academicJournals

Vol. 9(9), pp. 346-351, September 2015
DOI: 10.5897/AJPS2015.1275
Article Number: 52EC05B55506
ISSN 1996-0824

http://www.academicjournals.org/AJPS

African Journal of Plant Science

Full Length Research Paper

Management of plant parasitic nematodes with fulan in mechanized yam production

K. Osei*, S. A. Ennin, Y. Danso, E. Owusu Danquah and J. Adomako

CSIR- Crops Research Institute, Box 3785, Kumasi, Ghana.

Received 6 February, 2015; Accepted 16 September, 2015

The potential of Fulan (2,5-dimethoxytetrahydrofuran), a synthetic nematicide applied at 10 g /stand and two plant bed types; ridging and mounding to manage plant parasitic nematodes and increase the yield of yam was investigated at Ejura during 2011 and 2012 at three levels of N-P_20_5-K_50 (NPK). The factorial experiment was mounted on randomized complete block design and replicated three times. Ridged bed type + the highest level of fertilizer applied (60, 60, 80 kg/ha N-P_20_5-K_20) + Fulan application interacted positively ($P < 0.05$) resulting in significant yields (32 and 30%) over the control treatments in mound and ridged bed types, respectively. The same treatment resulted in the highest marketable weight of yam which was 61% over ridged bed type + fertilizer applied at 60, 60, 80 kg/ha N-P_20_5-K_20 without Fulan application. Cracks were significantly low in Fulan treated tubers. The outstanding reduction in cracks was recorded in mound + F4 + Fulan which were 92% less than mound bed type only (control) tubers. Additionally, Fulan application suppressed nematode densities. The remarkable suppression in *Meloidogyne incognita* and *Pratylenchus coffeae* occurred in ridged bed type + fertilizer applied at 45, 45, 60 kg/ha N-P_20_5-K_20 + Fulan treatment which was 93% over mound bed type without fertilizer and Fulan application and 97% over mound bed type + fertilizer applied at 60, 60, 80 kg/ha N-P_20_5-K_20 without Fulan application, respectively. Ridged bed type appeared to be the better plant bed type alternative since the highest yield and nematode suppression were recorded in that option; besides, ridging presents drudgery saving intervention which farmers could exploit.

Key words: *Dioscorea* species, drudgery saving intervention, Fulan, plant bed type.

INTRODUCTION

Yams (*Dioscorea* sp., family Dioscoreacea) constitute a major carbohydrate food source in West Africa (Osunde and Yisa, 2003). The tubers have organoleptic qualities which make them the preferred carbohydrate staple and can contribute up to 350 dietary calories per person each day (Asiedu et al., 2001). The plant has a tremendous sink capacity to store food reserves and individual tubers may weigh as much as 20-30 kg (Fuccillo et al., 2007).

*Corresponding author. E-mail: oseikingsley4@gmail.com. Fax: +233-51-60396.

Yam therefore has immense potential as an “insurance crop” in Africa where it is heavily depended upon, because it plays a vital role in food security both at household and national levels. Yams are utilized in different ways in West Africa, a known centre of yam diversity and production. In Ghana for instance, yams may be boiled, mashed, fried or roasted. Pounded yam or “fufu” eaten with soup is a very popular form of yam consumption. Ghana is the leading exporter of yam in Africa with yam contributing to 16% of the Agricultural GDP (FAOSTAT, 2006). Besides, tubers are processed into flour, noodles, chips, and dry slices (Zheng, 2011).

Being a popular food product, yam has a surprising number of alternative uses. In the pharmaceutical industry, diosgenin, a steroidal saponin is extracted from the root of wild yam (*D. villosa* L.) with the potential to minimize post-menopausal symptoms (Benghuzzi et al., 2003) while dioscorin is extracted from the tuber of Chinese yam (*Dioscorea batatas* Decne) with sufficient antioxidant potential which confers on it tremendous health benefits (Wen-Chi et al., 2001).

In the hedonistic world, (*Dioscorea opposita* Thunb.) yam has been successfully used for the preparation of beer (Xu, 2007). The general significance of yams in the lives of a people cannot be over emphasized. However, the production of this tuber crop is constrained by both biotic and abiotic factors. Plant parasitic nematodes constitute a major biotic factor that constrains the production of yams. Those known to cause serious damage are the yam nematode (*Scutellonema bradys* Steiner and LeHew), the lesion nematode (*Pratylenchus coffeae* Zimmermann) and the root knot nematodes (*Meloidogyne* Goeldi spp). The yam nematode, *S. bradys* causes a decay of tubers known as “dry rot disease”. *P. coffeae* cause deep cracks on tubers leading to a corky appearance and diseased tubers become spongy (Bridge et al., 2005). *Meloidogyne* species cause galling of roots and tubers which appear warty. Nematode infestation reduces the market value of yam tubers which negatively affects the farmers’ profit margin.

For sustainable yam production therefore, the nematode menace should be managed. Synthetic agro-pesticides (nematicides) appli-cation is the single most effective management strategy against nematodes (Noling, 2012). It is universally acknowledged that synthetic agro-pesticides usage presents environmental problems (Bell, 2000). However, recommended agro-pesticides applied at the recom-mended dosages could be successfully used for food production without endangering man and the environ-ment. Planting on ridges has been shown to increase root and tuber yields (Ennin et al., 2009). The seed bed type has also been reported to interact with fertilizer application with planting on ridges resulting in higher yam tuber yield response to fertilizer than the traditional method of planting on mounds (Ennin et al., 2013). The two-fold objectives of this study therefore, were to use a recommended nematicide, Fulan (a non-fumigant with 90 days waiting period and dimethoxytetrahydrofuran) in managing plant parasitic nematodes population, and to investigate nematode control interactions with seed bed type and fertilizer application on yam production.

MATERIALS AND METHODS

Study site

The field trial was conducted in 2011 and 2012 during the major rainy seasons at Ejura in the Ejura Sekyedumasi District of the Ashanti region. Ejura is located on 07º 24′N 01º 21′W in the forest-savanna transitional zone of Ghana. It experiences a bimodal rainfall pattern. The soil type is a “Amantin series” Chromic Lixisol.

Experimental set up and treatments

The experimental field had been cropped with two varieties of yam (Dente and Pona) for the previous two years and plant parasitic nematodes population was therefore perceived to be very high. The field was ploughed, harrowed and eight (8) of the 16 plots in a replication were ridged (mechanized) while the remaining eight were mounded. The three factor experiment had plant bed type (mounding or ridging) as the main plot; fertilizer application (F1= 0 (control); F2 = 45, 45, 60; F3 = 60, 60, 60; F4 = 60, 60, 80) kg/ha N-P_20_5-K_20 as sub plot and Fulan (2, 5-dimethoxytetrahydrofuran from Sigma-Aldrich) a nematicide applied at (0 (control) and 10 g /stand) as sub-sub plot. The fertilizer was 50% split and applied in bands at 4 and 12 weeks after planting. Treatments were replicated three times. A plot measured 12 x 4.8 m of 40 mounds or four ridges of 10 stands per ridge resulted in 40 stands. Spacing on both ridges and mounds was 1.2 x 1.2 m. One variety of yam, Dente was used in planting.

Sett treatment before planting

Disease-free yams were cut into 350 g sections with a sharp kitchen knife. These were neatly packed into cane basket and nested in a 15 l plastic receptacle containing-a mixture of ordinary wood ash, Dursban (chlorpyrifos at 80 ml) an insecticide and Mancozeb, a fungicide (dithiocarbamate 80%; 120 g) in 15 l of water. The preparation was well stirred with the aid of a metal rod. The chemical solution completely covered all the setts in the cane basket before removal and air-dried under tree shade for 24 h before planting. The purpose was to control insect pests and fungal infections respectively. Fulan,10 g/stand was placed in the planting hole, covered with a little soil and the yam sett placed in it with the cut surface directed upwards and properly covered with soil. 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) before planting of yam and at harvest of the crop (December) with a 5 cm wide soil auger to a depth of 20 cm. The soil samples, 200 cm^3 per treatment were extracted using the modified Baermann funnel method. After 24 h of extraction,

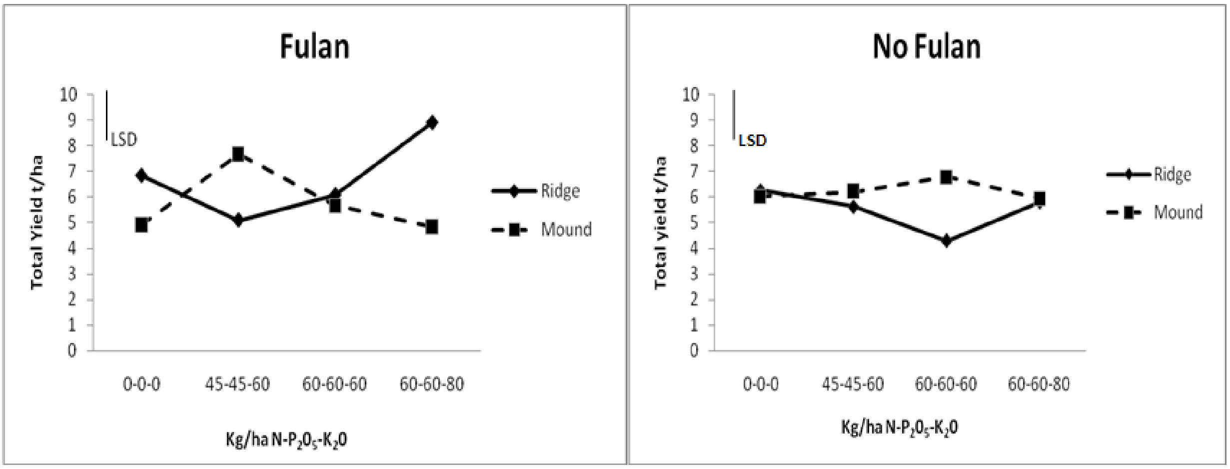

Figure 1. Effect of seedbed, fertilizer and fulan on yield of yam.

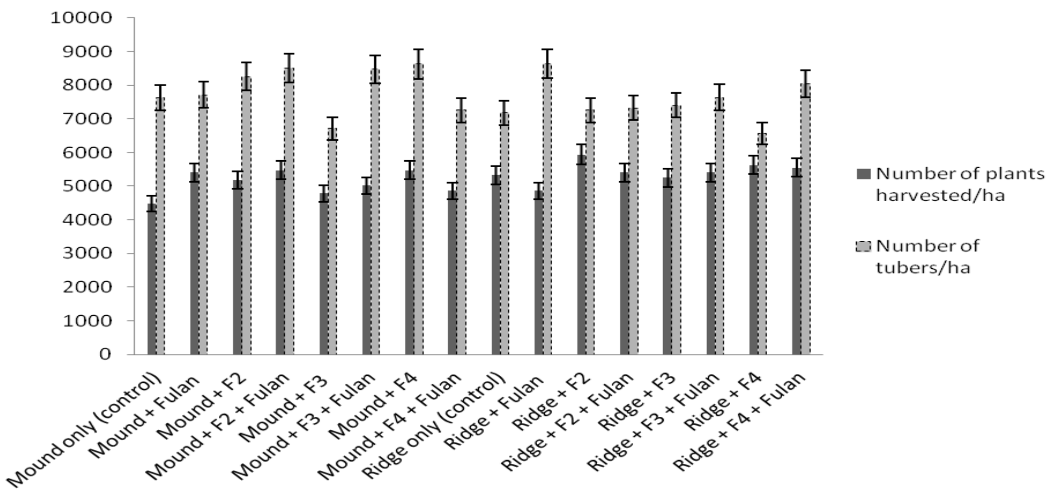

Figure 2. Number of plants and tubers harvested.

nematodes were relaxed in water at (60ºC) for 3 min and fixed with 40: 1: 89 (formalin: glacial acetic acid: distilled water). Second, third and fourth stage nematodes were mounted on aluminium double-cover glass slides and specimens were identified (CIH, 1978) by morphology under the stereo microscope at 100x while root-knot nematodes were identified through perineal pattern (Jepson, 1987). Tuber galling index (TGI) based on Zeck's 0-10 scale (Sikora and Fernandez, 2005) was recorded at harvest.

Data analysis

The two years data were pooled and analyzed once using the mixed model (REML) approach. Nematode count and indices based data were log (ln (x +1)) and square root $\sqrt{(1+0.5)}$ transformed to improve homogeneity of variance before analysis using GenStat 8.1 (Lawes Agricultural Trust, VSN International). Significant mean separation was determined with Fisher's Protected Least Significant Difference (LSD) Test at $\alpha \leq 0.05$.

RESULTS

Significant ($p < 0.05$) differences were observed amongst treatments in yield of yam. Ridged bed type + the highest level of fertilizer applied (60-60-80 kg/ha) N-P$_2$0$_5$-K$_2$0 + Fulan application interacted positively ($p < 0.05$) resulting in the highest yields which were 32% and 30% over the control treatments on mound and ridged bed type respectively (Figure 1).

The same treatment resulted in the highest total yield of yam which was 61% over ridged bed type + fertilizer applied at 60-60-60 kg/ha N-P$_2$0$_5$-K$_2$0 without Fulan application (Figure 1). However, no differences were observed in both the number of plants and tubers harvested amongst treatments (Figure 2). All treatments were equally affected by anthracnose and virus infections

Table 1. Effect of treatments on anthracnose and virus severity and cracks on tubers

Treatment	Anthracnose severity	Virus severity	Cracks
Mound only (control)	3.2a	2.6a	3.7a
Mound + Fulan	3.2a	3.0a	1.3c
Mound + F2	3.7a	3.3a	2.7b
Mound + F2 + Fulan	3.4a	2.6a	0.7c
Mound + F3	3.8a	2.6a	1.0c
Mound + F3 + Fulan	3.6a	3.3a	2.0c
Mound + F4	3.6a	2.6a	0.7c
Mound + F4 + Fulan	3.3a	3.1a	0.3d
Ridge only	3.3a	2.4a	0.3d
Ridge + Fulan	3.7a	2.3a	2.0c
Ridge + F2	3.5a	3.1a	2.6b
Ridge + F2 + Fulan	3.6a	3.3a	2.0c
Ridge + F3	3.8a	2.9a	2.3c
Ridge + F3 + Fulan	3.3a	3.2a	1.0c
Ridge + F4	3.6a	2.8a	1.7c
Ridge + F4 + Fulan	3.0a	2.8a	1.7c
Lsd	0.6NS	0.6NS	2.4

Data are means of three replications. Within the same column, mean values followed by the same letter are not significantly different at α = 5%.

(Table 1). Treatments did not either inhibit or increase the severity of anthracnose and virus infections. However, Fulan application resulted in reduced tuber cracks. Mound + F4 + Fulan recorded 92% less cracks compared with mound bed type only (control). Fulan application suppressed nematode population compared with untreated plots in the three nematode genera encountered; however, nematode suppression was significant only in the root-knot nematode, *M. incognita* and the lesion nematode, *P. coffeae*. The lowest *M. incognita* and *P. coffeae* population was recorded in ridged bed type + fertilizer applied at 45-45-60 kg/ha N-P_20_5-K_20 + Fulan treatment which was 93% over mound bed type without Fulan and fertilizer application and 97% over mound bed type + fertilizer applied at 60-60-80 kg/ha N-P_20_5-K_20 without Fulan application respectively (Table 2). However, population of the reniform nematode, *R. reniformis* was not affected by treatments. Similarly, there was no difference amongst treatments in tuber galling index (Table 2).

DISCUSSION

The use of synthetic pesticides in crop production has been seriously criticized by environmentalists on grounds of environmental degradation and consumer health. However, easy accessibility, sure and quick action against target pests, will continue to render synthetic chemical control the first choice of farmers (Sabir, 2013). It is important to note that judicious use of synthetic agro-products is essential to sustainable productivity. Lack of fertilizer application in farming systems has been associated with lower yields (Ennin and Dapaah, 2008) whilst optimum fertilizer application has been reported to increase yield (Wang et al., 2012). In the present study, the combination of chemical fertilizer (NPK) and synthetic nematicide, Fulan resulted in the highest yield of yam. It is therefore important that farmers are taught the basics of good agricultural practices (GAP) that address environmental, economic and social sustainability for on-farm processes which result in safe and quality food and non-food agricultural products (Anonymous, 2003) to use synthetic chemicals appropriately.

Treatments were not different in the number of plants harvested and also the number of tubers harvested. Since one variety of yams was used, the implication was that treatments did not have any effect on either the sprouting of yam or multiple tubers.

Treatments inability to effect any changes in the anthracnose and virus incidence and severity was expected. Indeed, plant bed type, fertilizer and nematicide application have never been documented to manage fungal and viral infections in crop production.

Interestingly, populations of root-knot nematodes, *M. incognita* and the lesion nematode, *P. coffeae* were suppressed by Fulan application irrespective of the bed type or fertilizer application. In both nematode species,

Table 2. Effect of treatments on population density of plant parasitic nematodes.

Treatment	Meloi	Praty	Roty	TGI
Mound only (control)	183 (2.3)*a	119 (2.0) a	70 (1.8) a	0.7 a
Mound + Fulan	36 (1.1) b	24 (1.0) c	44 (1.2) a	0.3 a
Mound + F2	111 (1.4) ab	137 (2.1) a	74 (1.8) a	1.0 a
Mound + F 2 + Fulan	44 (1.2) c	30 (1.1) c	58 (1.6) a	1.3 a
Mound + F3	134 (2.1) a	105 (1.9) ab	69 (1.8) a	0.8 a
Mound + F3 + Fulan	30 (1.1) c	16 (0.6) d	46 (1.2) a	0.7 a
Mound + F4	172 (2.2) a	256 (2.4) a	110 (2.0) a	1.0 a
Mound + F4 + Fulan	35 (1.1) b	25 (1.0) c	52 (1.3) a	0.7 a
Ridge only (control)	145 (1.5) ab	153 (2.2) a	79 (1.8) a	0.4 a
Ridge + Fulan	43 (1.2) b	49 (1.2) c	65 (1.8) a	0.3 a
Ridge + F2	57 (1.3) b	238 (2.3) a	114 (2.0) a	0.8 a
Ridge + F2 + Fulan	13 (0.5) c	7 (0.4) d	50 (1.3) a	1.0 a
Ridge + F3	178 (2.3) a	224 (2.3) a	114 (2.0) a	0.8 a
Ridge + F3 + Fulan	30 (1.1) b	87 (1.7) b	88 (1.8) a	1.0 a
Ridge + F4	160 (2.2) a	217 (2.3) a	123 (2.0) a	0.7 a
Ridge + F4 + Fulan	22 (1.0) b	27(1.1) c	74(1.8)a	1.0 a
Lsd	(1.0)	(0.5)	(0.9)NS	2.0 NS

Data are means of three replications. *Log (ln (x +1)) transformed data used in analysis in parenthesis. Meloi = *Meloidogyne incognita,* Praty = *Pratylenchus coffeae*, Roty = *Rotylenchulus reniformis*. TGI = Tuber gall index. Within the same column, mean values followed by the same letter are not significantly different at α = 5%.

Reductions of more than 90% were significant. Additionally, the potential of Fulan manifested in the development of insignificant cracks in Fulan treated tubers while untreated tubers suffered major cracks. Though, Fulan suppressed *R. reniformis* populations, such reductions when compared with untreated plots were not significant. Similarly, no difference existed between tuber galling from Fulan treated samples and untreated samples. The highest yield and nematode suppression were recorded in ridged method of planting. Ridging was effective in reducing nematode density because in ridging, nematodes and their eggs are more exposed to sunshine which kills them compared with mounding, and also resulted in a more efficient use of Fulan and fertilizer. Therefore, farmers' incentive in adopting ridging over mounding in addition to the foregoing is the fact that ridging represents drudgery saving intervention.

Conclusion

This study has revealed that the recommended nematicide Fulan, applied at 10 g/stand effectively managed plant parasitic nematodes irrespective of the other components of the factorial regime. Application of Fulan increased the response of yam tuber yield to fertilizer rate especially on ridges, with 60-60-80 kg/ha N-$P_2 0_5$-$K_2 0$ resulting in highest yields. Finally, ridging was a better alternative to mounding as yield was not compromised and the method also lends itself to mechanization. Fulan, the non-fumigant with a 90 day resting period is safe for yam production since yam matures at 210 days on the average.

The efficacy of synthetic agro products would continue to attract farmers, their implications on the environment notwithstanding. Pragmatic policies should therefore be put in place by governments to ensure their sustainable use by farmers.

Conflict of interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

Authors gratefully acknowledge the financial support of the West Africa Agricultural Productivity Programme (WAAPP), which made the study possible. We are also indebted to John Sackey-Asante and Sampson Obeng, Technicians of the Nematology laboratory and the Crop Resource and Management Division of the Crops Research Institute, respectively.

REFERENCES

Anon (2003). Development of a framework for good agricultural practices.

COAG 2003 GAP paper. FAO Committee on Agriculture (COAG), 17th session, Rome, 31 March-4 April, 2003.
Asiedu R, Mignounal H, Odu B, Huges Jd'A (2001). Yam breeding. Plant Virology in Sub- Saharan Africa (PVSSA) Conference in 2001. Int. Institute Trop. Agric. pp. 466-475.
Bell CA (2000). Fumigation in the 21 Century. Crop Protect. 19:563-569.
Benghuzzi H, Tucci M, Eckie R Huges J (2003). The effects of sustained delivery of diosgenin on the adrenal gland of female rats. Biomed. Sci. Instrum. 39:335-340.
Bridge J, Coyne DL, Kwoseh C (2005). Nematode parasites of tropical root and tuber crops. M. Luc, R. A. Sikora, J. Bridge. (Eds). In: "Plant parasitic nematodes in subtropical and tropical agriculture. (Second edition). CABI, Wallingford, UK, pp. 221-258.
CIH (1978). Commonwealth Institute of Helminthology. Descriptions of plant parasitic nematodes. Sets 1-8. CAB International, Wallingford, UK.
Ennin SA, Dapaah HK (2008). Legumes in sustainable maize and cassava cropping systems in Ghana. Agric. Food Sci. J. Ghana, 7:519-540.
Ennin SA, Owusu Danquah E, Acheampong PP (2013). Chemical and Integrated Nutrient Management options for sustainable Yam production. Yams 2013. First global conference on yams. 3-6 Oct 2013, Accra.
Ennin SA, Otoo E, Tetteh FM (2009). Ridging as a mechanized alternative to mounding for cassava and yam production. West Afr. J. Appl. Ecol. 15:25-36.
FAOSTAT (2006). FAO Statistics Division 2006.
Fuccillo DA, Sears L, Stapleton P (2007). Sink capacity of yams. In: Biodiversity in trust: Conservation and use of plant genetic resources in CGIAR centres. Digital version. Cambridge University Press, 371pp.
Jepson SB (1987). Identification of root-knot nematodes, *Meloidogyne* spp. CABI Publishing, Wallingford, UK, 265pp.
Noling JW (2012). Nematode management in tomato, peppers and eggplant. EDIS Publication # ENY 032/NG032
Osunde ZD, Yisa MG (2003). Effect of storage structures and storage period on weight loss and sprout growth on stored yams. Proceedings of the 1st International Conference NIAE. 22:196-199.
Sabir N (2013). IPM in vegetable cultivation in greenhouses. In: Singh B, Singh B, Sabir N. & Hasan M. (Eds.). Advances in Protected Cultivation. New India Publishing Agency, New Delhi. pp.194-232.
Sikora RA, Fernandez E (2005). Nematode Parasites of Vegetables. In: Luc M., Sikora R.A. & Bridge J. (Eds.). Plant parasitic nematodes in subtropical and tropical-Second edition. CABI Wallingford, UK, pp. 319-392.
Wang W, Lu J, Ren T, Yinshui L, Zou J, Su W, Li X(2012). Inorganic fertilizer application ensures high crop yields in modern agriculture: A case study in Central China. J. Food Agric. Environ. 10:703-709.
Wen-Chi H, Mei-Hsien L, Hsien-Jung C, Wen-Lee L, Chuan-Hsiao H, Yen-Wenn L, Yaw-Huei L (2001). Antioxidant activities of dioscorin, the storage protein of yam (*Dioscorea batatas* Decne) tuber. J. Agric. Food Chem. 49:4956-4960.
Xu Q (2007). Development of yam beer. Food Sci. 28(8):628-631.
Zheng Y (2011). China on the Sea. How the maritime world shaped modern China. Koninklijke BrillNV, Leiden, The Netherlands. 353pp.