Critical Levels of Dry Rotting of Yellow Yam (Dioscorea Cayenensis) Planting Material & Yield Responses After Disinfesting Heads of Pratylenchus Coffeae & After Post-plant Nematicide Applications

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CRITICAL LEVELS OF DRY ROTTING OF YELLOW YAM (DIOSCOREA CAYENENSIS) PLANTING MATERIAL AND YIELD RESPONSES AFTER DISINFESTING HEADS OF PRATYLENCHUS COFFEAE AND AFTER POST-PLANT NEMATICIDE APPLICATIONS 1/

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ABSTRACT

Several noxious nematodes are associated with yams (Dioscorea spp) in Jamaica but Pratylenchus coffeae is the only one found infesting yellow yam (D. cayenensis) tubers affected by a dry rot. In one trial, plants growing from yellow yam planting material (heads) disinfested of P. coffeae by dipping for 30 min in a 2,000 ppm solution of Oxamyl or for 45 min in water at 45C bore 36% and 23% greater quantitative yields of tubers respectively than undisinfested heads. Also, tubers showed lower levels of the nematode-related dry rot than tubers borne by plants arising from undisinfested heads. In a second trial, there was earlier and a signficantly higher incidence of sprouting of lightly or heavily dry-rotted heads dipped for 40 min in a 1500 ppm Oxamyl solution or lightly dry-rotted undisinfested heads and plants arising from them developed more vigourously compared with severely dry-rotted undisinfested heads. There was significantly less bearing plants in plots planted with severely dry-rotted undisinfested heads; greatest gross weights of tubers and marketable yams were produced in plots planted with lightly or severely dry-rotted

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1/ Parts of studies conducted jointly by the Ministry of Agriculture (MINAG), Jamaica and the Inter-American Institute for Co-operation on Agriculture (IICA) at Allsides and Olive River, Trelawny on the Project titled "Hillside Farming Development Project".

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disinfested heads or lightly dry-rotted undisinfested heads. Oxamyl or Ethoprop applied 11, 22 and 33 weeks after planting suppressed populations of P. coffeae in soil and roots at 39 weeks but did not influence quantitative production. Tubers from Oxamyl-treated plots showed significantly less of the dry rot. The dry rot appears to damage or destroy stem and root primordia resulting in severely affected planting material not sprouting or plants being unthrifty. Conditions favouring rapid development of the dry rot seem to prevail after heads are planted. Disinfestation of heads suppresses populations of the nematodes associated with the dry rot and development of the rot itself. Results suggest that only yellow yam heads with the least evidence of the dry rot or disinfested heads should be planted. It is recommended that an agency be established to disinfest available yam planting material in the first instance and eventually be responsible for providing "clean" planting material.

INTRODUCTION

Yams (Dioscorea spp) have traditionally been the staple root crop in the Jamaican diet. The yellow yam (D. cayenensis) is the most popular variety. Each year from 1970 to 1980, this variety constituted over 30% of total production which ranged from 80,800 to 165,000 tons; average tuber yields went from 10.8 to 13.2 tons/ha (data supplied by the Data Collection and Statistics Section, Ministry of Agriculture, Jamaica). This is considerably below the yield potential of this cultivar.

In Jamaica, several parasitic nematodes are associated with yam plants in the field (5,6). Pratylenchus coffeae, Scutellonema bradys and Hoplolaimus sp. are involved in the etiology of a dry rot of yam tubers (1,2,3,7,8,9). P. coffeae, considered to be the most noxious of the nematodes affecting yams (7,8), is the only nematode found infesting yellow yam tubers. The senior author has never observed a yellow yam tuber which was not infested by this nematode and affected to some extent by the dry rot, called "burning" or "burn" in Jamaica. The dry rot is characterised by cracking in the tuber skin underlaid by a brown, corky rot in the storage tissues (2,9). It spreads over the surface and progresses deeper into the yam tissues following harvest and prior to planting or consumption and is generally more pronounced towards the stem end of tubers. When a yellow yam tuber is harvested, the stem end (head) is cut off and retained for planting and the remainder consumed. The dry rot seems to injure or destroy stem and root primordia resulting in severely affected heads not sprouting, causing poor stands in the field, or vines growing from them being unthrifty.

When dry-rotted yam tubers were disinfested by hot water or nematicide dips in previous investigations, populations of the invading nematode were reduced and development of the dry rot suppressed. There was earlier and a higher incidence of sprouting of disinfested heads which bore more vigourous vines compared with undisinfested heads (1,2,3,6,7,8).

With banana, plantain, some ornamentals, etc., applying nematicides after planting is a standard feature of nematode control. In a trial with yellow yams, tubers harvested from plots treated with a nematicide twice during the season were less affected by the nematode-related dry rot than tubers from untreated plots (8). If the dry rot injures or destroys primordia, then any treatment or practice which results in yam planting material being less affected by it would be beneficial.

Two trials were conducted with yellow yam to determine (i) the level at which dry rotting of planting material becomes critical and therefore which heads should be acceptable and which should be rejected (ii) growth and yield responses after disinfesting heads of P. coffeae and (iii) the effects of post-planting nematicide treatments on qualitative and quantitative yields.

MATERIALS AND METHODS

Experiment 1

This trial was sited at Allsides on recently-terraced plots which had been cropped to yellow yam for two successive years. Yellow yam heads showing distinct symptoms of the nematode-related dry rot and infested with P. coffeae (avg. 400/10 gm tuber skin) were used.

The treatments were:

1. No treatment (control)
2. Heads dipped for 45 min in water at 45C
3. Heads dipped for 30 min in a 2,000 ppm solution of Oxamyl (Methyl N'N' - dimethyl-N-((methyl-carbamoyl)oxy)-1-thiooxamimidate).

Six days after being dipped, 12 heads were planted per plot. The three treatments were replicated thrice in a randomised complete block design. Cultural practices were those normally followed at Allsides. Weeds were controlled manually. The soil, an Ultisol, was found to be highly acidic (pH 4.9) and levels of available N, P and K were medium, low and very low respectively. Plants were supplied with a mixture of 200, 300 and 150 kg/ha of N, P_2O_5 and K_2O respectively divided equally at planting and at 16 and 25 weeks thereafter.

Forty weeks after planting, counts were made of P. coffeae in soil from each plot. Tubers were harvested at 43 weeks; then, counts were made of P. coffeae in the skin of the tubers.

Experiment 2

Lightly or severely dry-rotted yellow yam heads were selected from a batch of recently-harvested tubers. The first group consisted of heads with less than 15% of the surface showing symptoms of the nematode-related dry rot and with depth of the dry rot ranging from 1 - 2 mm (avg. 1.5 mm). The second group consisted of heads with

more than 66% of the surface having the dry rot which ranged in depth from 4 - 11.5 mm (avg. 6.6 mm). Half of the yams from each group were dipped for 40 min in a 1,500 ppm solution of Oxamyl. Three days later, the heads were planted 10 per plot. This trial was sited at Olive River in an area cropped to yellow yam continuously for at least 10 years. Eleven, 22 and 33 weeks after planting, plots were treated with Oxamyl G (12.2 kg ai/ha) or Ethoprop G (O-Ethyl S, S-dipropyl phosphorodithioate) (13.9 kg ai/ha) or left untreated giving 12 treatments viz:

1. Severely dry-rotted heads dipped in Oxamyl; Ethoprop applied post-planting
2. Severely dry-rotted heads dipped in Oxamyl; Oxamyl applied post-planting
3. Severely dry-rotted heads dipped in Oxamyl; no post-plant treatment
4. Severely dry-rotted heads untreated; Ethoprop applied post-planting
5. Severely dry-rotted heads untreated; Oxamyl applied post-planting
6. Severely dry-rotted heads untreated; no post-plant treatment
7. Lightly dry-rotted heads dipped in Oxamyl; Ethoprop applied post-planting
8. Lightly dry-rotted heads dipped in Oxamyl; Oxamyl applied post-planting
9. Lightly dry-rotted heads dipped in Oxamyl; no post-plant treatment
10. Lightly dry-rotted heads untreated; Ethoprop applied post-planting
11. Lightly dry-rotted heads untreated; Oxamyl applied post-planting

12. Lightly dry-rotted heads untreated; no post-plant treatment.

The 12 treatments were replicated thrice in a randomised complete block design. The nematicides applied after planting were sprinkled onto the ground around plants then worked in lightly. Plots were fertilized with 1,460 kg/ha of a 12:24:12 mixture split into two equal applications at six and 14 weeks after planting.

Six, seven, nine, 11 and 22 weeks after planting, germinated heads were counted. At six, nine and 11 weeks, vine height was measured and leaf width at six (first node) and 17 weeks (second node). Samples of soil and roots were taken at 39 weeks for estimating levels of P. coffeae. At harvest (47 weeks), P. coffeae in soil and tuber skin was again counted.

Features common to both trials

These trials were carried out at the original and adjunct sites respectively of the Allsides Pilot Development Project (10). The yellow yam heads were planted 0.67 m apart on continuous contour mounds spaced 1.5 m apart giving a crop density of 10,000 plants/ha. Economy of staking was achieved by using one 6 - 8 m long bamboo stake for four plants.

At harvest, bearing plants were counted; each tuber was rated for the nematode-related dry rot on a 1 - 5 scale where 1 = 20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80% and 5 = 81-100% of the tuber's surface affected by the dry rot. Gross tuber weight, weight of heads and weight of marketable yams produced by each plant were recorded.

RESULTS

Experiment 1

There was 100% germination of heads and every plant bore a tuber. Those borne by plants growing from heads disinfested by

Oxamyl or hot water showed less of the dry rot than tubers borne by plants from undisinfested heads. Plots planted with disinfested heads produced greater weights of heads and significantly greater quantitative yields of marketable yams than plots planted with untreated heads. Overall, disinfesting heads with hot water or Oxamyl resulted in 23% and 36% increased quantitative tuber yields respectively compared with no treatment (Table 1). Substantially higher numbers of P. coffeae were found in the skin of tubers borne by plants arising from undisinfested heads but three weeks before harvest, there was no difference between treatments in the numbers of this nematode in soil (Table 2).

Experiment 2

Severely dry-rotted heads which remained undisinfested of P. coffeae took longer to sprout compared with severely dry rotted disinfested heads and lightly dry rotted disinfested or undisinfested heads. Six, seven, nine and 11 weeks after planting, significantly more of the lightly dry-rotted disinfested or undisinfested heads had sprouted compared with severely dry-rotted undisinfested heads. Sprouting of severely dry-rotted heads dipped in Oxamyl occurred earlier than severely dry-rotted undisinfested heads. Overall, lightly dry-rotted heads which remained undipped sprouted earliest (Table 3). Plants arising from severely dry-rotted undisinfested heads were least vigorous as measured by vine height and leaf size (Table 3).

At 39 weeks from planting, highest numbers of P. coffeae were found in soil and root samples from plots which received no post-plant nematicide treatment. However, soil and root samples from plots in which undisinfested, severely dry rotted heads were planted and which received no post-plant nematicide treatment contained comparatively low levels of the nematode. Treatments with Ethoprop or Oxamyl suppressed P. coffeae but roots of plants from the Ethoprop-treated plots harboured lowest levels of the nematode at 39 weeks. However, at harvest there was no difference in the

levels of P. coffeae in soil nor skin of tubers irrespective of whether plots were treated with a nematicide or not (Table 4).

There was no evidence that the post-plant nematicide treatments influenced gross tuber production but Oxamyl treatments resulted in significant reductions in the dry rot ("burning") observed on harvested tubers (Table 5). However, planting lightly dry-rotted heads or heads disinfested of P. coffeae clearly influenced gross tuber yields. There was significantly less bearing among plants from severely dry-rotted undisinfested heads compared with those from lightly dry-rotted undisinfested heads or disinfested heads. Lowest tuber yields were observed in plots planted with severely dry-rotted undisinfested heads. Highest yields were produced by plants arising from lightly dry-rotted disinfested heads (Table 5).

DISCUSSION

It seems clear that as the nematode-related dry rotting on yellow yam heads becomes more severe, the more unfit these heads become as planting material. Degras and Mathurin (4) have reported that as tubers of certain Dioscorea spp mature, undifferentiated cellular blocks appear in the deep cortical layers. These cellular blocks are later involved in morphogenesis, generally according to a gradient in favour of the stem end of the tuber. As the dry rot spreads over and penetrates deeper into the yam head, it appears that these cellular blocks are injured or destroyed. The ability of severely affected heads to produce vigourous plants would gradually diminish and eventually when all primordia are destroyed, such heads would not germinate. Furthermore, it seems that when yam heads are planted, soil temperature and moisture favour rapid development of populations of noxious nematodes infesting the heads and of the nematode-related dry rot resulting in rapid disintegration of the heads. It has been shown that when yam planting material is disinfested, populations of invading nematodes and development of the dry rot are suppressed (6).

Trial 2 demonstrated that there are significant benefits to using yellow yam planting material with little evidence of the nematode-related dry rot. Earliest and the highest level of sprouting was observed among lightly dry-rotted undisinfested heads and plants showed the most vigourous early growth and development. Similar benefits resulted from disinfesting the heads with Oxamyl but were more pronounced where lightly dry-rotted heads were disinfested compared with severely dry-rotted heads. However, greatest quantitative yield benefits were noticed in plots where lightly dry-rotted disinfested heads were planted. It appears that poor stands and more non-bearing plants were the important factors related to decreased quantitative yields when severely dry-rotted undisinfested heads were planted compared to lightly dry-rotted undisinfested heads or disinfested heads.

Both trials demonstrated that disinfestation of yellow yam heads will result in increased gross tuber yields. Disinfesting yam heads can be costly (estimated at over J$100 = US$56 per ton for Oxamyl treatment). However, this high initial expenditure is easily recovered from the increased yields (estimated to result in revenue exceeding J$600 = US$336 from each ton of planted yellow yam heads).

Post planting applications of Oxamyl or Ethoprop suppressed levels of P. coffeae in the soil about and roots of the yellow yam plants. Applications of Oxamyl resulted in significantly less dry rotting of harvested tubers thus enhancing the suitability of these tubers as planting material.

The authors recommend that the Ministry of Agriculture or a designated agency establish pilot schemes in the major yam-growing areas for the purpose of disinfesting yam planting material, preferably with Oxamyl. We further recommend the establishment of large-scale field trials designed to assess the economic benefits of disinfested planting material. These actions followed by the deployment of an agency to provide "clean" yam planting material are seen as imperative if increased production and productivity of yams are to be realised in Jamaica.

TABLE 1. - Quantitative and qualitative yields of yellow yam (Dioscorea cayenensis) tubers harvested 43 weeks after planting Pratylenchus coffeae - infested planting pieces (heads) or infested heads disinfested by hot water or nematicide dips.

Treatment	Levels of dry rot on tubers[a]	Wt. of table yams harvested from 36 plants (kg)	Wt. of heads harvested from 36 plants (kg)	Total wt. of tubers harvested from 36 plants (kg)	Wt. of yams harvested per kg planted (kg)	Calculated gross yields (tons/ha)
Untreated heads	2.6	58.0	46.8	104.8	3.82	29.1
Hot water-dipped[1] heads	2.2	75.1	54.6	129.7	4.95	36.0
Oxamyl-dipped[2] heads	2.0	91.1	51.7	142.8	5.05	39.7
LSD 5%	-	2.8	-	5.2	-	-

[1]Heads dipped for 45 min in water at 45C.

[2]Heads dipped for 30 min in a 2000 ppm solution of Oxamyl.

[a]Dry rotting rated on a 1 - 5 scale where 1,2,3,4 and 5 = 1-20%, 21-40%, 41-60%, 61-80%, and 81-100%, respectively of the tuber's surface having the dry rot.

TABLE 2. - Numbers of *Pratylenchus coffeae* in soil and in the skin (peeling) of yellow yam (*Dioscorea cayenensis*) tubers harvested from plots in which nematode-infested planting pieces (heads) or infested heads disinfested by hot water or nematicide dips were planted.

Treatment	No. *P. coffeae*/ 100 cc soil at 40 weeks	No. *P. coffeae*/ 10 gm tuber skin at harvest (43 weeks)
Untreated heads	27	48
Hot water-dipped[1] heads	29	2
Oxamyl-dipped[2] heads	13	5

[1]Heads dipped for 45 min in water at 45C.

[2]Heads dipped for 30 min in a 2000 ppm solution of Oxamyl.

TABLE 3. - Earliness of sprouting of yellow yam (Dioscorea cayenensis) planting material (heads) and growth and development of plants in a trial to investigate inter alia, critical levels of dry rotting and the benefits of disinfesting the heads of Pratylenchus coffeae.

TREATMENTS	Sprouting after planting (%)					Plant height (m)			Leaf Width (cm)	
	6 wk	7 wk	9 wk	11 wk	22 wk	6 wk	9 wk	11 wk	6 wk 1st node	17 wk 2nd node
Heavily dry-rotted[a] heads disinfested with Oxamyl[c]	20	43	72	91	99	0.42	1.23	1.90	6.7	13.5
Heavily dry-rotted[a] undisinfested heads	15	27	64	77	92	0.38	0.90	1.68	6.4	12.9
Lightly dry-rotted[b] heads disinfested with Oxamyl[c]	35	51	88	97	99	0.29	1.12	1.99	6.6	13.6
Lightly dry-rotted[b] undisinfested heads	40	58	90	96	99	0.38	1.32	2.22	6.9	13.5
LSD 5%	9.0	10.7	8.3	9.4	-	-	-	0.37	-	0.56

a More than 66% of surface of head affected by the dry rot and depth of rot ranging from 4 - 11.5 mm (avg. 6.6 mm).

b Less than 15% of surface of head affected by the dry rot and depth of rot ranging from 1 - 2 mm (avg. 1.5 mm).

c Dipped for 40 min in a 1500 ppm solution.

TABLE 4. - Numbers of *Pratylenchus coffeae* found in soil about, roots of and skin of tubers borne by yellow yam (*Dioscorea cayenensis*) plants in a trial investigating critical levels of dry rotting of planting material (heads), the benefits of disinfesting the heads and the use of post-plant nematicide treatments.

TREATMENTS		NUMBERS OF *P. COFFEAE*			
		At 39 weeks		At harvest (47 weeks)	
Before planting	After planting	Per 100 ml soil	Per 10 gm root	Per 100 ml soil	Per 10 gm tuber skin
Heavily dry-rotted[a] heads disinfested with Oxamyl[c]	Ethoprop[d]	17	20	19	70
	Oxamyl[e]	3	160	21	40
	None	90	1270	20	110
Heavily dry-rotted[a] undisinfested heads	Ethoprop[d]	3	30	8	50
	Oxamyl[e]	1	200	9	60
	None	20	290	23	80
Lightly dry-rotted[b] heads disinfested with Oxamyl[c]	Ethoprop[d]	3	30	25	80
	Oxamyl[e]	5	340	2	40
	None	73	2250	26	90
Lightly dry-rotted[b] undisinfested heads	Ethoprop[d]	3	90	5	70
	Oxamyl[e]	3	330	27	100
	None	130	860	29	80
LSD 5%		62	795	-	-

a More than 66% of surface area of head affected by the dry rot and depth of rot ranging from 4 - 11.5 mm (avg. 6.6 mm).

b Less than 15% of surface area of head affected by the dry rot and depth of rot ranging from 1 - 2 mm (avg. 1.5 mm).

c Dipped for 40 min in a 1500 ppm solution.

d 13.9 kg ai/ha of Ethoprop 10G at 11, 22 and 33 weeks.

e 12.2 kg ai/ha of Oxamyl 10G at 11, 22 and 33 weeks.

TABLE 5. - Qualitative and gross tuber yields of yellow yam (Dioscorea cayenensis) in a trial to investigate critical levels of dry rotting of planting material (heads) and the benefits of disinfesting the heads of Pratylenchus coffeae at planting followed by post-plant nematicide treatments .

TREATMENTS		Bearing plants	Level of dry rotting[f] on tubers	Tuber yields per plot planted with 10 heads (kg)		
Before planting	After planting	(%)		Total	Heads	Marketable
Heavily dry-rotted[a] heads disinfested with Oxamyl[c]	Ethoprop[d]	94	3.2	40.93	11.93	25.27
	Oxamyl[e]	94	2.9	41.27	10.83	25.53
	None	94	3.7	41.97	11.80	21.33
Heavily dry-rotted[a] undisinfested heads	Ethoprop[d]	86	3.5	37.60	9.60	21.73
	Oxamyl[e]	78	2.6	29.30	9.03	17.57
	None	81	3.4	33.47	10.93	13.60
Lightly dry-rotted[b] heads disinfested with Oxamyl[c]	Ethoprop[d]	94	3.0	38.70	11.10	24.90
	Oxamyl[e]	100	3.1	50.33	12.90	30.37
	None	100	3.3	46.10	12.13	27.80
Lightly dry-rotted[b] undisinfested heads	Ethoprop[d]	90	3.7	35.60	11.47	21.80
	Oxamyl[e]	94	3.5	41.97	13.00	26.00
	None	94	4.3	37.47	12.17	20.40
LSD 5%		9.4	0.7	10.40	-	-

a More than 66% of surface of head affected by the dry rot and depth of rot ranging from 4 - 11.5 mm (avg. 6.6 mm).

b Less than 15% of surface of head affected by the dry rot and depth of rot ranging from 1 - 2 mm (avg. 1.5 mm).

c Dipped for 40 min in a 1500 ppm solution.

d 13.9 kg ai/ha of Ethoprop 10G at 11, 22 and 33 weeks.

e 12.2 kg ai/ha of Oxamyl 10G at 11, 22 and 33 weeks.

f Dry rotting rated on a 1 - 5 scale where 1,2,3,4 and 5 = 1-20%, 21-40%, 41-60%, 61-80%, and 81-100%, respectively of the tuber's surface having the dry rot.

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