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Research Paper

Reaction of *Dioscorea alata* clones to plant parasitic nematodes infection

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Abstract

Preliminary investigations of the potentials of five clones of water yam, *Dioscorea alata* to resist plant parasitic nematodes infection was conducted at two locations during 2010. TDa 01/0004, TDa 01/00029, TDa 00/0003, TDa 01/00046 and a local check Matches were planted on ridges in a randomized complete block design and replicated three times at Fumesua and Ejura. Nematode population density/200 cm^3 soil at harvest, tuber galling and yield of yam were analyzed. At harvest at Fumesua, Matches was heavily infected with J2 *Meloidogyne* spp. (202 /200 cm^3) soil. However, TDa 01/00029 significantly (P=0.05) inhibited infection of the pest (14 /200 cm^3) soil. At Ejura TDa 01/0004 was not infected by *Tylenchulus semipenetrans* whilst infection of the pest on the local check Matches was significant (162/200 cm^3) soil. Tuber galling symptom was identified only on the tubers of the local check at both locations. TDa 01/00046 yielded the highest 42.6 t/ha and 4 t/ha whilst TDa 01/00029 yielded the lowest 25.9 t /ha and 2.1 t/ha at Fumesua and Ejura respectively. Late planting of yam and use of exhausted land at Ejura might have accounted for the significantly low yields. TDa 01/00046 out-yielded TDa 01/00029 by 39% and approximately 48% at Fumesua and Ejura respectively.

Keywords: Clone, nematode infection, resistance, water yam.

Introduction

Yams (*Dioscorea* spp.) are annual or perennial tuber-bearing and climbing plants. The genus *Dioscorea* consists of over 600 species, but only ten of these are important food yams [1]. The edible species are grown in various tropical and subtropical countries of the world. A few species are cultivated on a small scale for extraction of pharmaceutical compounds. For instance, diosgenin, a steroidal saponin is extracted from the root of wild yam, *D. villosa* with the potential to minimize post-menopausal symptoms [2] while dioscorin is extracted from the tuber of Chinese yam, *Dioscorea batatas* with sufficient antioxidant potential which confers on it tremendous health benefits [3]. Some *Dioscorea* species such as *D. sylvatica* and *D. dregeana* show antibacterial activity against gram-positive bacteria and gram-negative *Escherichia coli* [4]. Yam tubers have organoleptic qualities which make them the preferred carbohydrate staple and can contribute up to 350 dietary calories per person each day [5]. Of the ten important edible yam species, water yam, *Dioscorea alata* has very good storage qualities and can survive for periods of 3-4 months or longer depending on efficient harvesting and appropriate storage conditions. In Ghana, production trend is gradually being shifted to *D. alata* since it could be relied upon for local food security and income generation. Most of the white yam varieties can be produced by the use of 'minisetts' or 'microsetts' cut from tubers [6]. Plant parasitic nematodes have been implicated as major constraint to yam production. The most economically important nematode pests include: the yam nematode, *Scutellonema bradys*, the lesion nematode, *Pratylenchus coffeae*, the root-knot nematode, *Meloidogyne incognita* and the reniform nematode, *Rotylenchulus reniformis* [1]. Generally, these nematode pests cause dry rot in yam tubers, flaking off of epidermis, galls and cracks on tubers, a corky appearance, unsightly tubers and general loss in yield [1, 7]. Thus, nematode infestation affects productivity, quality and commercial value of yam [7, 8]. The high-risk area for nematode infestation is estimated to be 45% in yam-growing regions of West Africa [9]. The productivity of yam is also constrained by infestation of other pests and diseases. Increasing pressure from a range of insect pests (eg. leaf and tuber beetles, mealybugs, and scale insects) as well as fungi and viruses contribute to sub-optimal yields and deterioration of tuber quality in storage [10]. In Ghana, yams can be mono-cropped but are more often intercropped with maize, millet and vegetables. Selection of intercrops might influence the diversity and density of pests. For instance, inter-cropping yam with crops highly susceptible to root-knot nematodes such as okra, *Abelmoscus esculentus* and pumpkin, *Cucurbita pepo* increases the damage to yam tubers by *M. incognita*[11]. Field trials were therefore conducted at Fumesua and Ejura to evaluate the reaction of water yam clones to plant parasitic nematodes infection.

Materials and Methods

Treatments and experimental design

Four *D. alata* clones, TDa 00/0003, TDa 01/00029, TDa 01/0004, TDa 01/00046 obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and a local check, Matches from Ghana, making a total of five were investigated in the study (Table 1). The clones were evaluated for resistance to plant parasitic nematodes infection. The clones were arranged in a randomized complete block design (RCBD) and replicated three times. The yams were planted on ridges made by tractor instead of mounds to reduce drudgery in yam production. A ridge measured 10 m x 1m, and yam setts were planted 1m apart, resulting in 10 stands/ridge. A plot comprised four ridges with 1m between ridges. A plot size was therefore approximately 40 m^2.

Table 1: Characteristics of clones used in the study

Clone	Source	Growth type	Vine colour	Leaf colour
TDa 00/0003	IITA, Nigeria	Climbing	Green with pale edges	Dark green
TDa 01/00029	IITA, Nigeria	Climbing	Green with pale edges	Dark green
TDa 01/0004	IITA, Nigeria	Climbing	Green with pale edges	Dark green
TDa 01/00046	IITA, Nigeria	Climbing	Green with pale edges	Dark green
Matches	Ghana	Climbing	Green with pale edges	Dark green

Experimental sites

The field trials were conducted at Fumesua (01^o 28′ N 06^o 41′ W) in the forest agro-ecological and Ejura (07^o 24′ N 01^o 21′ W) in the forest-savannah transitional zones of Ghana in 2010. The soil type at Fumesua is a "Bomso series" Ferric Acrisol [12] while the Ejura type is a "Amantin series" Chromic Lixisol [13]. The Ejura field had previously been cropped with yam, while the Fumesua field had been cropped with cocoyam. Plant parasitic nematodes population was therefore perceived to be very high on the experimental fields. The fields were ploughed, harrowed and ridged.

Sett treatment before planting

Disease-free ware yams were cut into 300 g sections with a sharp kitchen knife. These were neatly packed into cane baskets and nested in a 12 l plastic receptacle containing 80 ml Pyrinex, an insecticide and 60 g Topsin M34, a fungicide. The chemical solution was well stirred with the aid of a metal rod. The yam setts were gently packed in a plastic basket and nested in the chemical solution which completely covered all the setts before removal and air-dried under tree shade for 24 h. Yam setts were then planted with the cut surfaces directed upwards to prevent rotting. Planting was done in April 2010 at Fumesua and in July 2010 at Ejura. Hand weeding was done three times before harvesting of yam.

Sampling and extraction

Soil samples were collected at two time periods, at the start of the trial (April and July) for Fumesua and Ejura respectively before the planting of yam and at harvest of the crop (December) with a 5 cm soil auger to a depth of 20 cm. At harvest, yam rhizosphere soil samples were collected. The soil samples, 200 cm^3 per treatment were extracted using the modified Baermann funnel method. After 24 h of extraction, samples were fixed with TAF (Formalin-37% formaldehyde 7.6 ml, Tri-ethylamine 2 ml and distilled water 90.4 ml) and nematodes were mounted on aluminium double-coverglass slides and specimens were identified using morphological characteristics such as the spear, head skeleton, lumen of the oesophagus, excretory pore and spicules [14].

Data analysis

Yield (kg) data was not transformed but nematode count data was log (ln (x+1)) transformed to improve homogeneity of variance before analysis using Genstat 8.1. (Lawes Agricultural Trust, VSN International). Means were separated using Fisher's protected Least Significance Difference (LSD) test at ($p < 0.05$).

Results and Discussion

Four plant parasitic nematodes in order of abundance: *Pratylenchus coffeae* > *Meloidogyne* spp. (juveniles) > *Helicotylenchus multicintus* > *Rotylenchulus reniformis* were encountered on all the experimental plots at Fumesua. At Ejura however, five: *H. multicintus* > *P. coffeae* > *Meloidogyne* spp. > *Tylenchulus semipenetrans* > *Scutellonema bradys* were identified from the plots. At harvest, the same nematode species were encountered at the respective locations. At Fumesua, the local check, Matches recorded (202/200 cm^3) soil J2 *Meloidogyne* spp. while three entries: TDa 01/0004, TDa 01/00029 and TDa 00/0003 recorded significantly low populations (28, 14 and 24/200 cm^3) soil respectively ($p = 0.05$). Significantly low *P. coffeae* (30/200 cm^3) soil, infected TDa 01/00046 while high populations (97, 95, 146 and 96/200 cm^3) soil, were recorded for TDa 01/0004, TDa 01/00029, TDa 00/0003 and Matches respectively (Table 2).

Table 2: Plant parasitic nematodes population / 200 cm^3 soil at harvest at Fumesua

Treatment	*Meloi*	*Praty*	*Heli*	*Roty*
TDa 01/0004	28(1.3) ‡	97(1.9)	14(1.7)	37 (2.1)
TDa 01/00029	14(1.2)	95(1.9)	8(1.2)	24(1.9)
TDa 00/0003	24(1.3)	146(2.0)	0¤	24(1.9)
TDa 01/00046	42(1.6)	30(1.1)	51(1.8)	23(1.8)
Matches	202(2.2)	96(1.9)	8(1.2)	0¤
Grand mean	(1.5)	(1.8)	(1.5)	(1.9)
Lsd	(0.6)*	(0.5)*	(0.9)N	(1.1)NS
C.V (%)	(11.3)	(8.6)	(10.2)	(9.5)

Data are means of three replications: ¤Data not used in analysis
‡ln (x + 1) transformed data used in ANOVA in parenthesis
*****= Significant at the 0.05 level, NS= Not significant
Meloi = *Meloidogyne* spp., Praty = *Pratylenchus coffeae*, Heli = *Helicotylenchus multicintus*, Roty = *Rotylenchulus reniformis*.

At Ejura, there were no differences between treatments for *Meloidogyne* spp. and *P. coffeae*. However, TDa 00/0003 recorded significantly high *H. multicintus* (117/200 cm^3) soil, while the pest was not found on TDa 01/00029. Similarly, TDa 00/0003 and TDa 01/00046 were not infected with *S. bradys* but TDa 01/0004 recorded 43/200 cm^3 soil (Table 3).

Table 3: Plant parasitic nematodes population / 200 cm^3 soil at harvest at Ejura

Treatment	*Meloi*	*Praty*	*Heli*	*Scut*	*Tyl*
TDa 01/0004	60(1.8) ‡	76(1.7)	63(1.7)	43(1.6)	0¤
TDa 01/00029	40(1.8)	63(1.7)	0¤	13(1.3)	60(1.6)
TDa 00/0003	73(1.8)	77(1.7)	117(2.1)	0¤	72(1.6)
TDa 01/00046	107(1.9)	54(1.6)	50(1.6)	0	40(1.5)
Matches	120(2.1)	37(1.4)	26(1.4)	13(1.3)	162(2.3)
Grand mean	(1.9)	(1.6)	(1.4)	(1.4)	(1.7)
Lsd	(0.4)NS	(0.6)NS	(0.4)*	(0.2)*	(0.6)*
CV (%)	(14.1)	(12.5)	(8.6)	(10.3)	(9.7)

Data are means of three replications: ¤Data not used in analysis

‡ln (x + 1) transformed data used in ANOVA in parenthesis
*****= Significant at the 0.05 level, NS= Not significant
Meloi = *Meloidogyne* spp., Praty = *Pratylenchus coffeae*, Heli = *Helicotylenchus multicintus*, Scut = *Scutellonema bradys*, Tyl = *Tylenchulus semipenetrans*.

Galls on tubers caused by *Meloidogyne* spp. was observed only on the local check, Matches with a score of 6 out of 10 at both locations. TDa 01/00046 recorded the highest yield (170.2 and 16.0 kg/40m^2) while TDa 01/00029 recorded the lowest yield (103.7 and 8. 2 kg/40m^2) at Fumesua and Ejura respectively (Table 4). From the Meteorological data presented in (Table 5), sufficient rainfall was recorded at both locations to enhance higher yields of the crop. The highest total rainfall (225.8mm) and (248.3 mm) occurred in June and August at Fumesua and Ejura respectively.

Table 4: Yield of yam (kg)/40m^2 plot at the two locations

Clone	Fumesua	Ejura
TDa 01/0004	144.2	12.5
TDa 01/00029	103.7	8.2
TDa 00/0003	143.2	13.9
TDa 01/00046	170.2	16.0
Matches	126.0	8.8
Grand mean	137.5	11.9
Lsd	31.3*	3.6*
CV (%)	8.4	11.4

Data are means of three replications.
*****= Significant at the 0.05 level.

Resistance genes when available are specific against a single species or race of a pest and would not control other potential pests in fields with a poly-specific community [15]. This assertion was proven in the present study. The genetic potential of a clone could only suppress the infestation of only one species of nematodes while succumbing to other species. At Fumesua for instance, the clones, TDa 01/0004, TDa 01/00029 and TDa 00/0003 were not infected with *Meloidogyne* spp. but the same clones were infected with *P. coffeae*. Similarly, TDa 01/00046 was identified as a favourable host to *Meloidogyne* spp. but not to *P. coffeae*. The local check, Matches was highly infected with *Meloidogyne* spp., *P. coffeae* and *H. multicintus* but not at all with *Rotylenchulus reniformis* at Fumesua.

Table 2: Summary of mean temperatures and total rainfall recorded at Fumesua and Ejura in 2010 respectively

Month	**Mean Temp. (°C)**		**Total rainfall (mm)**	
January	28.3	29.2	14.7	0
February	29.3	30.5	52.7	38.2
March	28.8	30.5	52.6	61.5
April	28.6	29.2	77.3	-
May	27.9	29.2	108.9	224.2
June	26.6	28.0	225.8	165.1
July	25.7	26.7	83.3	161.3
August	25.8	26.5	113.1	248.3
September	26.5	26.8	165.9	198.2
October	27.1	28.3	178.0	221.3
November	27.2	28.3	80.9	127.0
December	29.8	28.2	38.3	0

A similar trend was observed at Ejura. While TDa 00/0003 and TDa 01/00046 were not infected with *S. bradys*, the clones were favourable hosts to *H. multicintus*. However, Matches was highly infected with *Tylenchulus semipentrans*.

The clone TDa 01/00046 recorded the highest yield (42.6 t/ha and 4 t/ha) whilst TDa 01/00029 recorded the lowest yield (25.9 t/ha and 2.1 t/ha) at Fumesua and Ejura respectively. At Ejura yields were significantly low. While TDa 01/00046 out-yielded TDa 01/00029 by 39% at Fumesua, the difference was 48% at Ejura. Ejura which recorded low yields was not disadvantaged rainfall-wise. The rather low yields recorded at Ejura might be attributed in part to the late planting, July as compared with April at Fumesua. Also, the experimental field had been cropped with yam the previous year and since the same crop with the same nutrients requirements, which feed from the same feeding zone was cultivated the following year, yields accordingly declined.

Conclusion

Late planting of yam and planting on exhausted soils should be avoided to enhance higher yields. The highest yielding clone at both locations, TDa 01/00046 with the potential to resist the infection of the lesion nematode, *P. coffeae* should be further studied for multiplication to farmers for cultivation. Two other clones, TDa 01/0004 and TDa 00/0003 which were not different from TDa 01/00046 yield-wise and were not susceptible to the root-knot nematodes *Meloidogyne* spp. are the other promising materials for further evaluation and eventual release to peasant farmers. For sustainable yam production in Ghana therefore, water yam with considerable longer shelf life could be exploited.

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