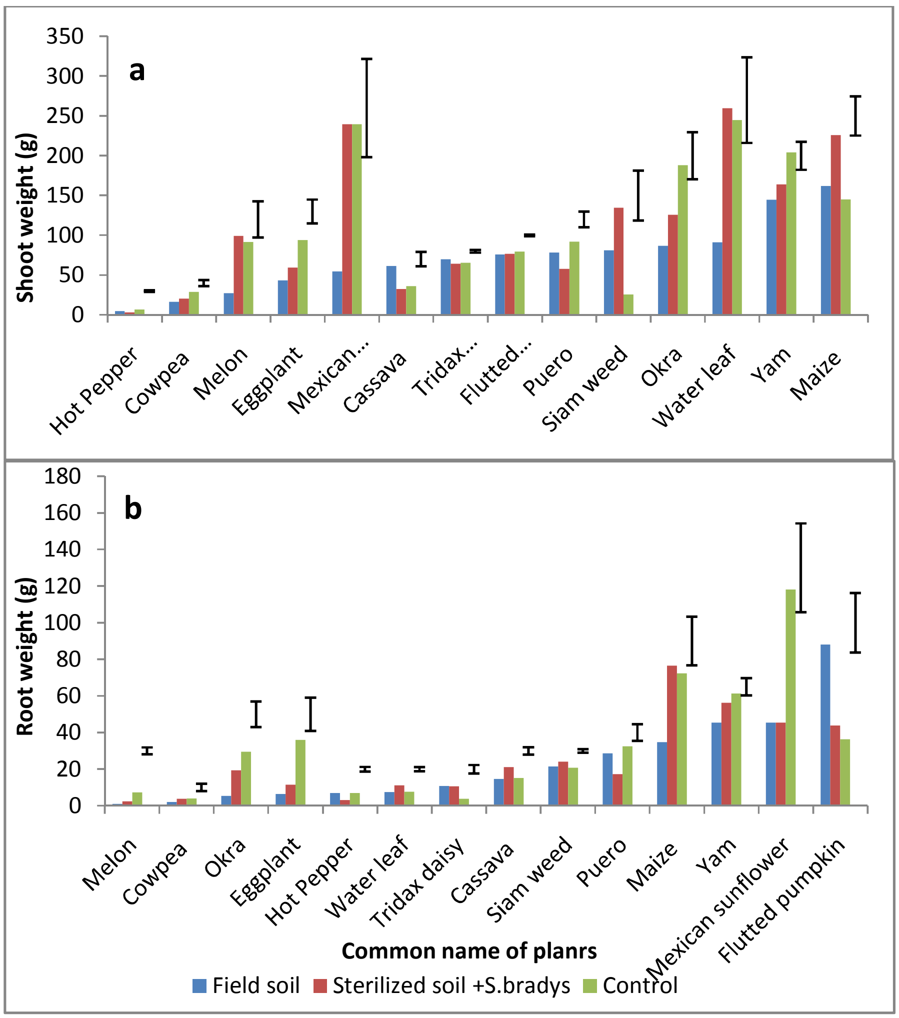

Fig 2: Fresh shoot (a) and root (b) weight of yam companion crops grown in *S. bradys* infested soil.

Bars are Standard error for comparing means.

3.3 Nematode population and host efficiency of yam companion plants infested with *S. bradys*.

Scutellonema bradys-inoculated soil produced higher nematode recovery from both soil and root samples of the treatment compared to field soil (Fig. 3). This can be accounted for by the lower populations (Pi = 3200) of the naturally infested field soil. It is also possible that the field soil contains other organisms which interact with *S. bradys*.

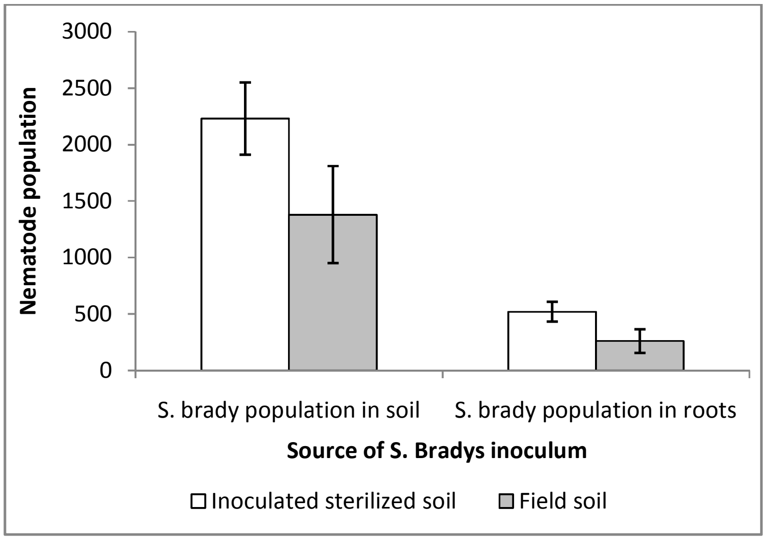

Figure 3. Total population of *Scutellonema bradys* in soil and roots of yam companion crops

Bars represent standard error

Cowpea yielded significantly higher (*P* = .05) nematode populations in the soil compared to other plants followed by egg plant (Table 1) in both field and inoculated soil. Soil population of *S. bradys* associated with fluted pumpkin, okra, and melon were not significantly different (*P* = .05) from nematode soil populations in yam while no *S. bradys* was found in the soil from other associated plants in inoculated soil. Whereas, in field soil, some S. bradys were recovered from soil with cassava, puero and tridax daisy (Table 1).

The population of *S. bradys* observed in yam roots was significantly higher (*P* = .05) than in roots of other plants by as much as 85 % (in inoculated pots). The number of *S. bradys* in roots of cowpea, fluted pumpkin, eggplant, okra, cassava and melon were not significantly different but were significantly higher (*P* = .05) than root populations of *S. bradys* in other plants (maize, hot pepper, mexican sunflower, tridax daisy, puero, siam weed and waterleaf). After yams, fluted pumpkin had the highest root nematode population in inoculated soil while in field soil cowpea had the next highest population to yams.

In both treatments, cowpea had significantly higher (*P* = .05) *S. bradys* reproductive factor (RF) compared to other plants including yams. The nematode RF in yams growing in inoculated sterilized soil was significantly higher than RF in other plants while in field soil RF of *S. bradys* on yams not significantly different from RF in fluted pumpkin, eggplant, okra, melon and tridax daisy. Based on the RF of *S. bradys*, eight plants, were designated as poor/non hosts, four as moderate hosts and two as good hosts.

Table 1.

Common name of plant	Mean number of nematode in soil (250 cm^3)		Mean number of nematode in root tissue (5 g)		Reproductive Factor (RF)		Host plant efficiency rating	
	Inoculated soil	Field soil	Inoculated soil	Field soil	Inoculated soil	Field soil	Inoculated soil	Field soil
Cowpea	146.0	97.5	15.0	20.1	4.8	2.8	Very Good host	Good host
Yam	28.2	17.2	70.4	48.4	3.5	1.2	Very Good host	Moderate
Flutted pumpkin	35.3	12.6	17.1	10.8	1.0	1.7	Moderate	Moderate
Eggplant	46.7	35.4	13.2	4.8	1.2	1.0	Moderate	Moderate
Okra	24.6	24.9	12.1	6.5	1.2	1.4	Moderate	Moderate
Melon	16.2	17.8	1.8	1.8	2.2	0.8	Good host	Poor host
Siam weed	0.7	0.7	0.7	0.7	0.0	0.0	Non Host	Non Host
Cassava	0.7	5.8	3.1	2.3	0.0	0.5	Non Host	Poor Host
Puero	0.7	7.6	0.7	0.7	0.0	0.3	Non Host	Poor Host
Pepper	0.7	0.7	0.7	0.7	0.0	0.0	Non Host	Non Host
Maize	0.7	0.7	0.7	0.7	0.0	0.0	Non Host	Non Host
Water leaf	0.7	0.7	0.7	0.7	0.0	0.0	Non Host	Non Host
Mexican sunflower	0.7	0.7	0.7	0.7	0.0	0.0	Non Host	Non Host
Tridax daisy	0.7	5.8	0.7	0.7	0.0	0.7	Non Host	Poor Host
LSD (P=.05)	20.8	34.4	13.2	13.4	4.8	2.8		

Values are transformed means of four replicates. Figures RF = final population/ initial population (RF =Pf/Pi)

Host plant efficiency rating: Very good host = a number increase of > 3 times, Good host = a number increase of 2-3 times, Moderate = no increase 1-2 times, Poor = no increase < 1, Non- host = entry of nematode into the root not accomplished.

It was observed that there are other hosts of *S. bradys* apart from yam namely cowpea, flutted pumpkin, eggplant, okra, cassava and melon. This indicates that some plants associated with yam can allow the persistence of *S. bradys* in yam fields as reported also by other authors (21, 22, 23, 24). *Scutellonema bradys* was unable to penetrate or multiply in the roots of maize. Maize was regarded as a non- host of *S. bradys* in sterilized and inoculated soil. A low population of *S. bradys* was found in unsterilized field soil, hence maize in the unsterilized field soil, was regarded as a poor host. According to McDonald et al (25), it was demonstrated that the most important nematodes which cause economic injury to the maize are *Pratylenchus* spp., *Meloidogyne* spp., and *Heterodera* sp. Hot pepper did not support *S. bradys* multiplication in its root tissue, although a few were found in field soil, it was still regarded as a non- host, because a reproductive factor of zero was recorded. This is in-line with a previous study (26) where chilli peppers did not support *S. bradys* multiplication in its root tissue. The weeds often associated with yams, water leaf, Mexican sunflower and tridax daisy, were found to be non-host of *S. bradys*. The plants did not allow the survival of *S. bradys* in their roots suggesting that either penetration, or development of the nematode was prevented. Roots of some plants simply may not be a good food source for some nematodes thereby reducing their numbers by starvation (27). *S. bradys* did not reproduce in the roots of peuro, and so no nematodes were recovered from it after extraction. It was therefore regarded as a non-host of *S. bradys*. Puero was regarded as a poor host of *S. bradys* (28, 29). The observed difference in host status of puero may be due to varietal differences used for the experiments. Cassava supported the survival of small population of *S. bradys* in the roots, but there was no reproduction, hence it was regarded as a poor host. *S. bradys* is reported to survive in root and tuber crops such as cassava, cocoyam and Irish potato but reproduction was found to be low in cassava (24, 30, 31).

Melon and okra were designated as moderate hosts of *S. bradys*. The nematode established entry and survived in the roots and soil of melon and okra. Small populations of *S. bradys* survived endoparasitically in the root of melon (13, 24). *S. bradys* survived and reproduced endoparasitically in the roots of okra, suggesting that it could increase with time (13). Both of these crops should, therefore be avoided in yam cropping systems.

Like the main host crop, yam, the largest number of *S. bradys* was recovered from cowpea. *S. bradys* survived and reproduced up to 4 times. The reproductive rate of *S. bradys* on cowpea indicates its suitability as host. Cowpea was reported to be a very good host of *S. bradys*, due to a two to three fold population increase (32, 13). For the first time, eggplant and fluted pumpkin are being reported as moderate hosts of *S. bradys*. The nematode was able to enter the roots and survive endoparasitically in the roots. The nematode is a potential problem to these crops by limiting their yield, if they are planted on a field continuously or if intercropped or used in rotation with yam.

As a result of the economic importance of *S. bradys* on yams, the need to identify plants that harbour this nematode cannot be over-emphasized. Such alternative hosts should be excluded in rotation sequence or from yam field if they are weeds. Rotation of non-hosts like maize, hot pepper or peuro with yam may give an effective control management to reduce field infestation of yam with *S. bradys*.

4. CONCLUSION

Yams are vulnerable to nematode damage as they reduce the yield and quality of the tubers. Cowpea, flutted pumpkin, eggplant and okra, which are commonly used in mixed cropping with yams are examples of plants that can support populations. However, Tridax daisy, Mexican sunflower, puero plant or water leaf are non-hosts of S*. bradys* and could be included in the yam cropping system for the integrated management of the nematode. Effective crop rotation involving the use of non-hosts can contribute to an integrated pest management programme with reduced used of nematicides.

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