Yam (Dioscorea spp.) Management for Control of Tuber Decay

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ABSTRACT

Yam tubers appear most susceptible to decay during early stages of sprouting, at late stages of field senescence, and during storage. In Puerto Rico, major organisms associated with tuber decay are: fungi (Penicillium spp., Fusarium oxisporum, F. solani, and Rhizoctonia sp.), nematodes (Pratylenchus coffeae and Scutellonema bradys), soft rot bacteria (Erwinia sp.) and white grubs (Diaprepes abreviatus). Decay results from interaction of organisms related to yam susceptibility, cultural and storage practices, and environment (temperature, humidity, and aeration). Studies are directed toward improvement of tuber quality by reducing decay. Commercial fungicides with thiabendazole, applied before storage, effectively reduced tuber fungi during storage and increased yam field stands and yield. Dioscorea alata cv. Florido and whole tubers showed less rapid and extensive tuber decay in storage than D. rotundada cv. Habanero and seed-pieces, respectively. Storing yams on raised slatted beds of bamboo reduced storage decay compared to commonly used soil surface storage. Pre-plant fungicide treatment of seed-pieces from high quality Habanero tubers increased emergence and yield. Treatment with Captan alone or with captan plus Benomyl or plus thiabendazole resulted in more than 90% emergence compared to 52% for untreated pieces. Field emergence and yam tuber yield were directly related.

Introduction

Edible yams (Dioscorea spp.) are long season (6 to 12 months) tropical vines cultivated for their starchy tubers (Martin, 1972). Although yams are mostly used for their high content of complex carbohydrates, they have a higher protein content and better balance of amino acids than many other root crops, particularly cassava (Splittstoesser and Rhodes, 1973). Two species of yams, D. alata and D. rotundata are grown comercially in Puerto Rico.

In Puerto Rico yams are grown in humid mountain areas. Because of high labor requirement for staking and hand harvest, most yams are produced in small fields (1 to 3 hectares) as a family operation. Yam farmers generally sell their best quality yams for consumption and use low quality yams for planting. Besides this practice, continuous monoculture in the same field and crude handling and storage practices allow yams to be heavily attacked by pests.

Dioscorea spp. are easily propagated by tuber-pieces or by whole tubers; in most cases true seeds are lacking. Vegetative propagation assures perpetuation of important agronomic characteristics. However, it also facilitates propagation of various pests. The need to use a large amount of expensive tuber material for planting and sensitivity of tubers to drying and to mechanical damage are other disadvantages of asexual propagation of yams.

Yams tubers may deteriorate from several mechanical or biological causes. Biological causes include yam respiration and action of a variety of microflora and microfauna. Yam tubers may be degraded by insects, nematodes, fungi, and bacteria. Although damage by insects is fairly obvious, symptoms from nematodes, fungi and bacteria are often overlapping.

Tuber deterioration can occur anytime between planting and emergence and during tuber formation through harvest and storage. The types of organisms that attack tubers in the field, in storage, and at planting and their relative importance may differ depending on environmental conditions.

Preservation of yam tuber viability and vigor necessitates a seed tuber management program that includes a variety of cultural and control practices (Mignucci and Cordero, 1981). Of the limited amount of research on yams, most has centered on the control of storage deterioration (Burton, 1970; Coursey, 1967; Ogundana, 1972; Thompson et al., 1977). The major objectives of the present studies were to define components of yam deterioration and to develop control measures.

Materials and Methods

Farm Survey: Storage Conditions, Tuber Losses, and Tuber Microflora. Observations on handling and storage practices, tuber losses, pest and diseases were obtained by comprehensively surveying 48 farms of *D. alata* cv. Florido and *D. rotundada* cv. Habanero in the yam growing zone of Puerto Rico during the 1980 and 1981 harvests. Newly harvested and stored tubers were evaluated for deterioration and associated microflora. Isolations included cortical tissues of the cortex and internal tissues of the tuber. Isolations were made from both healthy-appearing and rotting tubers. Samples from the different tuber areas were either cut into small pieces, soaked for 3 to 5 minutes in 0.5% NaOCl (10% Clorox), plated on sterile potato dextrose agar, and incubated 7 days or more at 27°C until sporulation permitted identification or were placed directly in moist chambers until developing fungi could be identified. Fifteen tissue pieces were plated for each sample. Fungi were identified with the aid of the stereomicroscope (4-40X) and/or the light transmission compound microscope (100-1000 X).

Pre-storage Fungicides: Influence on Field Performance of Yams. *D. rotundata* cv. Habanero from Corozal were harvested and sound tubers cut into 113 g seed-pieces. Pieces were either dipped in water (check) or fungicide baths for 5 minutes and then stored for 40 days in the yam storage room. Fungicide treatments included three different products including two formulations of thiabendzole (Tecto B and Mertect 340F) and an experimental benzimidazole fungicide (ME-147). Fungicides selected were based on a previous screening of nine commercial formulations of eight active products representing five chemical families of fungicides that included protectants and systemic compounds at several dosages each. Selected products had shown a high degree of efficacy in controlling decay and all were formulated by Merck, Dohme, and Sharp. Each treatment consisted of four replicates of 25 yam pieces each which were randomly arranged in the storage trays. At the end of 40 days storage, yam pieces were rated for the presence of visible fungal growth and the incidence of advanced decay (over 50% of the tuber-piece rotted). The field trial used a randomized complete block design with four replications of 25 tuber-pieces each. The field was in Corozal in a silty clay soil (Ultisol) with a pH of 5.9. Seed-tuber-pieces were planted 8 cm deep every 30 cm in banks which were 90 cm high and with an inter-bank separation of 1.20 cm. Emergence counts were taken at 56 days after planting. Yam plants were counted and harvested at normal maturity and tubers were separated based on marketability.

Types of Yam Storage and Their Influence on Decay. Four types of storage were evaluated for influence on yam decay. Whole sound tubers of *D. alata* cv. Florido and *D. rotundata* cv. Habanero were stored either on (i) soil and covered with dried yam vines; (ii) bamboo tables covered by vines; (iii) as in (ii) but with the bamboo tables having a tin roof 90 cm above the table surface; and (iv) the wooden slats of open boxes in a storage room. The first treatment was to simulate farmer practice and the bamboo tables were designed as possible low technology alternatives. Tables were 90 cm high and built into a slope to conserve building materials and to allow good drainage and aeration. Each storage type was replicated four times with 25 tubers per replicate for each yam cultivar. Every 4 days tubers were individually rated for fungal development and degree of deterioration using the following scale: 1 = no fungi or deterioration, 2 = 1% to 25% fungi or deterioration, 3 = 26% to 50% fungi or deterioration, 4 = 51% to 75% fungi or deterioration, and 5 = 76% to 100% fungi or deterioration.

Pre-plant Treatment of Yam Seed-pieces. On December 15, 1980, Habanero tubers were harvested at the Corozal Substation and stored in trays in the storage house. Three months later, sound tubers of good appearance were selected and cut into sections of 115 g each, treated for one hour in fungicide baths or in water. Fungicide baths at 27°C were agitated by stirring every 10 minutes for a total of five times. Water-treated seed-pieces served as experimental checks. Afterwards, baths were drained and seed-pieces were placed at 35°C and 80% RH for two days to allow wounds to heal. Seed-pieces were planted on 28 March 1981 at the Alzamora Farm of the College of Agriculture at Mayaquez. The experimental site consisted of a silty-clay Ultisol of pH 5.0 typical of many yam production areas in Puerto Rico. The field was cropped in three previous seasons to soybeans and was not planted to yams previously. Samples of soil from the site were analyzed for pathogenic nematodes before planting and after harvesting.

Fungicide treatments were based on commercial formulations of captan alone, captan plus thiabendazole, and captan plus benomyl. For all fungicides 2,000 ppm baths of the captan component were prepared. A randomized complete block design with four replications of 25 seed-pieces each was used for the experiment. Seed-pieces were hand planted 8 cm deep every 20 cm on 50 cm high banks with 67 cm between adjacent banks. Emergence was recorded at 5, 6, 7, 8 and 9 weeks after planting. Yams were harvested at maturity on 14 January 1981. Tubers and plants per plot were counted and weighed. Mean tuber weight was calculated and data was analyzed for variance with treatment mean separation by Fischer's Least Significant Difference (FLSD). Simple linear correlations were used in associating experimental parameters.

Results and Discussion

In Puerto Rico, planting dates, yam species preference, and selection of seed-tuber size varies considerably especially among distinct yam growing zones. For planting, most farmers use tubers which are not marketable as food because of small size or poor appearance. About 79% of all yam farmers store their tubers by forming large leaf - and vine - covered mounds on the ground or on the floor of existing farm sheds. About 58% of tubers have symptoms of nematode (*Pratylenchus coffeae*) damage. Forty-eight percent of stored tubers showed fungal rot (mostly associated with *Penicillium* spp., *Fusarium okysporum* and *F. solani*) and 44% of tubers showed perforations caused by the larvae of *Diaprepres abbreviatus*.

In order of prevalence, fungi associated with cortical tissues of yams were: *Fusarium oxysporum*, *Penicillium* spp., *F. solani*, *Rhizopus* sp., and *Mucor* sp. In yam tubers stored for prolonged periods bacteria, *Penicillium* spp., *Aspergillus* sp., *Trachysphaera* sp., *F. oxysporum*, and *F. solani* were isolated in that order of prevalence. *Penicillium* spp., *Fusarium* spp., *Rhizoctonia* sp., *Curvularia* sp., and a sterile mycelial basidiomycete were consistently isolated from internal tissues of yam tubers which were with or without rot symptoms.

D. alata cv. Florido was more resistant to storage deterioration than *D. rotundata* cv. Habanero. Mechanically injured and cut tubers decayed more rapidly than whole tubers. Visible decay was less on tubers stored on bamboo tables than those stored on field soil or in an enclosed shed. In order of prevalence, *Penicillium* spp., *Fusarium* spp., *Rhizoctonia* sp., and a mycelia basidiomycete resembling *Sclerotium* were associated with tuber rot in these studies of storage facilities.

In pre-storage treatment experiments, non-treated tuber-pieces showed extensive visible fungal colonization after being stored for 40 days at Corozal (Table 1). Although 17% of these emerged in the field, no economic yield resulted due to post-emergence damping-off. Four and eight thousand ppm thiabendazole as Mertect 340 F gave over 90% tuber-piece emergence and less than 10% fungal colonization. This was associated with increased harvested stand and yield. Mean number of tubers per plant and tuber yield per plant were not different among any fungicide treatment. The Tecto B formulation of thiabendazole was less effective than either ME-147 or Mertect 340 in preventing fungal deterioration and stand and yield losses. Control by all formulations increased with increasing dosage.

Several workers (Coursey, 1967; Ogundana, 1972; Thompson et al., 1977) reported storage deterioration of yam tubers. The influence of storage deterioration on yam field performance is not reported. From this study, pre-storage fungicides appear to be a powerful tool for increasing stand and yield of yams.

Fungicide pre-plant seed-piece treatments were highly effective in preventing emergence losses and in increasing yield (Tables 2 and 3). Emergence was 91% to 96% in fungicide-treated seed pieces compared to 52% for the nontreated control. Early emergence (5 weeks after planting) was higher for captan plus thiabendazole than for those treated with captan plus benomyl, captan alone, or nontreated seed-pieces (1% to 2%). From this experiment it appears that even when sound, healthy appearing tubers are used and optimum seedbed conditions are secured, seed-piece decay can almost halve emergence. Yam yields were directly related to field stands (r=0.94).

Table 2. Pre-plant fungicide treatments of Habanero yam seed-pieces and their influence on speed and frequency of field emergence at Mayaquez.

Treatments and rate[1]	Percentage emergence Weeks after planting 5	6	7	8	9
Orthocide plus (20 g/l)	24 **[2]	54 **	73 **	73 **	96 **
Orthocide 4F (5.4 g/l)	2	23 **	71 **	85 **	95 **
DPX 115B (4.0 g/l)	1	16 **	53 **	72 **	91 **
Check (water)	1	2	10	36	52

[1]Fungicide treatments contained 2000 ppm Captan. Pieces were immersed for 1 hour.

[2]Double asterisks below the treatment mean indicates that at that date the difference between that mean and the control is highly significant (P = 0.01) using FLSD.

Table 3. The effect of yam (Dioscorea rotundata cv. Habanero) seed-piece fungicide treatment on the yield of yams and its components in Mayaquez, Puerto Rico.

Treatment*	Total tuber yield (kg/plot)	Total number of tubers	Per plant yield (kg)	Number of tubers per plant	Mean tuber weight (g)
Captan plus Thiabendazole, 10% Captan + 0.5% Thiabendazole, Orthocide plus	27.0** A***	28.5 aA	1.1 a	1.20 A	942 aA
Captan alone, Orthocide 4F, 36% Captan	22.0 B	28.5 aA	0.9 a	1.16 A	770 bAB
Captan plus Benomyl, DPX-115B = 50% Captan + 10% Benomyl	22.5 B	26.3 aA	1.0 a	1.20 A	858 aBA
Nontreated (check)	12.6 C	22.5 bA	1.0 a	1.64 B	560 cB

*Seedpieces were placed in fungicide baths for 1 hour at 27°C. All fungicide baths contained 2000 ppm captan.

**Means based on four replications of 25-seed-pieces each planted in 6.1 m row lengths on 1.1 m centers.

***A common lower or upper case letter signifies no statistical difference between treatment means at P = 0.05 and P = 0.01, respectively, based on Fischer's Least Significant Difference (FLSD).

Table 1. Performance of yam (*Dioscorea rotundata* cv. Habanero) seed-pieces treated with prestorage fungicides.

Prestorage[a] fungicide and dosage (ppm a.i.)	Tuber pieces with visible fungi	Tuber piece emergence	Plants at harvest	Tubers at Harvest: Market	Tubers at Harvest: Non-market	Tubers at Harvest: Total	Yield: Market	Yield: Non-market	Yield: Total	Mean No. of tubers	Tuber yield (g)	Mean tuber weight
hiabendazole (Mertect™)	(%)[b]		(No. x 10^3/ ha)				(Kg. x 10^3/ha)			(g/plant)		(g)
2,000	61	53	11.7	15.6	6.6	22.3	6.3	0.5	6.8	1.9	0.58	306
4,000	2	96	25.8	26.6	14.1	40.6	11.9	1.4	13.3	1.6	0.52	327
8,000	4	92	29.7	38.0	14.1	52.0	17.2	1.7	18.8	1.8	0.63	362
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5,500	76	29	8.3	9.1	3.6	12.7	5.3	0.4	5.6	1.5	0.68	442
11,000	71	54	16.1	17.2	5.2	22.3	7.4	8.8	8.2	1.4	0.51	368
22,000	32	69	23.4	25.6	12.5	38.1	13.7	1.2	14.8	1.7	0.63	379
hiabendazole (Tecto B™)												
5,500	93	27	6.3	9.4	2.8	12.2	4.9	0.2	5.1	2.0	0.82	416
11,000	92	26	5.9	7.5	2.3	9.8	3.8	0.2	4.0	1.7	0.67	401
22,000	77	29	7.8	10.9	2.8	13.8	7.0	1.0	8.0	1.8	1.02	480
o Fungicide	100	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	000

[a] Prestorage fungicides were applied to yam seed-pieces (∿ 110 grams each) by their immersion for 5 minutes in 100 l baths of the test solutions. Seed-pieces were stored 60 days under ambient conditions in Corozal, Puerto Rico.

[b] Treatments consisted of 5 replications of 20 seed-pieces each. Planted in a randomized complete block design in the field after 40 days of storage.

Because of ability to reduce labor costs, decay and mechanical transmission of pathogens, use of small whole potato seed tubers have gained popularity in seed production areas (Hooker, 1981). Specialized production and use of small whole yam tubers for seed may help promote healthier and more vigorous yam seedlings and possibly reduce the need to use pesticides.

Based on this work, a failure to treat yam seed pieces from sound tubers with appropriate fungicides will probably result in significant economic losses to farmers. Yam seed tubers or seed pieces are a significant production expense considering that compared to most seed crops, a tremendous mass is planted on a per area basis. If 10,000 to 20,000 plants per hectare are desired, seed piece costs based on using 117 g pieces at a cost of $0.80 to $1.00 per kg will range from $800 to $2,000 per hectare investment in seed alone. Considering a 50% mortality of non-treated seed pieces, direct losses could amount to from $400 to $1,000 per hectare. Besides the direct loss of seed pieces, the biggest loss is caused by reduction in total yield. In normal practice, farmers use seed pieces and or whole tubers which range from 225 to 900 g in most cases, considerably larger than those used in this experiment (115 g). Therefore, at the farm level, yam losses are probably greater than what we have calculated. Fungicide treatment of seed pieces is a promising practice for increasing yam production with a modest capital outlay.

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