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Evaluation of yam varieties for reaction to plant parasitic nematodes infestation in three agro-ecologies of Ghana

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Three popular yam varieties; Pona, Dente and Afebetua were evaluated for their reaction to plant parasitic nematodes infestation in three districts (Atebubu, Kintampo and Wenchi) of Ghana where yam is intensively cultivated. Plant population/12 m^2 plot, nematode population/200 cm^3 rhizosphere soil, nematode population/5g tuber peels, tuber gall index and yield were analyzed using the mixed model (REML) approach in GenStat. Plant establishment of Pona at Wenchi was 63% higher than at Atebubu. Three nematodes; *Meloidogyne* spp., *Pratylenchus coffeae* and *Scutellonema bradys* were isolated from rhizosphere soils across the locations. *Meloidogyne* spp. population on Afebetua was 41 and 61% higher than on Dente at Kintampo and Wenchi respectively. Similarly, 64 and 89% more *Pratylenchus coffeae* were found on Afebetua than on Dente at Atebubu and Wenchi, respectively. Significantly higher (P < 0.05) populations of *Meloidogyne* spp. juveniles were extracted from tuber peels in Pona, Dente and Afebetua at Wenchi than at Atebubu. Afebetua was the highest yielding variety. It out yielded Pona by (87, 45 and 71)% and Dente by (66, 81 and 62)% at Atebubu, Kintampo and Wenchi, respectively.

Keywords: *Dioscorea rotundata, Meloidogyne* spp., *Pratylenchus coffeae, Scutellonema bradys*

INTRODUCTION

White yam, *Dioscorea rotundata,* a subspecies of *Dioscorea cayenensis* is an important economic crop especially, in the yam belt zone of West Africa (CGIAR, 2008). Many farm-families depend on the tubers for food, cash, local food security and other traditional uses. The tubers provide a substantial intake of vitamins (thiamine and vitamin C), iron and potassium (Rudrappa, 2013). Peels and over matured tubers are used to feed domestic animals such as pigs, goats, and chickens. More importantly, many of the *Dioscorea* spp. have high content of steroidal saponins which make them suitable for industrial applications as corticosteroids precursors and anti-cancer bioactive compounds (Avula et al., 2014; Yutong et al., 2015). White yam is gradually being realized as an important non-traditional crop for export in Ghana. Yam ranks second after pineapple in terms of volume and value of non-traditional export crops in Ghana (Asuming-Brempong, 1994) and the second highest producer in the world after Nigeria (FAO stats, 2005). Yam stores relatively longer in comparison with other tropical fresh produce, and therefore represents stored wealth, which can be sold all-year-round by the farmer or marketer (Aidoo, 2009).

However, diseases and pests constitute a major constraint to *D. rotundata* production in the field. It is severely damaged by plant parasitic nematodes (PPN) reducing yield, food quality, and market value; and sprouting (Yusuf and Okunsanya, 2008). Reduction of 20-30% in tuber weight at harvest has been reported (Plowright and Kwoseh, 2000). Also, nematode infection contributes to long term storage losses estimated as 50%, and in some instances loss could be total (Amusa et al., 2003).

Three economically important nematode pest species namely: yam nematode, *Scutellonema bradys*; root-knot nematodes, *Meloidogyne* spp. and lesion nematode, *Pratylenchus coffeae* are known to infect *D. rotundata*. Nematodes are usually concentrated between 2 mm and 6 mm in infected yam tubers (Coyne et al., 2006).

Chemicals, bionematicides, cultural methods such as hot water treatment of infected seed yams prior to planting, crop rotation, biological control, the use of resistant varieties and integrated management, could be used to control plant parasitic nematodes. Most of the management options are limited in use due to high costs, time, feasibility and adverse effects on the environment and mammalian toxicity (Plowright and Kwoseh, 2000). *Dioscorea rotundata* cultivars with resistance to nematodes infection would provide a cheapest and an attractive nematode management option appropriate to smallholder farm families.

In the present study, three popular *D. rotundata* cultivars in Ghana were evaluated for their reaction to nematodes infection under natural field conditions at Atebubu, Kintampo and Wenchi all in the Brong Ahafo region of Ghana.

MATERIALS AND METHODS

Study sites

The trials were conducted in three districts in the Brong Ahafo region of Ghana. The sites were; Prumu Keae (Atebubu district), Gyina Pintin (Kintampo district) and Amponsakrom (Wenchi district). *D. rotundata* is extensively cultivated in these areas and initial parasitic nematode population densities were perceived to be very high. All the sites experience bimodal rainfall pattern. The geo-ecological, climatic and edaphic descriptions of the sites are presented in Table 1.

Experimental design

Land preparation was done manually by clearing weeds with a cutlass and debris was collected. Stumps were removed with a mattock and pick-axe before mounds were raised at a planting distance of 1m x 1m. There were 20 mounds of four rows on a 3 m x 4 m plot size. Trials were mounted on Randomized Complete Block Design (RCBD) with five replications on a total land area of 450 m^2 at each site.

Plant material

Three popular *D. rotundata* cultivars; Afebetua, Dente and Pona commonly cultivated by farmers and highly patronized by buyers were selected for the trials. The cultivars were purchased from the open markets at the respective districts (Atebubu, Kintampo and Wenchi). Yam setts averaging 350 g were used for planting. Setts were tested for presence of plant parasitic nematodes prior to planting. Five gram tuber peel samples were taken at planting and processed for plant parasitic nematodes. Peel samples were replicated five times. Setts were placed in the hole made with a hoe in the mound and properly covered with soil. Dry straw was placed on top of the mounds for moisture preservation after planting. After sprouting, yam vines were supported with stakes and the experimental trials were each weeded three times before harvest. The trials had five replications at each location and repeated two times during (2013 and 2014) planting seasons.

Soil sampling for nematodes

Initial soil sampling was collected prior to planting to determine plant parasitic nematodes population densities at the various sites. Stand establishment was taken 3 months after planting. At harvest, soil samples (200 cm^3/ mound) were randomly collected with a 2.5 cm diam soil probe to a depth of 20 cm from the mounds. Three soil cores were collected from each mound. Five gram tuber peel samples were processed for nematodes from the tubers at harvest. Three tubers per plot were peeled for extraction. Nematodes were extracted from soil and peel samples 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 second, third and fourth stage nematodes were mounted on aluminium double-coverglass slides and specimens were identified (CIH, 1978) by morphology. Plant parasitic nematode population data are expressed as number of nematodes/200 cm^3 soil and number of endo-parasitic nematodes population/5 g of tuber peel.

Data analysis

The two years data (2013 and 2014) was analyzed using the mixed model (REML) approach. Yield (kg) of yam

Table 1: Geo-ecological, climatic and edaphic descriptions of study sites

Study sites	Location	Mean Rainfall(mm)	Mean temperature (°C)	Relative humidity(%)	Soil type
Prumu Keae	7º 23′N 1º26′W	1,600	26.8	90	Laterite
Gyina Pintin	8º 45′N 2º1′E	1,600	27.0	95	Ochrosols
Amponsakrom	7º 30′N 1º55′E	1,200	24.5	90	Ochrosols

Source: Districts information, 2006.

Table 2: Root-knot nematode population/200 cm^3 of rhizosphere soil

Variety	Atebubu	Kintampo	Wenchi
Pona	31 (4.6)* a	1450 (30.2) b	445 (17.4) a
Dente	74 (8.4) a	775 (3.1) a	695 (20.1) a
Afebetua	136 (10.8) b	1320 (28.7) b	1800 (33.7) b
Lsd (α = 0.05)	(4.3)	(13.2)	(11.4)

*Log transformed ln (x + 1) data used in analysis in parenthesis. The values are means of five replicates. The values followed by the same letter(s) in a column are not different according to the Fisher's Least Significance Difference (LSD) test.

Table 3: *Pratylenchus coffeae* population/200 cm^3 of rhizosphere soil

Variety	Atebubu	Kintampo	Wenchi
Pona	26 (4.0)* b	112 (8.3) a	185 (10.3) b
Dente	9 (2.3) a	154 (11.2) a	60 (6.1) a
Afebetua	22 (3.6) c	110 (8.3) a	560 (15.5) c
LSD (α = 0.05)	(1.1)	(9.9)	(2.7)

*Log transformed ln (x + 1) data used in analysis in parenthesis. The values are means of five replicates. The values followed by the same letter(s) in a column are not different according to the Fisher's Least Significance Difference (LSD) test.

being continuous data was not transformed. Nematode count data however was log transformed (ln (x +1)) to improve homogeneity of variance before analysis using GenStat 8.1 (Lawes Agricultural Trust, VSN International). Means were separated using Fisher's Least Significant Difference (LSD) at α = 0.05.

RESULTS AND DISCUSSION

Plant establishment of Pona at Wenchi was significantly ($P < 0.05$) higher (63%) than at Atebubu and not different at Kintampo (Figure 1). Sprouting and establishment of yam is an index of seed quality. Diseased and partially rotten seed yam would not sprout and if it does would not produce a healthy plant. The Pona variety compared with the other varieties easily go bad particularly under intense heat storage system as obtains in farmers' fields. The Pona seed procured at Atebubu was comparatively bad which resulted in very poor sprouting percentage. The comparatively better seed procured from Wenchi resulted in uniform establishment for all the varieties.

Three nematodes; the root-knot nematode, *Meloidogyne* spp., the lesion nematode, *Pratylenchus coffeae* and the yam nematode, *Scutellonema bradys* were isolated from rhizosphere soils across the locations (Tables 2, 3 and 4). The three plant parasitic nematodes encountered have been recorded as major yam pests (Coyne et al., 2006).

Afebetua variety suffered significant root-knot nematode infestation at Kintampo and Wenchi while Dente was least affected at both locations. Forty-one and 61% more root-knot nematodes were recovered from the rhizosphere of Afebetua than Dente at Kintampo and Wenchi, respectively (Table 2). Similarly, 64 and 89% more *Pratylenchus coffeae* were found on Afebetua than on Dente at Atebubu and Wenchi, respectively (Table 3). With regards to *Scutellonema bradys* infestation however, there were no differences in the pest levels between Dente and Afebetua across locations. Pona was the worst affected variety at Wenchi. Significantly less (75%) nematodes were found on Dente than on Pona

Table 4: *Scutellonema bradys* population/200 cm^3 of rhizosphere soil

Variety	Atebubu	Kintampo	Wenchi
Pona	8 (2.2)* a	770 (17.4) b	1365 (33.2) b
Dente	10 (2.7) a	325 (9.3) a	780 (22.3) a
Afebetua	26 (4.2) a	375 (11.2) a	460 (20.9) a
LSD (α = 0.05)	(3.3)	(6.1)	(8.6)

*Log transformed ln (x + 1) data used in analysis in parenthesis. The values are means of five replicates. The values followed by the same letter(s) in a column are not different according to the Fisher's Least Significance Difference (LSD) test.

Table 5: Yield (t/ha) of varieties at the three locations

Location	Atebubu	Kintampo	Wenchi
Pona	2.9	11.2	8.6
Dente	7.6	3.9	11.3
Afebetua	22.1	20.3	29.8
LSD (α = 0.05)	8.2	8.4	7.3

The values are means of five replicates

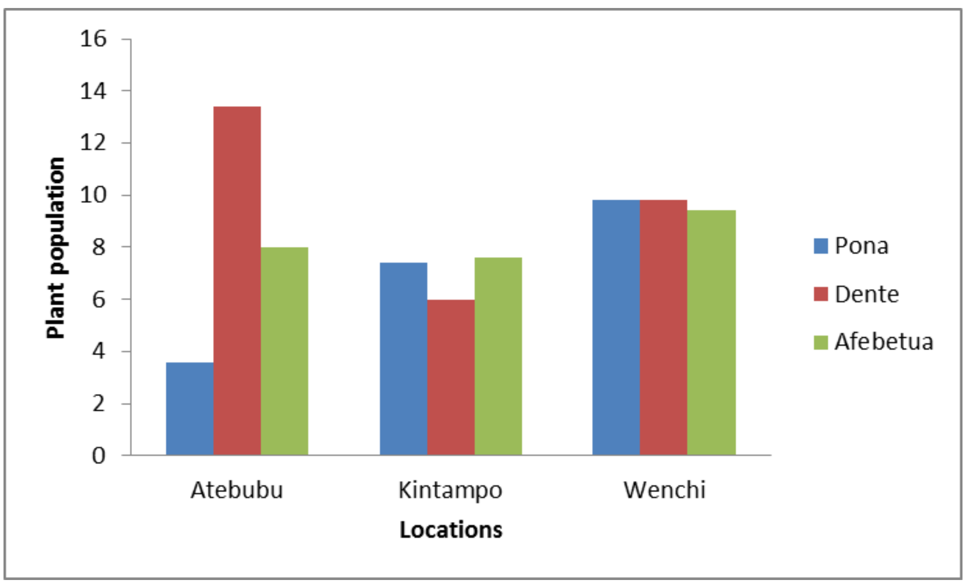

Figure 1. Plant population of varieties at the three locations

(Table 4). Peel samples from the planting material extracted for nematodes prior to planting did not yield any. However, at harvest, as many as (325, 655 and 345) root-knot nematodes juveniles were extracted from 5g tuber peels in Pona, Dente and Afebetua, respectively at Wenchi compared with significantly low levels (26, 58 and 28) at Atebubu, respectively (Figure 2). Generally, nematode pressure was highest at Wenchi.

There were no differences in yam varieties reaction to feeding by root-knot nematodes in inciting tuber galls (Figure 3).

Plant parasitic nematodes have been reported to cause yield losses in yam production (Bridge et al., 2005). However, in the current study, different results were obtained as Wenchi, which recorded the highest nematode population densities recorded the highest yields of varieties (Table 5). Afebetua was the highest yielding variety. It out yielded Pona by (87, 45 and 71)% and Dente by (66, 81 and 62)% at Atebubu, Kintampo and Wenchi, respectively. Thus, the variety could be said

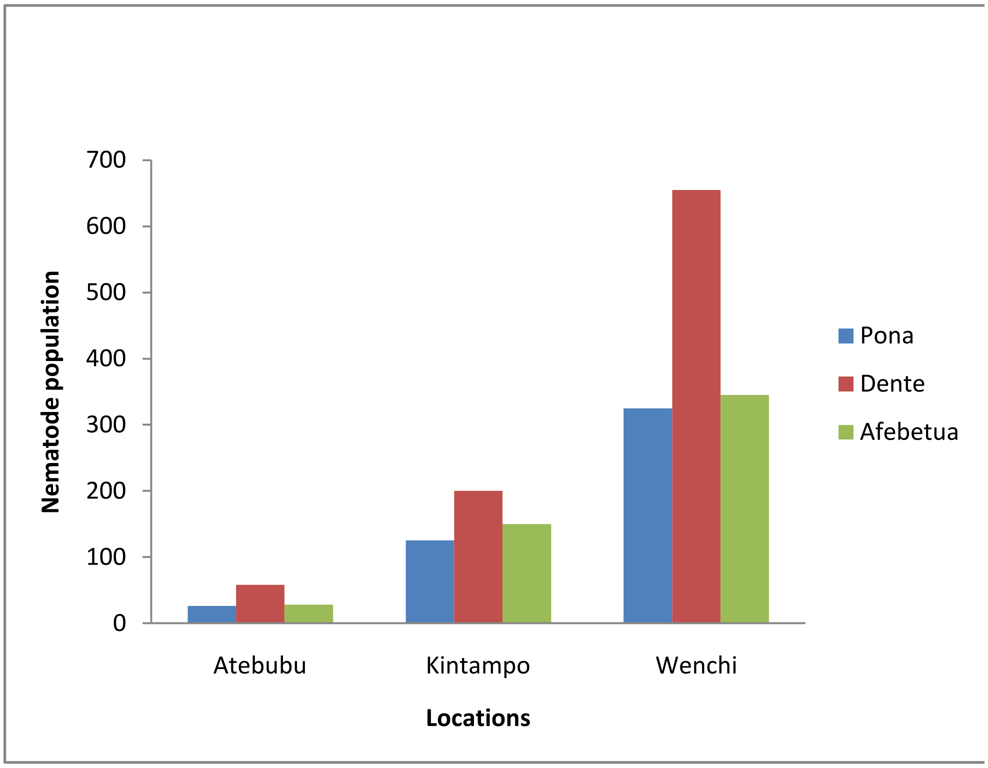

Figure 2. Root-knot nematode population/5g tuber peels at the three locations

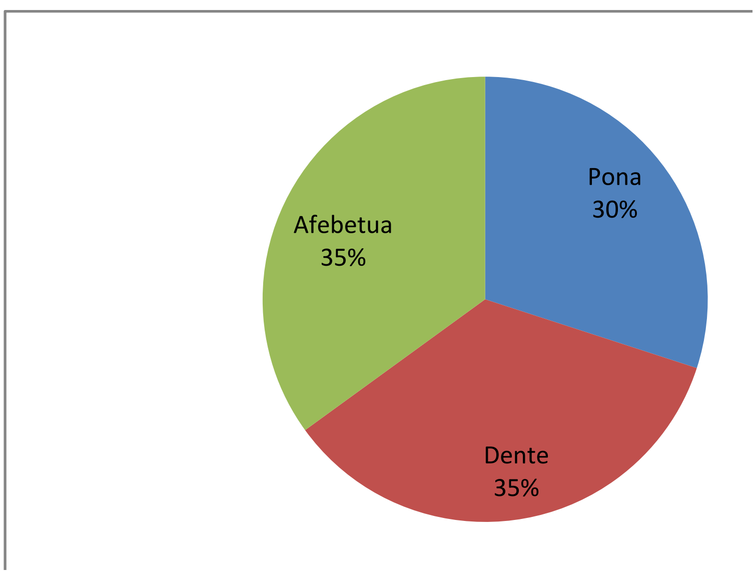

Figure 3. Tuber gall index of varieties at the three locations

to possess some levels of nematode tolerance. Across locations, Dente's performance regarding resisting nematode population build up was the best.

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REFERENCES

Aidoo R (2009). An analysis of yam consumption patterns in Ghanaian urban communities. PhD. Thesis submitted to the School of Graduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Amusa NA, Adegbite AA, Muhammed S, Baiyewu RA (2003). Yam diseases and its related management in Nigeria. African Journal of Biotechnology 2(12): 497-502.

Asuming-Brempong S (1994). Yam for foreign exchange: potentials and prospects in Ghana; ISHS Acta Horticulture 380, Symposium on tropical root crops in a developing economy, November 1994.

Avula B, Wang YH, Ali Z, Smillie TJ, Khan IA (2014). Chemical fingerprint analysis and quantitative determination of steroidal compounds from *Dioscorea villosa, Dioscorea* species and dietary supplements using UHPLC-ELSD. Biomedical Chromatography 28 (2):281-294.

Bridge J, Coyne DL, Kwoseh C (2005). Nematode parasites of tropical root and tuber crops. In: “Plant parasitic nematodes in subtropical and tropical agriculture” (Second edition). M Luc, RA Sikora, J Bridge (eds), CABI Wallingford, UK, 221-258.

CGIAR (2008). What’s bad for yam? Cgiar News, May 2008. http://www.cgiarNews.org/enews/May2008.

CIH (1978). Commonwealth Institute of Helminthology Description of plant parasitic nematodes. CAB International, Wallingford, UK.

Coyne DL, Tchabi A, Baimey H, Labuschagne N, Rotifa I (2006). Distribution and prevalence of nematodes (*Scutellonema bradys* and *Meloidogyne* spp.). Field Crops Research 69 (1): 142-150.

Districts information (2006). Profile of Municipal and district Assemblies. Available at www.ghanadistricts.gov.gh.

FAOSTAT (2005). FAOSTAT Crop production data. Retrieved from http://faostat.fao.org FAO, Rome, Italy.

Plowright R, Kwoseh C (2000). Identification of resistance to major nematode pests of yams (*Dioscorea* spp.) in West Africa. R6694 (ZA0021). Final Technical Report, 1 April 1996-31 March 2000. CABI Bioscience, Bakeham Lane, Egham Surrey TWT20 9TY.

Rudrappa U (2013). Yams nutrition facts and health benefits. http://www.nutrition-and-you.com/yams.html

Yusuf C, Okunsanya BAO (2008). Fungi associated with storage of yam (*Dioscorea rotundata*) in Yola, Adamawa state. Journal of Sustainable Development in Agriculture and Environment 3(2): 99-103.

Yutong C, Chun D, Chengcai H, Yuling Z (2015). Enhanced production of diosgenin from *Dioscorea zingiberensis* in mixed culture solid state fermentation with *Trichoderma reesei* and *Aspergillus fumigatus*, Biotechnology and Biotechnological Equipment, DOI: 10.1080/13102818.2015.1032352