A Research Article in AJRTC (2011) Vol. 9 No. 1: Pages 24-29

Studies on population build-up of *Scutellonema bradys* in *Dioscorea* species

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Manuscript received: 06/12/2010; accepted: 15/02/2011

Abstract

Field and storage evaluation of four yam cultivars TDr 131 (*Dioscorea rotundata*), TDa 85/00257 (*D. alata*), Igangan (*Dioscorea cayenensis*), TDe 3041 (*D. esculenta*) in intercrop with three other crops, cocoyam (*Xanthosoma sagittifolium*), ginger (*Zingiber officinale*) and maize (*Zea mays*) to the occurrence and abundance of the yam nematode, *Scutellonema bradys* showed significant variation in dry rot incidence which increased throughout the period of storage. There was a significant positive correlation (r = 0.77; $P \leq 0.05$) between soil nematode population and number of nematodes extracted from the peels of the tubers. Intercropping susceptible yam cultivars with maize, ginger, and cocoyam significantly ($P \leq 0.05$) reduced soil nematode population by 38%, 42%, and 54%. Data analysis showed that fewer nematodes were able to survive on tubers in the intercropped plots as compared to the sole plots. Nematode populations increased 14-foldin the untreated plots and 2-fold in the intercropped plots.

Key words*: Scutellonema bradys*, nematode population, dry rot

Introduction

Steiner and LeHew (1933) first discovered the species *Scutellonema bradys* to be the cause of a disease of yam. Symptoms of attack include necrotic lesions produced just beneath the yam skin, extending slightly to the starchy tissue and these are generally associated with the dry rot of yam tubers that occurs in the outer 1 to 2 mm of tuber directly associated with *S. bradys*. The initial stage of dry rot consists of cream and light yellow lesions below the outer skin of the tuber. There are no external symptoms at this stage. *S. bradys* reproduces and builds up large populations in stored yam tubers and causes severe damage during storage. The life cycle of *S. bradys* is simple. Eggs are laid in soil or plant tissues (roots and tubers) where they hatch and the juveniles develop into adults by subsequent moulting. All stages are infective. *S. bradys* invaded the young, developing tubers through the tissues of the tuber growing point, alongside emerging roots and shoots, and also through cracks or damaged areas in the suberized epidermis (Bridge 1972). *S. bradys* continues to feed and reproduce in stored yam. They feed intracellularly in tuber tissues, resulting in rupture of cell walls, loss of cell contents, and the formation of cavities.

Material and methods

Four yam cultivars (TDr 131, TDa 85/00257, Igangan, and TDe 3041) and three of the resistant crops (*Xanthosoma sagittifolium*, *Zingiber officinale* and *Zea mays*) were selected out of the crops screened for resistance to *S. bradys* in which these three crops proved to be non-host. Mounds were made and all treatment combinations were planted. Plants were artificially infested with approximately 500 *S. bradys* per mound (Pi) by introducing known weights of infested yam peels close to the bases of the plants. There were four replications.

Nematode numbers (plants and soil) were assessed at harvest. Tubers were further stored and assessed for population build-up of the nematode. Soil nematode population densities were assessed at 8, 16, and 32 weeks after artificial infestation. Soil samples were processed by modified Baermann funnel extraction method to extract motile stages of *S. bradys*. Initial and final population density values included all motile stages. Nematode counts were recorded as number /100- cm^3 soil and /100 g tuber peel. Mature tubers were rated visually on a 0–10 scale: 0 = clean tubers; 2 = small yellowish

lesions; 4 = dark brown lesions; 6 = continuous dark dry rot layer; 8 = deep cracks in the tuber skin; 10 = malformation of tuber and flaking off of parts of the epidermal layers.

Harvested tubers (all cultivars used) were stored in the barn (Fig. 1) to investigate population build-up of *S. bradys*.

Tubers were sampled at harvest and stored, thereafter, tubers were sampled at 8 weeks after harvest and 16 weeks after harvest to examine population build-up of the nematodes. The difference in sampling period was to allow ample time for the nematodes to complete their life cycle and to multiply. The sampled tubers were peeled and nematodes were extracted from the peels and counted. Initial (Pi) and final (Pf) nematode population density ratios were calculated.

One tuber from each variety was sampled at every sampling time. Tuber weight was taken from specific tubers from the various cultivars kept aside for that purpose.

Record was also taken of tuber weight in storage at every sampling period. Dry matter accumulation of tubers was taken by oven-drying (60^{o} C) 140 g weight of the various species to constant weight. The final weight was recorded and the loss in weight through drying was used to calculate the dry matter percentage.

Analysis of variance (ANOVA) was used to test the hypothesis that there was no difference in yield,

Figure 1 Stored tubers used for population build-up study.

visible symptoms of infection, and level of infestation by the nematode on tubers. Mean separation was by Least Square Means (LS Means) with option Pdiff (probability associated with the difference) of SAS statistical package version 6.12 as a test for significance.

Results and Discussion

The variation of soil nematode population with increase in the age of yam *(S. bradys* counts at different sampling times) is shown (Fig. 2). Different trends in the population density of nematode were observed in both sole and intercropping, and between the cultivars in the same plot. A low population density of *S. bradys* was found in the soils of intercropped plots. The difference between the nematode population of the cocoyam, ginger, and maize intercrop for each yam species was not significant, but that of sole yam and intercrop for each yam species was highly significant with the nematode population of the sole yam plot continuously on the increase until tuber maturity, for all the yam species. At crop maturity, nematode population was sparse in most of the plots, except for the sole yam crops. Nematodes increased mostly from inoculation to 8 weeks after inoculation in the intercrop plots, and thereafter, the population density decreased significantly with the establishment of the resistant plant materials on the field.

However, in the sole crop plots, the nematode population density increased throughout the growth period, leading to a soil population increase of about 14-fold at harvest compared to 2-fold increase in the intercropped plots. The number of nematodes in the soil increased from an initial 500 to 8501 for untreated sole plots and 1756 for the intercrop (Fig. 1 above). Intercropping yam cultivars with cocoyam significantly ($P \leq 0.05$} reduced soil nematode population by 54%, with ginger by 42% and with maize by 38%.

Fresh tuber weights and numbers were affected (P=0.05) by *S. bradys* (Table 1). Fresh tuber weights decreased (P=0.05), whereas tuber disease severity increased with increasing final population (Pf) per tuber as a function of increasing *S. bradys* initial population (Pi). Final population densities of *S. bradys* in stored tubers increased (P=0.05) as a function of increasing Pi (Table 2). The observed Pf were highest at Pi 10,000. Final population densities in tubers were 10.0 to 10.4 times higher than in soil at Pi = 10,000 and 4.6 times higher at Pi =500. There was a gradual increase in the nematode population in the tubers during storage. Damage in storage was more pronounced in tubers from sole plots. This showed that *S. bradys* infestation had significant effects on the storability of tubers. Reproductive rates (Pf/Pi) of *S. bradys* in tubers were inversely related (P=0.05) to Pi. There were no differences among treatment initial population densities. At harvest there were significantly greater numbers of nematodes in tubers and the surrounding soil of the sole yam (host to *S. bradys*) than in the intercrops. Sole *D. cayenensis* yielded significantly higher soil population densities than the remaining treatments. Also, there were significantly fewer nematodes in the peels of tubers from the intercropped plots than from the sole.

Population densities of *S. bradys* increased and caused severe damage on tubers and crops under greenhouse conditions. These results are consistent with field observations and those of storage where large numbers of *S. bradys* were associated with high yield losses. Inoculation of yam tissues with 500 *S. bradys* juveniles and adults isolated from infested tubers resulted in a 12-fold increase in nematode numbers within 10 weeks (Adesiyan 1976). In our study, the rate of nematode increase at Pi 10000 and Pi 500 in soil and tubers combined was 34-fold. The true rate of nematode increase was probably much higher, since peels and soil for 24 hours in water yield only about 50% of the total population (Bolton et al 1990). There was a significant variation in the reaction of the cultivars at the indicated weeks of storage. Cultivars intercropped with cocoyam, ginger, or maize showed favorable responses, with the lowest nematode population of 770 recorded in *D. esculenta*/cocoyam intercrop at 16 weeks of storage. A marked increase in nematode population within 8 weeks was recorded in *D. rotundata, D. alata, D. esculenta* and *D. cayenensis* planted sole. From the results of this study, nematode population in the infested tubers increased throughout the period of storage and it is evident that *S. bradys* has the ability to reproduce fast in yam during storage.

This agrees with the findings of Adesiyan (1976), and Cadet and Daly (1996), who reported evidence of the effect of feeding and reproduction of S. bradys on stored tubers resulting in weight loss and dry rot symptoms. Weight reduction can occur with late harvested tubers in dry soil and during storage as a result of moisture loss through cracked epidermal layers. Smith (personal communication) in Cote d'Ivoire estimated that weight differences between healthy and diseased tubers harvested from the field were about 20 to 30%. These

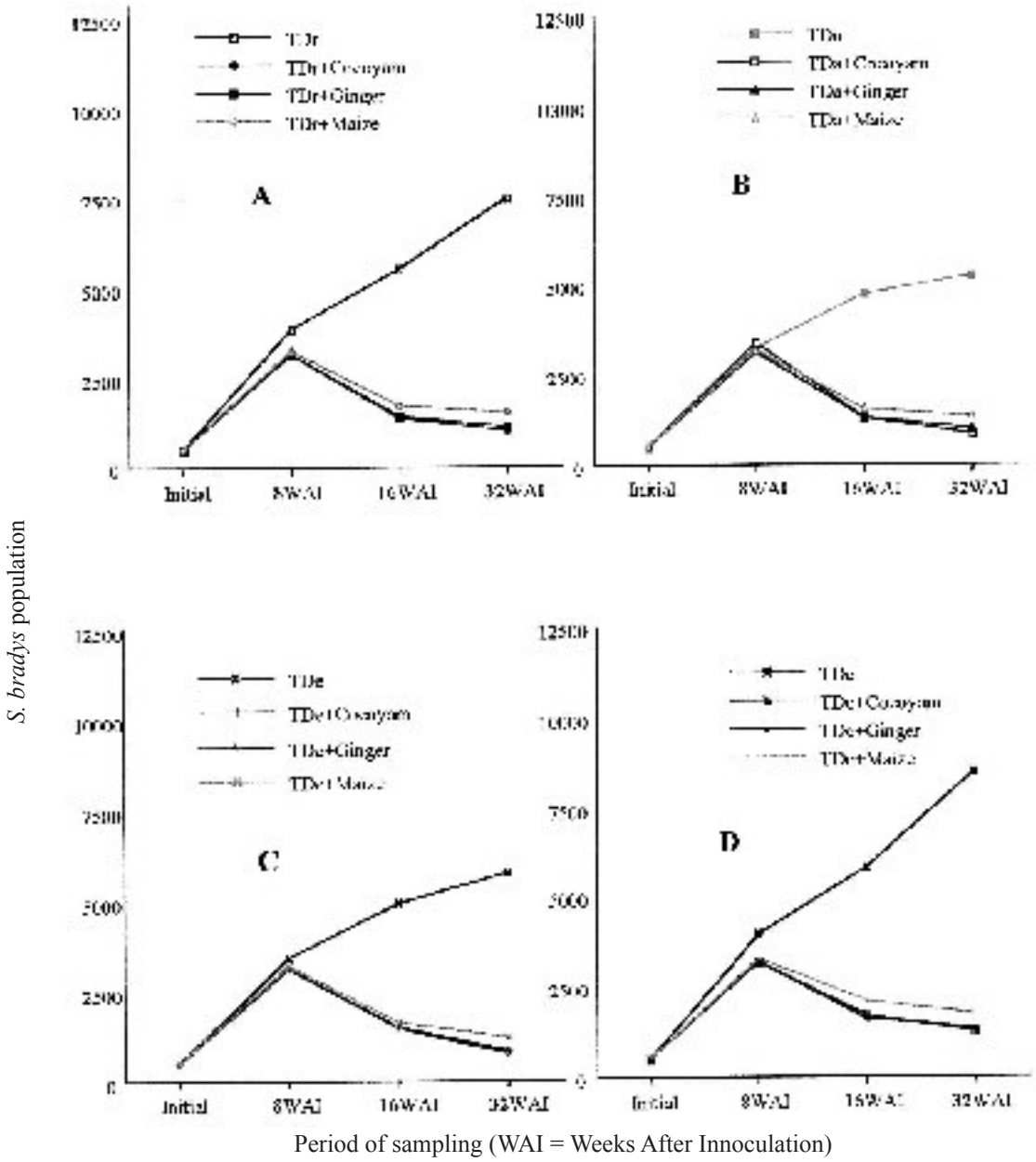

Figure 2. Scutellonema bradys counts at diffferrent sampling periods

A = *Dioscorea routundata*, B = *Dioscorea alata*, C = *Dioscorea esculenta* and D = *Dioscorea cayenesis*

differences would become more marked by the losses in tubers during storage. Adesiyan et al 1975) showed that, during storage, *S. bradys* infection resulted in a significant increase in water loss from *D. rotundata* and *D. cayenensis* tubers and a reduction in the edible portions of tubers of these species and also in the *D. alata* in yam barn. According to Adesiyan (1976), the variation in the weight loss amongst different species and between the healthy and infected tubers, is due to an increase in respiratory activity in the nematode-infected yam tubers and hence a higher rate of weight loss than in the healthy yam. This indicates that high weight losses during storage are mostly caused by pathogens, and that healthy yam tubers can be stored for a few months without appreciable losses in the weight of the edible portion. Kwoseh et al (1998) observed increases in the S.bradys population by 10 to 170 times over a 5-month period and 340 to 820 times over 12-months. In another study, Augustus and Jeffrey

Conclusions

Crop yield depends upon the initial nematode density and the rate of reproduction. The level of susceptibility is expressed as the ability of the nematode to survive and cause damage on the plants. A considerable quantity of yam is lost during storage. On a global

Table 1. Tuber weights (gm) at harvest and in storage (mean ± s.e.)

Cropping System	At Harvest		6 Weeks after Harvest		12 Weeks after Harvest		Disease severity
	Treated	Untreated	Treated	Untreated	Treated	Untreated	
TDr sole	*2100 ±86	900 ±86	* 1965 ±86	718 ±86	*1893 ±86	606 ±86	7.56
TDr +	* 1900 ±78	1300 ±79	* 1765±78	1120 ±79	* 1693 ±78	1007 ±79	1.55
Cocoyam TDr + Ginger	* 1900 ±74	1300 ±71	* 1697 ±121	1118 ±71	*1681 ±85	1006±71	2.98
TDr + Maize	*1700 ±70	1200 ±64	*1600 ±70	1018 ±64	*1493 ±70	908 ±64	3.37
TDa sole	*2800 ±59	800 ±58	*2663 ±59	658 ±58	*2580 ±59	586 ±58	6.75
TDa + Cocoyam	* 1900 ±50	1500 f50	*1763 ±50	1358 ±50	* 1682 ±50	1286 ±50	1.74
TDa + Ginger	*2600 ±43	1700 ±43	*2463 ±43	1557 ±43	*2381 ±43	1486 ±43	3.13
TDa + Maize	*2600 ±37	1300 ±38	*2461 ±37	1153 ±38	*2381±37	1082 ±38	2.84
TDc sole	* 1500 ±29	500 ±29	*1385 ±29	352 ±29	*1333 ±29	270 ±29	7.94
TDc + Cocoyam	* 1300 ±22	1000±21	* 1185 ±22	850 ±31	* 1134 ±22	772 ±21	1.52
TDc + Ginger	* 1400 ±14	1000 ±16	* 1285 ±14	850 t16	* 1232 ±14	770 ±16	3.33
TDc + Maize	* 1200 ±8	1000±7	* 1085 t8	827 ±51	* 1040 ±8	670 ±7	3.39
TDe sole	*200 ±14	96 ±6	* 178 ±19	57 ±6	* 163 ±13	32 ±5	6.80
TDe + Cocoyam	100 ±8	100 ±14	80 ±8	66 ±17	67 ±5	38 ±4	1.55
TDe + Ginger	100 ±16	100 ±8	84 ±6	61 ±9	66 ±7	35 ±8	3.34
TDe + Maize	100 ±14	100 ±0	80 ±14	61 ±1	63 ±13	31 ±2	3.15

Values are means of four replicates. Within experiments means of the same figure in vertical columns are not significantly different.
TDr = Tropical *Dioscorea rotundata* TDe = Tropical *Dioscorea esculenta*
TDa = Tropical *Dioscorea alata* TDc = Tropical *Dioscorea cayenensis*
* refer to treated tuber significantly ($P \leq 0.05$) different from the untreated

Table 2: Nematode numbers from yam tubers (100 g peel) at harvest and in storage from untreated plots (mean+s.e.).

Cropping System	At harvest	8 weeks after harvest	16 weeks after harvest	Rate of nematode increase (RF) Pf/Pi
TDr sole	4575 ± 45	13825 ±46	27455 ± 41	6.0
TDr + Cocoyam	175 ± 6	525 ±11	1053 ±12	6.0
TDr + Ginger	225 ±7	676 ±24	1284 ±14	5.7
TDr + Maize	375 ±9	1120 ±22	2180 ±29	5.8
TDa sole	5225 ±20	7652 ±41	15174 ±15	6.0
TDa + Cocoyam	181 ±8	466 ±5	937 ±3	3.2
TDa Ginger	219 ±14	609 ±8	1324 ±14	4.0
TDa + Maize	499 ±14	1050 ±4	2006 ±6	5.2
TDe sole	2852 ±38	8549 ±2	16994 ±4	6.1
TDe + Cocoyam	127 ±6	384 ±3	770 t36	6.0
TDe + Ginger	211 ±9	643 ±2	1266 ±44	6.0
TDe + Maize	302 ±4	906 ±5	1803 ±15	6.0
TDc sole	2534 ±25	15605 ±86	31347 ±34	12.4
TDc + Cocoyam	156 ±0	555 ±13	1084 ± 6	6.0
TDc + Ginger	223 ±15	667 ±0	1307 ±5	7.0
TDc + Maize	350 ±14	1491 ±30	2904 ±10	8.3

Values are means of four replicates. Within experiments means of the same figure in vertical columns are not significantly different. RF = Reproductive Factor, Pf = nematode population density at sampling date,
Pi = initial nematode population density #/100g peel
TDr = Tropical *Dioscorea rotundata* TDe = Tropical *Dioscorea esculenta*
TDa = Tropical *Dioscorea alata* TDc = Tropical *Dioscorea cayenensis*

basis, postharvest losses account for about 26% of world yam production (Anon 1974). Most of the yam decay in storage in Nigeria is a disease complex initiated by nematodes and aggravated by fungi and bacteria (Odihirin 1977) which are, in effect, secondary invaders. He pointed out that in the absence of nematode infection or harvest wounds on yam tubers, fungi are incapable of causing infection. Nematodes, therefore, in addition to their own direct effects, predispose the tubers to secondary invaders, which contribute immensely to the heavy storage losses. The possibility exists to exploit allelochemicals for yam nematode control, either by rotation or intercropping.

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