African Crop Science Journal, Vol. 28, No. 2, pp. 203 - 211
ISSN 1021-9730/2020 $4.00

DOI: https://dx.doi.org/10.4314/acsj.v28i2.6

STORAGE ROT OF SEED YAM RESULTING FROM SPEARGRASS INJURIES

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(*Received 15 July 2019; accepted 26 June 2020*)

ABSTRACT

Postharvest rot due to injury is a major contributing factor to the declining quality of stored seed yams (*Dioscorea* spp.). Among the several known injuries, the piercing effect of speargrass rhizomes has become a serious constraint for yam production in Ghana. The objective of this study was to assess injuries on seed yams resulting from piercing of speargrass rhizomes and their effects on postharvest rots in Ghana. Eighty farmer fields from Mem, Watro, Asanteboa and Abour in the Atebubu-Amantin Municipal in the Bono East Region of Ghana were screened for speargrass incidence and injury on harvested tubers, for laboratory analysis of pathogens in 2016 and 2017. The tubers were sorted into four categories of seed yam based on weight. Thirty seed yams each of two selected white yam cultivars (Dente and Kpamyo) with visible speargrass rhizome-pierced-tubers (VSRPT) and non-speargrass rhizome pierced healthy tubers (NSRPHT) were randomly selected and stored in a ban for weekly assessment of rot. The rotten tissues from the localised area of VPSRT were subjected to pathological investigations in the laboratory. The incidence of injury seemingly increased with increasing tuber weight. It was 0% for < 100 g samples and averagely 14% for > 1 kg samples, irrespective of cultivars and locations. Incidence of rot from NSRPHT sample was observed 5 weeks after storage (WAS) for both cultivars; and 2 WAS from the VSRPT sample and 40% higher than NSRPHT at 8 WAS. Eight and six known rot pathogens were isolated from the rotten tissues of VSRPT of Dente and Kpamyo, respectively. Injury from the piercing of speargrass rhizome significantly contributed to hastening of tuber rots; while tuber injury increased with increasing speargrass density. Appropriate management of speargrass is essential for commercial seed yam growers to reduce tuber damage which affects yam quality, storage and marketing.

Key Words: *Dioscorea,* postharvest, rot pathogen, speargrass rhizome

RÉSUMÉ

La pourriture post-récolte due à une déchirure est un facteur majeur contribuant à la baisse de la qualité des ignames des semences stockées (*Dioscorea* spp.). Parmi les nombreuses déchirures connues, l'effet perçant des rhizomes de la gerbe d'herbe est devenu une contrainte sérieuse pour la production d'igname au Ghana. L'objectif de cette étude était d'évaluer les déchirures sur les ignames de semence résultant du perçage des rhizomes de gerbe d'herbe et leurs effets sur les pourritures post-récolte au Ghana. Quatre-vingts champs d'agriculteurs de Mem, Watro, Asanteboa et Abour dans la municipalité d'Atebubu-Amantin dans la region de l' Est de Bono au Ghana ont été examinés pour déterminer l'incidence et les dommages de la gerbe d'herbe sur les tubercules récoltés, pour une analyse en laboratoire des agents pathogènes en 2016 et 2017. Les tubercules ont été triés en quatre catégories d'igname de semence en fonction du poids. Trente ignames de semence de chacun des deux cultivars sélectionnés d'igname blanche (Dente et Kpamyo) avec des tubercules percés de rhizome de gerbe d'herbe (VSRPT) et des tubercules sains percés de rhizome non- gerbe d'herbe (NSRPHT) ont été sélectionnés au hasard et stockés dans une interdiction pour une évaluation hebdomadaire de la pourriture . Les tissus pourris de la zone localisée de VPSRT ont été soumis à des investigations pathologiques en laboratoire. L'incidence des déchirures a apparemment augmenté avec l'augmentation du poids des tubercules. Il était de 0% pour les échantillons <100 g et de 14% en moyenne pour les échantillons > 1 kg, quels que soient les cultivars et les emplacements. L'incidence de pourriture de l'échantillon NSRPHT a été observée 5 semaines après stockage (WAS) pour les deux cultivars; et 2 WAS de l'échantillon VSRPT et 40% plus élevés que NSRPHT à 8 WAS. Huit et six agents pathogènes de la pourriture connus ont été isolés respectivement dans les tissus pourris du VSRPT de Dente et de Kpamyo. Les déchirures causées par le perçage du rhizome de gerbe d'herbe ont considérablement contribué à accélérer la pourriture des tubercules; tandis que les dommages aux tubercules augmentaient avec l'augmentation de la densité de la gerbe d'herbe. Une gestion appropriée de la groseille verte est essentielle pour les producteurs commerciaux d'ignames de semence afin de réduire les dommages aux tubercules qui affectent la qualité, le stockage et la commercialisation des ignames.

Mots Clés: *Dioscorea*, post-récolte, pathogène de la pourriture, rhizome de la gerbe d'herbe

INTRODUCTION

Yam (*Dioscorea* spp.) is a prominent staple crop for food security and income generation in the tropical regions of Africa. Various yam cultivars are produced, but white yam (*Dioscorea rotundata*) is the most important and popular species grown in the tropics (Aighewi *et al.*, 2015). According to Anaadumba (2013), yam accounts for 16 percent of Ghana's agricultural contribution to gross domestic product (GDP). The country is currently the leading exporter of yam in Sub-Saharan Africa contributing 36% of the world's total (Asante *et al.*, 2013).

Despite the importance of this crop to Ghana, its production faces several challenges, all of which threaten rural livelihood and urban food security. A major reason for poor yield is the limited availability of quality planting materials, devoid of pest, diseases and damage caused by weed infestation, especially the rhizomes of speargrass (*Imperata cylindrica* Linn.*)*. Quality seed yam supply chain, generally is scarce due to low multiplication rates and, therefore, very expensive (Aidoo *et al.,* 2011).

Speargrass is listed as one of the top ten most troublesome weeds in the world because of its invasiveness and difficulty to control (Koger and Bryson, 2004; MacDonald, 2004). It has colonised many areas in Latin America, tropical Asia, and some parts of West Africa due to its ability to propagate through both sexual and asexual means, among other adaptive characteristics (Chikoye *et al.*, 2000; King and Grace, 2000; Sellers *et al.*, 2015). It is known to cause a lot of injuries to roots and tubers in Sub-Saharan African countries, which affects crop quality (Bolfrey-Arku *et al.*, 2006).

Postharvest rot is a major factor limiting the shelf life of yam, and losses could be high, which subsequently affect the income of traders and farmers, availability of planting materials and food security (Aidoo, 2015a). The objective of this study was to assess injuries on seed yams resulting from the piercing mechanism of speargrass rhizomes and their effects on postharved rots, as well as determining the associated rot causal agents.

MATERIALS AND METHODS

Study area. The study was conducted in the Atebubu-Amantin Municipal Assembly of Ghana (lat. 7.7500° long. -0.983300°) in 2016 and 2017 planting seasons. Data were collected from forty farms in each year. Four communities were selected for this study based on their high level of involvement in seed yam production during the period of study. The communities were inhabitants of Mem (lat. 7.651122° long. -0.952794°), Watro (lat. 7.597775° long. -0.955133°), Abour (lat. 7.628164° long. -1.132014°) and Asanteboa (lat. 7.652683° long. -1.104072°). All fields were planted with white yam cultivars, namely, Dente, Serwa, Leelee, Pona, Yesu Mogya, Maama Koma and Kpamyo. The average cultivated area for all screened seed yam farms was 404.7 m^2. The fields were manually cleared and ridged at 1 m spacing, using cutlasses and hoes.

Planting materials and field establishment. The source of planting materials was mostly from previous season's harvest and open market. Planting materials were cut into minisetts size of 30 - 50 g and treated with *Lambda cyhalothrin* insecticide and *Ethylene bisdithiocarbamate* fungicide.

Treated minisetts were air-dried under shade, before planting at within row spacing of 30 - 50 cm. Minisetts were planted between May and June, while seed yams were harvested in December and January for each year. Management of weeds was done manually, with cutlasses and hoes, 3 to 5 times before harvesting of crop.

Weed assessment. Speargrass plants were counted within a quadrat (0.25 m^2) placed randomly, three times within the middle rows in a 30 m^2 designated plot to measure density (plant m^{-2}) at 4 and 6 months after planting (MAP). The above ground part of speargrass within the quadrat area was harvested at ground level, with a sharp knife, air dried for 3 - 4 days and oven dried to obtain dry weight.

Speargrass injury on tubers. On the designated 30 m^2 plot area within each farm, seed yams were harvested and sorted into four different categories, based on weight as: ware yam (> 1000 g), seed yam A (500 - 999 g), seed yam B (100- 499 g) and micro-tubers (< 100 g), (CAY-Seed Report, 2018). Damage caused by speargrass was assessed by expressing the yield weights of injured seed yams as a percentage of the total weight of seed yams harvested for a particular category.

Storage rot assessment. An *in vitro* study was conducted in the second year at CSIR - Crops Research Institute, Fumesua – Kumasi. Thirty seed yams each of two selected white yam cultivars (Dente and Kpamyo) from the VSRPT and NSRPHT samples, were randomly selected and stored in a ban at the CSIR-CRI for weekly assessment of rot for eight weeks. The NSRPHT samples served as controls. Rotten tubers were sampled and the rotten tissues from the localised area of VSRPT were subjected to pathological investigations in the laboratory. Pieces of tissues (1 cm^{-3}) were cut from the periphery of the rotten portions with a sterile knife, and surface-sterilised in 5% sodium hypochlorite solution for 2-3 minutes; and washed three times with distilled water.

The tissues were allowed to dry in a sterile laminar flow chamber (BASSAIRE, Southampton, UK) for 1 hr. For each sample, 20 pieces of rotten tissues were seeded in Petri dishes containing solidified potato dextrose agar (PDA) medium (Oxoid Ltd, Hants, UK); and incubated at a temperature of 27±2 °C by placing them in an incubator (GALLENKAMP, SN. 8095/10/295, UK). Mycelia that grew 2 days from the plated yam tissues were sub-cultured onto fresh PDA. Subsequent sub-culturing was done until pure cultures of isolates were obtained. These isolates were identified using morphological characteristics, following the standards of Mathur and Kongsdal (2003) and Barnett and Hunter (1972).

For bacteria, the rotten tissues were plated on a nutrient agar medium (Oxoid Ltd, Hants, UK). The frequency of occurrence was calculated for each yam cultivar by determining the number of times a pathogen was isolated from the rotten tubers expressed as a percentage of the total number of pathogen specific colonies observed.

Statistical analysis. Data on speargrass density, biomass, rhizome-pierced injury and damage on tubers were subjected to analysis of variance, following the procedure of GenStat 12.0. The raw count data were square root transformed (i.e. $\sqrt{(1+0.5)}$) before the analysis. Significant treatment means were separated using standard error of deviation (SED). The Pearson correlation was performed on speargrass density, biomass, damage and injury on seed yam.

RESULTS AND DISCUSSION

Speargrass density, injury and damage Seventy three percent of fields visited were infested with speargrass. A significantly high speargrass density of 172 - 223 plants m^{-2} were recorded at Watro and Mem fields, relative to < 42 plant m^{-2} at Abour and Asanteboa (Table 1) during the developmental phase of the crop. This indicates a probable initial dominance of speargrass in the former two communities. Bolfrey-Arku (2006) reported 51% farmers in the same ecological zone, noting inadequate control of speargrass manually. The type of manual implement used in the control of persistent weed as speargrass, has relevance on its density and growth. MacDonald (2004) confirms that commonly used weed control practices like manual slashing encourages the spread and growth of rhizomes. It may also be that, besides the inappropriate choice of control method, the control of speargrass and other weeds may not have been on time.

Generally, 26% of the harvested tubers were visibly pierced by speargrass rhizomes across categories, with the highest incidence

TABLE 1. Speargrass density and above ground biomass for Atebubu-Amantin Municipality, Ghana

Community	Speargrass density (plant m^{-2})		Speargrass biomass (g m^{-2})	
	4 MAP	6 MAP	4 MAP	6 MAP
Abour	35.33	39.50	11.00	14.00
Asanteboa	39.84	42.17	15.34	13.33
Mem	186.35	172.17	87.33	83.33
Watro	223.34	223.86	96.67	125.15
SED	23.97	15.38	10.15	23.45

MAP = Months after planting

of 45% from the Watro fields, followed by Mem (Table 2). These two communities are in close proximity; therefore, they may have similar management practices which inadequately disrupts the piercing activities of the growing rhizomes and emerging shoots on the tubers.

Significant differences in incidence of injury existed among the seed yam categories (Table 2). Ware yam consistently recorded the highest incidence, among communities with an average of 14.1%, followed by seed yam A; while the micro-tubers had no visible speargrass rhizome pierced injury. This could be due to the surface area of exposure; bigger tubers provided relatively more surface area for speargrass rhizome interaction and injury. It can be inferred that tubers that stay longer in the soil may not escape speargrass rhizome injury; thus for quality tubers which attract premium price, they should not be stored for long on speargrass infested fields. In Ghana, speargrass causes significant reduction in the quality and market value of root and tuber crops especially yam, cassava, cocoyam and sweet potato (Aflakpui and Bolfrey-Arku, 2007).

A critical analysis of the probability (P) and coefficient of correlation (r^2) values indicate a strong relationship between speargrass infestation and rhizome injury on all categories of tubers up to 6 MAP, except seed yam B. Table 3 indicates that 51% of damage to tubers is related to speargrass infestation. Rhizomes make more than 60% of the entire plant biomass, with about 72 or 50% occurring in 15 or 20 cm soil depth, respectively (Brook, 1989; MacDonald, 2004; Daneshgar *et al.*, 2008). Apart from seed yam B, the r^2 of 60-80% seemed to confirm that the bigger the surface area of exposure, the higher the incidence of speargrass rhizome injury on tubers; thereby increasing the risk of postharvest tuber rot. However, the duration of speargrass infestation on the field also strongly correlated with rhizome injury, and confirmed by the non-significant correlation (Table 3) of speargrass density at 6 MAP and seed B (small seed size).

Rot assessment. The rate of rot was faster in the visible speargrass rhizome-pierced tubers (VSRPT) than the non speargrass rhizome-pierced healthy tubers (NSRPHT) (Fig. 1). The incidence of rot from the VSRPT sample was observed 2 weeks after storage (WAS) for both cultivars, and 5 WAS from the NSRPHT sample. By 8 WAS, the incidence of rot from the VSRPT was 40% higher over the NSRPHT. The rot incidence at the end of storage for Dente and Kpamyo was 67 and 60%, respectively for VSRPT. Comparatively, Dente recorded 27% rot while Kpamyo had 13% for the NSRPHT. This confirms other studies that speargrass injury on tubers create entry points for rot pathogens (Chikoye *et al.*,

TABLE 2. Incidence of speargrass injury on harvested seed yams for Atebubu-Amantin Municipal, Ghana

Yam category	Incidence of speargrass injury on tubers (%)				Average
	Abour	Asanteboa	Mem	Watro	
Ware	5.14	5.94	17.90	27.59	14.14
Seed A	3.23	2.82	12.92	11.10	7.52
Seed B	1.34	2.44	6.17	5.89	3.96
Micro	0.00	0.00	0.00	0.00	0.0
SED = 1.31					

TABLE 3. Pearson correlations for speargrass density, speargrass biomass, seed A, B and Ware injury incidence and % damage pooled over experiments

Parameter	P value	R^2
Speargrass density @ 4MAP vrs Seed B injury incidence	0.038	0.507
Speargrass density @ 4MAP vrs Seed A injury incidence	0.006	0.638
Speargrass density @ 4MAP vrs Ware injury incidence	0.0001	0.817
Speargrass density @ 4MAP vrs % Damage	0.037	0.509
Speargrass density @ 6MAP vrs Seed B injury incidence	0.125	0.38
Speargrass density @ 6MAP vrs Seed A injury incidence	0.02	0.539
Speargrass density @ 6MAP vrs Ware injury incidence	0.0002	0.781
Speargrass density @ 6MAP vrs % Damage	0.0381	0.506
Speargrass biomass @ 4MAP vrs seed B injury incidence	0.095	0.418
Speargrass biomass @ 4MAP vrs seed A injury incidence	0.0053	0.644
Speargrass biomass @ 4MAP vrs Ware injury incidence	<0.0001	0.832
Speargrass biomass @ 4MAP vrs % Damage	0.0159	0.576
Speargrass biomass @ 6MAP vrs seed B injury incidence	0.124	0.388
Speargrass biomass @ 6MAP vrs seed A injury incidence	0.0166	0.571
Speargrass biomass @ 6MAP vrs Ware injury incidence	<0.0001	0.833
Speargrass biomass @ 6MAP vrs % Damage	0.0194	0.560

*Data were pooled over 2 years with 4 communities and 2 varieties at P = 0.05

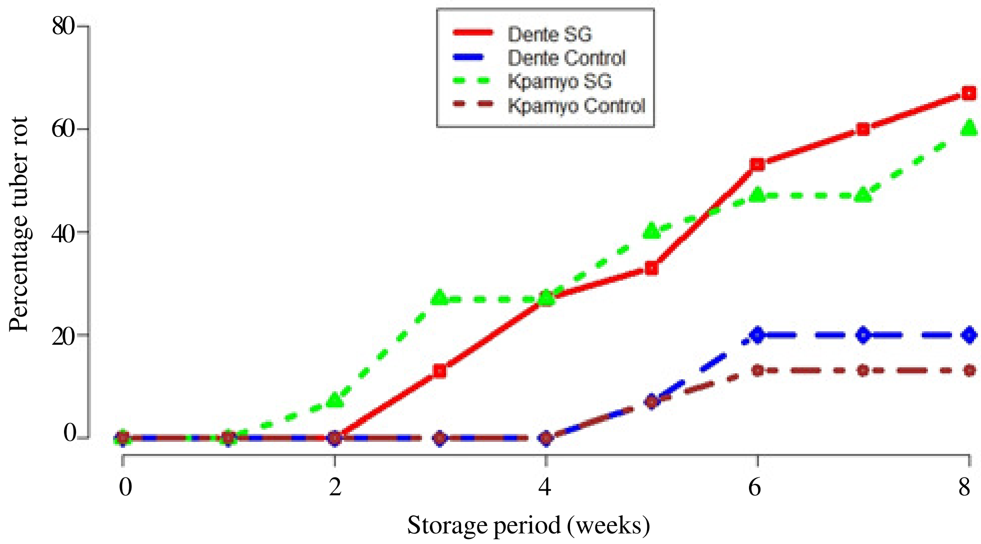

Figure 1. Effect of speargrass injuries on postharvest rot of Dente and Kpamyo seed yams.

TABLE 4. Morphological characteristics of identified fungi associated with rotten yam tubers from storage

Identified Fungus	Colony texture	Colony diameter (cm)	Upper view	Reverse view	Nature of hyphae	Nature of conidiophore	Conidia
Alternaria alternata		5.5-7	Dark brown	Blackish	Branched hyphae, septated	Simple and straight	Ovoid, formed in long chains
Lasiodiplodia theobromae	Cottony	7- 8	Blackish	Greyish	Thin, uniform and thread-like	Not clearly visible	Hyaline, double layered and unicellular
Aspergillus niger	Powdery	5-6	Dark brown	Off-white	Presence of phialides	Brown and broad	Globose to irregularly rough
Aspergillus flavus	Powdery	6-7	Yellowish green	Pale yellow	Conidial head radiate	Long, hyaline and walled	Subglobose or globose
Rhizopus stolonifer	Fluffy	Covered plate	Greyish	Brownish	Columella oval	Subglobose and rigid sporangiophore	Sporangia thick walled, pale to brown
Fusarium oxysporum	Floccose	5-6	Whitish	Purple	Presence of macroconidia		
Penicillium italicum		4-6	Blue	Pale yellow	Septated and hyaline	Smooth	Ellipsoidal to cylindrical

TABLE 5. Frequency of occurrence for identified rot pathogens from rotten yam tubers for two yam cultivars

Identified fungi	Frequency of occurrence (%)	
	Dente	Kpamyo
A. alternata	4.2	0
L. theobromae	35.3	30.9
A. niger	20.8	19.1
A. flavus	18.8	14.3
R. stolonifer	6.3	11.9
F. oxysporum	10.4	14.3
P. italicum	4.2	9.5
A bacterium	2.6	0

2000; Aflakpui and Bolfrey-Arku, 2007). The results point to the fact that tubers with speargrass rhizome injuries rot faster than healthy-looking tubers with no speargrass rhizome injury.

Isolation and identification of rot pathogens. A total of 90 fungal colonies were recorded on 40 plated tissues of rotten tubers. Seven fungal species from six genera, were identified to be associated with storage rots. These were *Alternaria alternata, Lasiodiplodia theobromae, Aspergillus niger, A. flavus, Rhizopus stolonifer, Fusarium oxysporum* and *Penicillium italicum* (Table 4). A bacterium, *Erwinia* sp. was also identified as a rot pathogen. *Lasiodiplodia theobromae* with the highest frequency of occurrence of 35.3 and 30.9% was recorded on Dente and Kpamyo, respectively (Table 5). These pathogens have been identified as being associated with postharvest yam tuber rot disease in Ghana (Aboagye-Nuamah *et al.*, 2005; Aidoo, 2015b).

The present study has established the perceived association between speargrass rhizome injury and storage rot by actors in the yam value chain. Storage rot organisms currently constitute a major threat to the massive potential of yam in improving food security and safety, hence the integrated management of speargrass on the field should be an integral part of postharvest storage practices of seed yam.

ACKNOWLEDGEMENT

We acknowledge the financial support from the CAY-Seed project, which was implemented by CSIR-Crops Research Institute, Ghana. Contributions from Messrs Augustine Agyekum, Micah Offei Apraku and the staff of the Plant Health Division of CSIR-CRI, Ghana, are acknowledged.

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