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Screening of new yam clones (*D. alata* and *D. rotundata*) in nematode prone ecology of guinea savanna zone in West Africa.

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ABSTRACT
Objectives: The main objective of this study was to identify some yam assessions that are tolerant to the most invasive nematodes like *Scutellonema bradys* and *Meloidogyne spp.*
Methodology and results: New assessions of *Dioscorea spp.* were screened in the savanna zone of central Côte d'Ivoire. Fourteen of *D. alata* and thirty seven assessions of *D. rotundata* were tested respectively and separately against two and four local yam varieties in an augmented design from 2000 to 2001. Nine varieties of *D. rotundata* were more resistant to *S. bradys* and Meloidogyne when *D. alata* were less tolerant. The effect of *S. bradys* on *D. alata* was higher in 2001 compared to 2000. The effect of *Meloidogyne* was significantly ($P<0.001$) depressive on the production of *D. rotundata* every year while they were tolerant to *S. bradys*.
Conclusion and application: Identified assessions among *D. rotundata* can be considered as promising varieties in nematode prone ecology. These varieties are 95/01864, 89/02665, 85/01864, 96/00480, 95/18937, 95/00902, BD10, 96/01524 and TDr608. More positive perspective can be achieved by crossing some clones of *D. alata* and these *D. rotundata* .

INTRODUCTION
Yam (*Dioscorea* spp) is important for food security in West Africa which produces more than 90% of the worldwide production (FAO, 2009). Besides its importance as food source, yam also plays a significant role in the socio-cultural lives of people in some producing regions like the celebrated New Yam Festival in West Africa (Osunde and Orhevba, 2009) and wedding ceremonies in Oceania (O'Sullivan, 2008). Yam also provides cash income for a wide range of smallholders, including many women as producers, processors and traders (Asiedu, 2003). Therefore, improving yam productivity can increase food production and farmers' income in the producing areas, particularly in West Africa as propounded by Hgaza *et al*. (2010).

However, yam production in West Africa is affected by several threats including effects low soil fertility, pests and diseases. In the last decade, more investigations (Diby, 2005; O'Sullivan and Ernest, 2008; Ettien *et al*., 2009) were done for soil diagnostic and for recommendation of fertilizer strategy in yam production. Meanwhile, limited works were addressing disease and pest occurrences in yam production systems, especially in Côte d'Ivoire where plant-parasitic nematodes damage is an important factor in yam tuber quality reduction and yield losses in the field and storage. These pests include *Scutellonema bradys, a* yam nematode, *and* root-knot nematode, *Meloidogyne* spp. (Kofoid & White, 2009) which are field and post-harvest pest

(Agbaje *et al*., 2002; 2003; Adegbite *et al*., 2005) frequently observed in yam growing ecology in Côte d'Ivoire. The actual study was initiated to identify tolerant new assessions of *D.alata* and *D. Rotundulata* to *Scutellonema bradys* and *Meloidogyne* spp. injuring in field. The overall goal was to recommend some resistant new assessions to the damages of these pests in order to improve yam cropping system in the agro-ecological zone of West Africa, particularly in Côte d'Ivoire.

MATERIALS AND METHODS

Experiment site description: This study was conducted in Bringakro (6 401'N °, 5 ° 091'W, 150 m alt.) after a long fallow of *Imperata cylindrica.* The site is a transition forest-savanna zone in Côte d'Ivoire. It is an equatorial transition climatic zone with a bimodal rainfall pattern. Total rainfall ranged from 900 to 1300 mm annually. The annual rainfall of 2000 and 2001 are illustrated in Figure 1. Annual average temperature and hygroscopy were 27 °C and 70 % respectively.

Field works: A plot of 600 m^2 was cleaned manually and ploughed (about 20 cm) using a hoe. An earthing up was done to prepare the planting bed of 15 m x 1 m in size. Each planting bed was a replication and four replications were established early in May every year (2000 and 2001). Seeds of *D. alata* were planted in lines at 30 000 plants/ha for eight months of vegetation (May-December) and seeds of *D. rotundata* were planted in lines at 40 000 plants/ha. The length of the subplot was 15 m and the width was 10 m. These parameters of the trial were the same for both species. The total surface used per subplot was 150 m^2. The total surface of the trial is 600 m2. Two trials were setup; one for *D. alata* and one for *D. rotundata*. A line corresponds to one variety of yam was used in each block. For *Dioscorea rotundata*, four yam seeds were planted in a square meter vs 3 yam seed for *D. alata*. Four manual weeding were made from May to December every year. The harvest was done for each variety in December every year after 8 months of vegetation.

Vegetative materials and experimental design: Fourteen (14) new assessions of *D. alata* were tested and compared to two local varieties (table 1) over the two years when thirty seven (37) clones of *D. rotundata* were used with four local varieties (table 2). The experimental design used for each species was the Augmented Design with for replications. In this experimental design the varieties tested is not replicated; only the checks are replicated in the subplot as described by Petersen (1994) and Nokoe (1999).The checks in *D. alata* trial are local cultivars (table 1) and for *D. rotundata* trials' also local varieties (table 2). In 2001, we added for *D. alata* three other varieties from National Agronomic Research Centre: EM-10, C123 and OA-07. For *D. rotundata* it was added *Kangba*, TDr 608 and BD-10**.**

Table 1. Assessions of *D. alata* species and local checks tested in the trial

Yam varieties	Type of Yam	Year 1 of evaluation	Year 2 of evaluation	Origin of assessions
95/001184	assession	2000	2001	IITA
95/00387	assession	2000	2001	IITA
95/00010	assession	2000	2001	IITA
95/00226	assession	2000	2001	IITA
95/00079	assession	2000	2001	IITA
95/00799	assession	2000	2001	IITA
98/01176	assession	2000	2001	IITA
98/01177	assession	2000	2001	IITA
Florido	Control (Local cv)	2000	2001	IITA
Bètè-bètè	Control (Local cv)	2000	2001	IITA
EM-10	assession	-	2001	CNRA
C123	assession	-	2001	CNRA
OA-07	assession	-	2001	CNRA
98/01183	assession	2000	2001	IITA
98/01187	assession	2000	2001	IITA
98/01174	assession	2000	2001	IITA

CNRA: National Agronomic Research Centre
IITA: International Institute of Tropical Agriculture (Ibadan, Nigeria)

Table 2: Assessions of *D. rotundata* specie and the local check tested in the trial

Yam varieties	Type of Yam	Year 1 of assessment	Year 2 of assessment	Origin
89/02672	assession	2000	2001	IITA
95/17120	assession	2000	2001	IITA
96/00165	assession	2000	2001	IITA
89/02474	assession	2000	2001	IITA
89/02602	assession	2000	2001	IITA
95/01967	assession	2000	2001	IITA
96/01469	assession	2000	2001	IITA
95/01469	assession	2000	2001	IITA
95/19177	assession	2000	2001	IITA
89/02677	assession	2000	2001	IITA
95/02040	assession	2000	2001	IITA
96/02614	assession	2000	2001	IITA
96/00116	assession	2000	2001	IITA
95/19127	assession	2000	2001	IITA
Djate	*local check*	2000	2001	farmers
Krengle	*local check*	2000	2001	farmers
Kponan	*local check*	2000	2001	farmers
Kangba	*local check*	--	2001	farmers
96/00504	assession	2000	2001	IITA
96/00110	assession	2000	2001	IITA
96/00172	assession	2000	2001	IITA
96/00420	assession	2000	2001	IITA
95/00827	assession	2000	2001	IITA
95/01864	assession	2000	2001	IITA
96/00153	assession	2000	2001	IITA
89/02665	assession	2000	2001	IITA
85/01864	assession	2000	2001	IITA
95/18531	assession	2000	2001	IITA
91/01176	assession	2000	2001	IITA
96/00480	assession	2000	2001	IITA
96/00330	assession	2000	2001	IITA
96/00629	assession	2000	2001	IITA
95/18937	assession	2000	2001	IITA
89/02475	assession	2000	2001	IITA
95/00902	assession	2000	2001	IITA
96/00573	assession	2000	2001	IITA
95/18158	assession	2000	2001	IITA
89/02655	assession	2000	2001	IITA
96/01524	assession	-	2001	IITA
BD10	assession	-	2001	CNRA
TDr608	assession	-	2001	CNRA

Data collection: At the harvest, each tuber was observed and noted according to its infestation by nematodes and an average was made. The tubers of each variety affected by the nematodes were counted among the tuber per variety. The yield of each variety was determined every year at the harvest by measuring the fresh tuber weight according to the surface. The occurrence of parasites was recorded at harvest according to the scale adopted by IITA (1996) ranging from 1 to 5: 1 (highly tolerance) means no infection, 2 (tolerance) is related to 1-25% of infected tubers, 3 (moderate tolerance) having 26-50 % of infested tubers, 4 (low tolerance) with 51-75% of infested tubers and score 5 related to no tolerance of tuber when more than 75% of total tubers are infested. Each variety per species was observed for *Scutellonema bradys* and *Meloidogynea* spp respectively. *Scutelonema bradys* was described as cracking or lesion of slot on the tuber and Knot-nematode is described as galled and flaky (Fawole, 1988). After the harvest, yam tubers were stored in groups (*D. alata* spp and *D. rotundata* spp.) and fresh weight of tuber was recorded for each clone in a given group.

Statistical analysis: Mean values of tuber yields and the score of nematode occurrence (*Scutellonema bradys* and *Meloidogynea* spp.) were obtained by performing ANOVA for each group (*D. rotundula* and *D. alata*) of yam and for each clone within a group. Annual mean value of each studied nematode occurrence was also obtained by ANOVA. Student-Newman-Keul classification was used to separate mean values. Pearson correlation was performed between the yield of yam tuber and the score of nematode occurrence to investigate the sensitive clone to both studied nematodes. SAS version 8 package was used for the statistical analysis.

RESULTS

Climatic growth conditions: The climatic of the region was described according to the rainfall distribution as a bimodal distribution pattern with two rainy seasons (figure 1). The main rainy season starts from April to the middle of July and the small one runs from September to October. The short dry and long seasons are located between these two rainy seasons (November to February and July to august). The experiments were carried out in the savanna zone. The soils characteristics were described as a sandy loam in the depth of 0 to 30 cm (Hgaza *et al.*, 2010).

Higher potentials of *D. Alata:* Figure 1 shows the overall mean of score related to studied pests (*Meloidogyne* spp, *S. Bradys*) occurrence as observed on yam tubers (*D. rotundula* and *D. alata*) . Significant higher values are observed for *Melodogyne* spp. occurrence on the tubers of *D. Rotundula* than *D. alata* in every year of experimentation. Meanwhile, no significant difference was observed for the occurrence of *S. Brady*s in both groups of yam. However, *S. Bradys* occurrence in 2001 was twice higher for *D. alata* compared to the first year (2000). Definitively, no effect (scored at 1 every year) of *Meloidogyne* spp is observed in the field of *D. alata.*

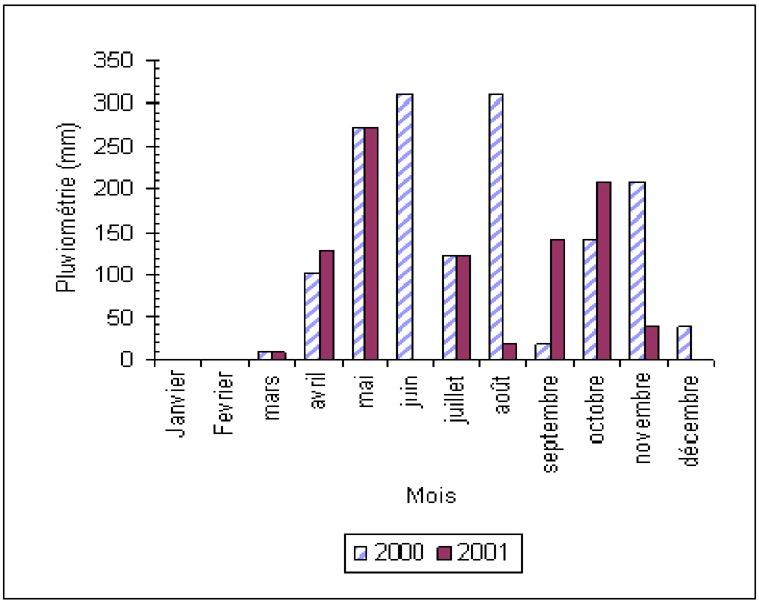

Figure 1: Monthly rainfall site testing in 2000 and 2001

Figure 2 shows the overall mean values of fresh tuber yields for *D. rotundula* and *D. alata* every year (2000 and 2001) of experimentation. Significant higher yields ranging from 16 to 18 t ha^{-1} are observed for *D. alata* compared to the low (10 – 12 tha^{-1}) yield of *D. rotundulata.*

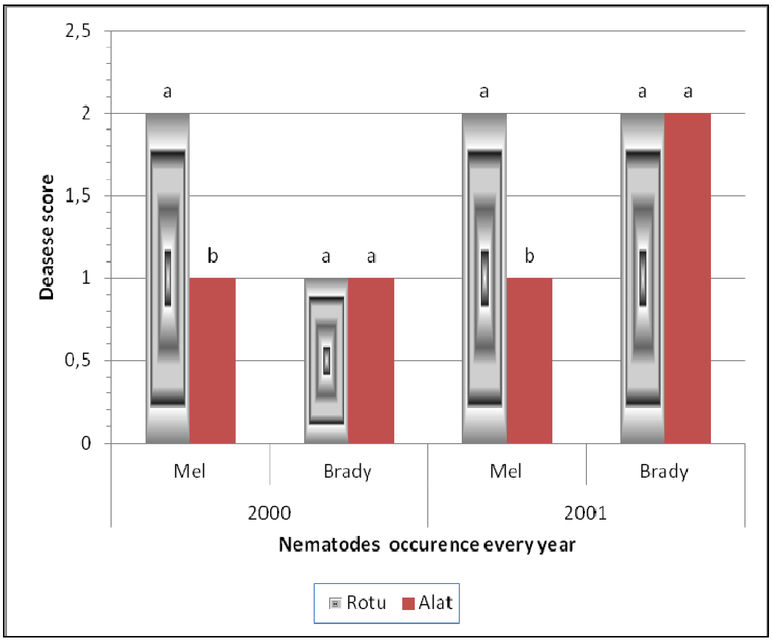

Figure 2: Mean values of score for nematode (Mel and Brady) occurrences in yam field (*D. rotundata and D. alata*) in 2000 and 2001 (a and b are indicating significant mean values).

Figures 1 and 2 reveal lower infection of nematode parasites in the field of *D. alata* whereas, higher yield of fresh tubers are recorded. Potential limitation of *D. alata* and advantage of *D. rotundulata.* Table 1 and table 2 show the type of *D. alata* and *D. rotundata* we evaluated in the trials over the two years. Details of nematodes (*S. bradys* and *Meloidogyne* spp) occurrence in *D. alata* fields are observed in Table 3 as scored on tubers after harvest. Score mean values are low for *Meloidogyne* spp (P=0.694) occurrence with no significant difference between the studied clones and the controls. Nevertheless, a score mean value of 2 is observed for a1183. In contrast, the scores of *S. bradys* damage are observed with significant probability (P<0.001) ranging from 1 to 3 revealing significant difference between studied clones. Traditional cultivars (Florido and Betebete) used as controls have moderate score mean values (1.25 – 1.5). Most sensitive clones to *S. bradys* damage are a226 and OA07, and five others (EM10, a1174, a1184, c123 and a71) are the most tolerant. No clone of *D. alata* scored at 1 for all the studied nematodes. Detailed study of nematode occurrence in *D. rotundulata* field is exposed in Table 4. There are significant differences between score mean values of clones including controls for each of the *Meloidogyne* spp and *S. brady*. The scores are ranging from 1 to 5 for *Meloidogyne* spp and 1 to 3 for *S. brady*. Traditional cultivars (Djate, Krengle, and Kponan) have moderate scores (1.8 – 2.5) for each of the nematode occurrences. More sensitive clones to both nematode damages are 95/01967 and 96/01469 scoring at 3 respectively. Nine clones named 95/01864, 89/02665, 85/01864, 96/00480, 95/18937, 95/00902, BD10, 96/01524 and TDr608, scoring at 1 for each of the nematodes are the most tolerant *D. rotundata* to nematodes occurrence in the studied ecology.

Table 3: Average values of occurrence score for *Scutellonema bradys* and *Meloidogyne* spp observed on the tuber of different clones in the group of *D. Alata*.

	Scutellonema bradys	***Meloidogyne* spp**
a226	3a	1a
OA07	2b	1.5a
a1183	1.5c	2a
Florido (local *control*)	1.5c	1.25a
a10	1.5c	1a
a799	1.5c	1a
a367	1.5c	1a
a1187	1.5c	1a
a1177	1.5c	1.25a
Betebete *(local control)*	1.25cd	1.25a
a1176	1.25cd	1.25a
EM10	1d	1.25a
a1174	1d	1.5a
a1184	1d	1.5a
c123	1d	1.5a
a71	1d	-----
P>F	<0.001	0.694

a, b, c and d are indicating significant mean values at p<0.05 ; -----: data does not reach much.
***The codes of *D. alata* used in this table simplified. The normal codes are mentioned in table 1 (e.g. a226 means TDa 95/00226).

Table 4: Extreme average values of score for *Scutellonema brady* and *Meloidogyne* spp infestations on tuber of *D. Rotundula*.

	***Meloidogyne* spp**	***Scutellonema bradys***
89/02672	5a	1.5cd
95/17120	5a	1d
96/00165	4b	1d
89/02474	-----	3a
89/02602	4b	1d
95/01967	3c	3a
96/01469	3c	3a
95/19177	3c	---
89/02677	2.6cd	2bc
95/02040	2.5cde	1d
96/02614	2.5cde	----
96/00116	2def	1.5cd
95/19127	2def	1d
Djate (control)	*1.8defg*	*1.6bcd*
Krengle (control)	*1.7defg*	*1.3cd*
Kponan (control)	*1.6efg*	*1.5cd*
Kangba (control)	*1.5fg*	*2.5ab*
96/00504	1.5fg	1d
96/00110	1.5fg	1d
96/00172	1.5fg	1d
96/00420	1.5fg	1d
95/00827	1g	1.5cd
95/01864	1g	1d
96/00153	1g	2bc

89/02665	1g	1d
85/01864	1g	1d
95/18531	1g	2.5ab
95/18531	1g	2.5ab
91/01176	1g	3a
96/00480	1g	1d
96/00330	1g	1.5cd
96/00629	1g	------
95/18937	1g	1d
89/02475	1g	3a
95/00902	1g	1d
96/00573	1g	-----
95/18158	1g	-----
89/02655	1g	-----
BD10	1g	1d
96/01524	1g	1d
TDr608	1g	1d
P>F	<0.0001	0.0006

a, b, c, d, e, f and g are indicating significant mean values at p value; -----: data does not reach much.

DISCUSSION

The four most commonly cultivated yams are the water yam (*D. alata* L.), yellow yam (*D. cayenensis* Lam.), Chinese yam (*D. esculenta* [Lour.] Burk.) and the white yam (*D. rotundata* Poir). *D. cayenensis* and *D. rotundata* are indigenous to West Africa. *D. alata* and *D. esculenta* are native to Asia. *D. rotundata* is the most important species of yams in Africa; followed by *D.cayenensis* (Adegbite *et al*. 2006). This information can help to understand the tolerance of some clones of *D. rotundata* to both studied nematodes contrasting with data recorded for *D. alata* : They are probably more adapted to West Africa ecology constraints than *D. alata* . This assertion can be supported by the fact that 95/19177 as a clone of *D. rotundata* was yielding up to 23.08 tha^{-1} very closely to the yields of 89/02461 (24.2 tha^{-1}) and a226 (26.7 tha^{-1}) which are clones of *D. alata* (Figure 3).

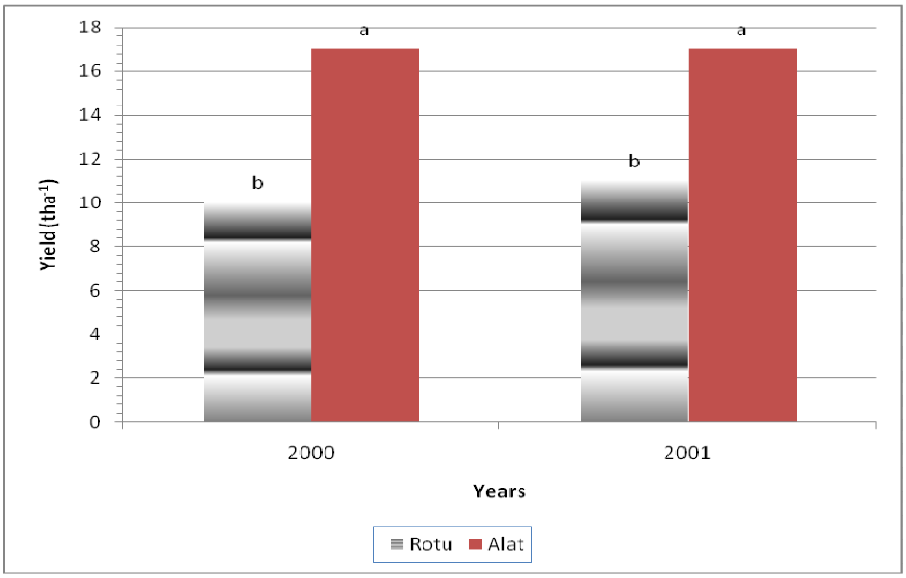

Figure 3: Average yields of yams (*D. rotundata* and D. alata) in 2000 and 2001 (a and b are indicating significant mean values).

However, this specific clone of *D. rotundata* was not identified among the tolerant according to damage score recorded for *Meloidogyne* spp. and *S. bradys* in our results. In opposite, the nine clones that were presumed tolerant didn't appeared among the most yielding clones in figure 3. It looks like that, nematodes infestation did not always impair yam tuber yield in the group of *D. rotundata*. This was supported by the few correlations (limited by the number of data according to experiment design) obtained in Table 3. No significant correlation was observed for *S. bradys* especially. A score mean value of 3 is observed for 95/0167 and 96/01469. The score of Meloidogyne is observed with high significant probability ($p<0.001$ at $\alpha=0.05$). The score of *S. bradys* damage are observed with significant probability ($P<0.0006$ $\alpha=0.05$) ranging from 1 to 3 revealing significant difference between studied clones. Traditional cultivars (Kponan, Krengle, Djate, Kangba) used as controls have moderate score mean values from 1.5 to 1.8 and from 2.5 to 1.3 respectively for *Meloidogyne spp.* and *S. bradys*. Most sensitive clones to *Meloidogyne spp.* damage are 89/02672, 95/17120 and 96/0165. No score over 3 was observed with S. Bradys on *D.rotundata* which could mean that *D. rotundata* are more tolerant to *S. bradys* than to *Meloidogyne spp*. According to the result in table 4 among *D.rotundata* 80% varieties are tolerant to *Melodoigyne spp*. Concerning *S. bradys* the result showed 83% of varieties in table 4 had a score between 1 and 2 theses varieties have been considered tolerant to this pest. These results are important in farming system to increase the yield of yam and to manage cropping system in the tropics (De Waele and Elsen, 2007). Bridge (1996) suggested some solution to improve farming system under tropics conditions where crops are affected by nematodes. He also suggested fighting against nematodes by maintaining or enhancing the biodiversity inherent in multiple cropping and multiple cultivar traditional farming systems to increase the available resistance or tolerance to nematodes. Our results were obtained in a semi traditional cropping system to improve the productivity of yam and farmers were involved in the implementation of the trial to facilitate the adoption of the resistant yam varieties. It was noted in table 5, that for *D. alata*, Florido, a1176 and a1177 are correlated positively to *Meloidogyne spp.* and *S. bradys* when betebete is correlated negatively to the two pests (table 5). The correlation to Meloidogyne spp. is negative for 89/00264 when it is positive for *S. bradys*. Only a variety belong to *D. rotundata* is highly correlated to *Meloidogyne spp*. It means that this variety is sensitive to the damage while the other varieties were revealed tolerant. A local check (Kponan) got a highly correlated coefficient and showed that it is sensitive to Meloidogyne (r=0.94). Some important aspects of diseases and pest and their relationship with new yam varieties and other roots and tubers crops were studied by Coyne and Claudius-Cole (2009). These results showed the resilience of the varieties of *D. rotundata* and of *D. alata* to pest and diseases pressure in the environment.

Table 5: Pearson correlation values between yam yields and the score of *Meloidogyne* spp. and *Scutellonema bradys* damages in some clone of *D. alata* and *D. rotundulata.*

		Pearson correlation (R)	
		***Meloidogyne* spp**	***Scutellonema bradys***
D. Alata	Florido	0.015	0.44
	a1176	-0.25	-0.25
	a1177	-0.40	-0.67
	Betebete	-0.53	-0.53
D. rotundata	89/00264	-0.23	0.54
	89/02461	-0.29	0.07
	89/02569	0.16	0.62
	89/02677	0.90**	-0.11
	Djate	0.10	-0.24
	Kponan	0.94**	-0.08
	Krengle	0.05	0.43

**: highly significant for $P<0.01$.

Low occurrence of nematode damages was observed among the clone of *D. alata* with highest yields (Figures 2 and 3). But, this yam didn't show tolerance to both studied nematodes as did *D. rotundata* according to damage scores recorded. However, we observed highest score of *S. bradys* and lower score of *Meloidogyne* spp.

occurrences (Table 2) for a226 while it had highest yield (26.7 tha^{-1}) in Figure 3. Corroborating with data in table 3, this analyze shows more depressive effect of *Meloidogyne* spp on yam production than *S. Brady*. In fact, root-knot nematodes, *Meloidogyne* spp. are important pests of edible yams, *Dioscorea* spp., wherever they are grown (Bridge, 1982, Fawole, 1988). If preplanted populations of root-knot nematodes are high enough, plant growth and tuber yield are severely affected (Acosta *et al*., 1975; Nwauzor *et al*., 1982; Atu *et al*., 1983, Fawole, 1988). Infected tubers are galled and flaky and may develop abnormal rootlets, especially after a period of storage (Jenkins and Bird, 1962; Fawole, 1988). The occurrence of high score of nematode damages in some clones which had also higher yield, prove the possibility of yield improvement if we can combine high potential yielding to higher tolerance to nematode damage. Based on the results obtained in our study, hydride clone of *D. alata* and *D. rotundata* can help in this way: crossing a226 to one of the eight clones of *D. rotundata* revealed to be tolerant to both nematodes is recommended. Successful breeding of NERICA rice (Jones *et al*., 1997) was drawn from such a strategy: crossing Asian rice (*O. sativa*) with most adapted Africa rice (*O. glaberrima*) even if yam and rice don't belong to the same species. However, further study should also considered ecological factors as rainfall and the variation of soil humidity as random controlling factors of nematodes occurrence. In fact, the variation observed in the results across year for both *Meloidgogyne* and *S. bradys* can be consequence of such factors.

Regarding the yield of the assessions, the figure 4 shows the important yield obtained by a226 and a1176 (*D. ala*), 89/02461, 95/19177 and 95/19156 (*D. rotundata*) over 20 t/ha in comparison with yield in the traditional system with local yam. The yield of local yam as Kponan and Krengle vary usually between 8 to 10 t/ha. Although the nematode pressure on yam is important, the yields of yam evaluated are promising. The highest yield was recorded by a226 (*D. alata*) because less affected par the nematodes. The cracking symptoms caused by *S. bradys* were observed on *D. alata* and on *D. rotundata* tubers at the harvest. The damages were described in Uganda and in Nigeria as dangerous for roots and tubers as yam in African tropical soil (Mudiope *et al*., 2007; Amusa *et al*., 2003). They limit yam yield when they appear in the soil. To reduce the pressure of the nematode, people propose to use a good cropping system that as the integrated soil fertility management (ISFM) by associating legumes and yam in the field.

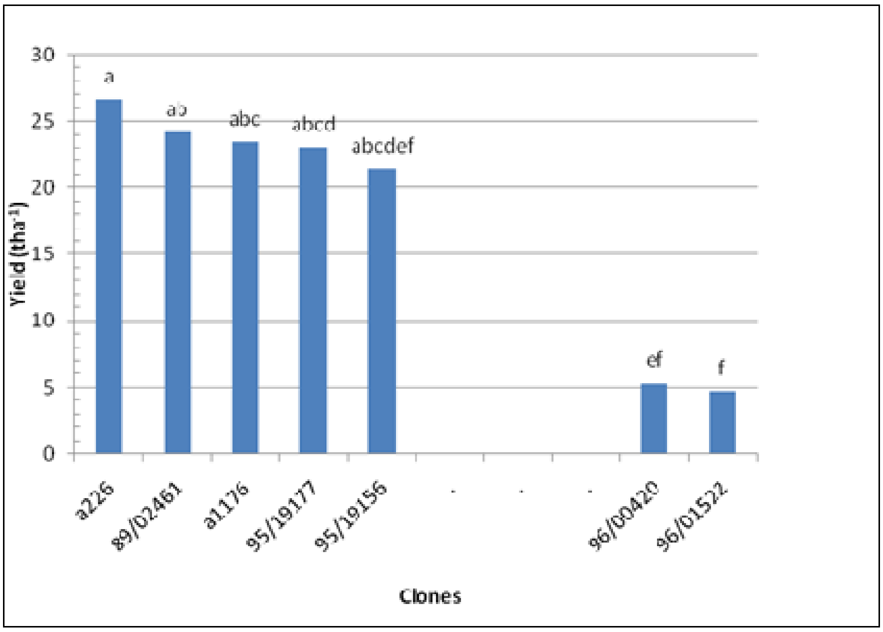

Figure 4: Extreme mean values of yam tuber yields as represented by some studied assessions during the experiment (….: clones not mentioned).

CONCLUSION

In this study it was shown that a few varieties of yam recorded are resistant to the nematode damages. nine varieties of *D.rotundata* specie were identified as more tolerant to the both nematodes while the clones among D.alata species were less sensitive to *S. bradys* and to *Meloidogyne*. Identified clones among *D. rotundata* can be considered as promising varieties in nematode prone ecology. These varieties are 95/01864, 89/02665, 85/01864, 96/00480, 95/18937, 95/00902, BD10, 96/01524 and TDr608. More positive perspective can be achieved by crossing those improved varieties of *D. rotundata* and *D. alata*.

REFERENCES

Acosta N and Ayala A. 1975. Pathogenicity of *Pratylenchus coffeae, Scutellonema bradys, Meloidogyne incognita* and *Rotylenchulus reniformis* on *Dioscorea rotundata.* Journal of Nematology 7:1-6.

Agbaje G.O, Adegbite A. A, Akinlosotu T.A. 2003. Performance of new hybrid yam (*D. rotundata* Poir) varieties in the forest zone of Nigeria. Tropicultura 21(3): 149-152.

Adegbite A. A., Adesiyan S.O, Agbaje G.O, Omoloye A. A. 2005. Host Suitability of Crops under Yam Intercrop to Root-knot Nematode (*Meloidogyne incognita* Race 2) in South-Western Nigeria. J. Agric.Rural Develop. Trop. Subtrop. 106 (2): 113-118.

Adegbite, A.A, Saka, J.O, Agbaje, G.O, Owolade, O.F, Olaifa, G.O, Lawal, A, and Ojo, S.T. 2006. Survey of plant-parasitic nematodes associated with yams in Edo, Ekiti and Oyo states of Nigeria. African Journal of Agricultural Research Vol. 1 (4), pp. 125-130.

Amusa N. A., Adegbite A. A,, Muhammed S. and Baiyewu R. A.. 2003. Yam diseases and its management in Nigeria. African Journal of Biotechnology Vol. 2 (12), pp. 497-502.

Available online at http://www.academicjournals.org

Asiedu R. 2003. Yams production in West Africa and collaborative research. Agron. Afr. Numero Special 4: 173-176.

Atu U. G., Odurukwe, S.O, and Ogbuji, R.O., 1983. Root-knot nematode damage to *Dioscorea totug,data.* Plant Disease 67:814-815.

Bridge J. 1982. Nematodes of yams. Pp. 263-274 *inJ.* Miege and S. N. Lyonga, eds. Yams: Ignames. Oxford: Clarendon Press.

Bridge J. 1996. Nematode management in sustainable and subsistence agriculture. Annu. Rev. Phytopathol. 34:201-225. Downloaded from www.annualreviews.org

De Waele D. and Elsen A. 2007. Challenges in Tropical Plant Nematology. Annu. Rev. Phytopathol. 45:457-485. Downloaded from www.annualreviews.org

Diby N.L 2005. Etude de l'elaboration du rendement chez deux espèces d'igname (*Dioscorea* spp.). Thèse unique de Doctorat, Universite de Cocody, Abidjan. 180p.

Ettien D.J.B, Kone B, Kouadio K.K.H, Kouadio, N.E., Yao-Kouame A., Girardin, O. 2009. Fertilisation minérale des ferralsols pour la production d'igname en zone de Savane Guinéenne de l'Afrique de l'Ouest: cas des variétés d'igname traditionnelles sur dystric ferralsols du Centre de la Côte d'Ivoire. J. Appl. Biosci. 23: 1394-1402.

FAO. 2009. FAOSTAT Crop production data. http://faostat.fao.org

Gifford R.M, Thorne JH, Hitz MD, Glaquinta, R.T. 1984. Crop productivity and photo-assimilate partitioning. Sci. 225: 801-808

Hgaza V.K, Diby L.N, Assa, A. and Ake, S. 2010. How fertilization affects yam (*Dioscorea alata* L.) growth and tuber yield across the years. African Journal of Plant Science, Vol. 4(3): 053-060.

Jenkins W. R., and Bird, G.W. 1962. Nematodes associated with wild yam, *Dioscorea* spp., with special reference to the Pathogenicity of *Meloidogyne incognita.* Plant Disease Reporter 46:858-860.

Jones M.P., Dingkuhn G.K, Aluko, G.K, Semon, M. 1997. Interspecific Oryza saltiva × O. glaberrima Steud. Progenies in upland rice improvement. *Euphytica.,* **94**: 237–246.

Mudiope J., Speijer P.R., Coyne D., Maslen R.N., and Adipala E. 2007. Nematode distribution and damage to yam in Central and Eastern Uganda. African Crop Science Journal, Vol. 15, No. 2, pp. 93 – 99.

Nwauzor E. C., and Fawole, B. 1982. Root knot nematodes on yams in Eastern Nigeria. Pp. 161-167 *in* Proceedings of the Third Research Planning Conference on Root-knot Nematodes, *Meloidogyne* spp. Raleigh: North Carolina State University Graphics.

Nokoe S. 1999. On-farm trials: surgical or preventive approach? Journal of Tropical Forestry Resources. 15 (2), 93-103.

O'Sullivan J.N. 2008. Root distribution of yam (*Dioscorea alata*) determined by strontium taker. Expl. Agric. 44: 223-233.

O'Sullivan J.N, Ernest, J. 2008. Yam nutrition and soil fertility management in the Pacific. Australian Centre for International Agricultural Research, Brisbane.143p.

Osunde Z.D, Orhevba, B.A. 2009. Effects of storage conditions and storage period on nutritional and other qualities of stored yam (*Dioscorea spp*) tubers. Afr. J. Food Agric. Nutr. Dev. 9(2): 678-690.

Petersen R. G. 1994. Agricultural field experiments: design and analysis. Marcel Dekker, Inc. 409.