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Studies on storage rot of tuber crops in Konkan region

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Abstract
Due to storage rot, heavy losses occurring in tubers. Considering heavy losses and regular incidence of the disease of in elephant foot yam, lesser yam and greater yam in recent years, created interest to conduct this research study. This review presents different diseases associated with yam and the management strategies. *Sclerotium rolfsii*, *Aspergillus flavus* and *Rhizopus stolonifer* were isolated from rotten tubers of elephant foot yam, *Fusarium solani* was isolated from rotten tubers of lesser yam and *Rhizopus stolonifer* was isolated from rotten tubers of greater yam. Pathogenicity test revealed that all the isolated fungus were pathogenic on tuber crops. In storage, four different fungicides (12% WP + mancozeb 63% WP, mancozeb 75% WP, carbendazim 50% WP and captan 50% WP), organic (cow dung slurry) and bio-agent (*T. harzianum*) were evaluated against storage rot of tuber crops. In all tuber crops, T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) was most effective treatment and showed less weight loss percentage, less rotting percentage and more sprouting percentage at 120 days of storage. In elephant foot yam, this treatment showed 36.00% weight loss, 13.33% rotting and 86.67% sprouting at 120 days of storage. Also, in lesser yam, this treatment showed less weight loss percent (34.20%), less rotting percent (17.78%) and more sprouting percent (82.2%). Similarly, in greater yam, treatment T_4 showed 23.15% weight loss, 13.33% rotting and 88.89% sprouting at 120 days of storage.

Keywords: Elephant foot yam, lesser yam, greater yam, fungicides, organic, bio-agent, *Sclerotium rolfsii*, *Aspergillus flavus*, *Rhizopus stolonifer*, *Fusarium solani*

Introduction

For more than a billion people in the developing world, tropical tuber crops like casava, sweet potato, yams (greater, lesser and white) and aroids (elephant foot yam, taro and tannia) are the most important source of food. After cereals and grain legumes, tuber crops rank third in terms of importance as food crops. 6% of the world's dietary energy is thought to come from tuber crops, which are also excellent providers of carotene, antioxidants, dietary fiber and minerals. Due to their high calorific value and carbohydrate content, tuber crops play a significant role in the food security of the developing globe (Mhaskar *et al*., 2013) [12]. Post-harvest rot pathogen is a major threat to the huge potential of yam tubers (*Dioscorea* spp.) to improve food security and safety (Adeniji, 2019) [1]. Post-harvest 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. Their high moisture content and metabolic rate lead to losses of both mass and quality. The primary causes of these losses are abiotic and biotic stresses, growth responses (e.g., sprouting, rooting) and quality alterations (e.g., diseases, normal metabolic processes) (Afek and Kays, 2010) [2]. The important pathogens associated with yam tuber rot in storage are *viz*., *Sclerotium rolfsii* that causes *Sclerotium* rot, *Botryodiplodia theobromae* that causes Black rot or *Botryodiplodia*, *Rhizopus* spp. (*Rhizopus rot*), (*Fusarium* spp.) *Fusarium* rot and *Erwinia carotovora* (*Erwinia* rot), *Fusarium oxysporum*, *Fusarium solani*, *Aspergillus flavus*, *Aspergillus niger*, *Penicillium chrysogenum*, *Penicillium oxalicum*, *Trichoderma viride*, *Rhizoctonia* spp. and *Rhizopus nodosus* (Adeniji, 2019) [1]. Elephant Foot Yam and Yam (greater yam and lesser yam) have an extremely high rate of post-harvest losses at all phases, from harvest to consumption. The tubers are more susceptible to rotting fungus and bacteria because to the mechanical damage they sustain during harvesting and transportation.

Materials and Methods

The present study was conducted at AICRP on tuber crops, CES, Wakavali and Department of Plant Pathology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, in year 2022-2023.

Isolation

For isolation of the pathogen, naturally infected tuber sample of elephant foot yam, lesser yam and greater yam showing typical symptoms of rot collected from tuber germ plasm block. The diseased tubers with rotting symptoms were cut into small bits (2 mm), keeping half healthy and half diseased portion unharmed and surface sterilized with 0.1 percent aqueous Mercury chloride solution for 2-3 min. then the bits were washed by giving three successive changes with sterile distilled water in Petri plates to remove traces mercury chloride. These bits were then placed on sterilized blotter papers for drying. The dried bits were inoculated aseptically in sterilized Petri plates containing sterilized, solidified Potato Dextrose Agar (PDA) medium under the Laminar Flow Cabinet. The plates were incubated at room temperature at 27±2 °C till the fungal mycelium fully covered with the surface of the medium. The bits of well-developed fungal growth were cut (5 mm) with sterilized cork borer and transferred to slants and preserved as stock culture for further investigations. The culture was maintained by periodic transfer.

Pathogenicity

The pathogenicity test was carried out to establish which of the fungal isolates caused the rot and to determine whether they could induce similar symptoms on inoculation and re-isolated, thus fulfilling Koch's postulates. Healthy yam tubers of elephant foot yam, lesser yam and greater yam were surface sterilized by dipping completely in 0.1% of Mercury chloride solution for 2 minutes and rinsed three different times, each for one minute in sterile distilled water. The tuber were places on sterile Whatman filter paper, Number 9, in the inoculating chamber beside lighted spirit lamp to dry for 10 minutes. Each healthy tuber was bored into about 1 cm deep, with a sterile 6mm diameter cork borer at three different points on the yam tuber surface. Another 6mm sterile cork borer was used to cut about 5 mm of mycelia disc from edge of a 48-hours old culture of each fungus isolate. The mycelia discs were used to inoculate the holes created by scooping out the yam tissue. The scope out tissue of the yam tuber was replaced after 5 mm pieces has been cut off to compensate for the thickness of the fungal culture. The wounds were sealed with petroleum jelly and inoculated tubers were placed in transparent polythene bags whose inside has been moistened with cotton wool soaked in sterile distilled water to maintain a high humidity. The inoculated tubers were kept in the laboratory at room temperature for about 7 to 10 days (Ogunleye and Ayansola, 2014) [13].

Preparation of Phytoextract: The plant material (Soap Nut) was weighed to 100 g and thoroughly washed with clean water to remove dirt. Then plant material was blended in a food processor by adding 100ml of distilled water. The crude extract thus obtained was passed through double layered muslin cloth which was further centrifuged at 4000 ppm for 5 minutes. After centrifuging, the supernatant formed was removed and pellet was discarded. For avoiding bacterial contamination, the supernatant was passed through Whatman filter paper, Number 1. Thus, the standard plant extract with 100% concentration will be obtained (Bhattin, 1998) [5].

Soaking/dipping method: Four fungicides (mancozeb, carbendazim, captan, carbendazim + mancozeb), Organic (cow dung slurry) and bio-agent (*Trichoderma harzianum*) were evaluated *in vitro* against the test pathogens separately by using dipping/soaking method in Completely Randomized Design. Seven treatments and three replications (15 corms/replication) were imposed within 2-3 days after harvest. The corms were cleaned with water and infected parts were removed before giving the treatments. Then corms were cleaned with Soap nut rind extract (SNRE). After that the corms were fully dipped in the respective treatments for 10 minutes. Treated corms were dried in the shade (it may take 2-3 days depends on the weather). After drying corms were stored in well-ventilated place and observed weight loss, rotting and sprouting percent in storage upto 120 days at 30 days of interval.

The weight loss of tubers of different treatments was recorded by subtracting the fresh weight of tuber and weight of tuber at one month after storage and this difference was expressed in percent (Sarita Sahu and Kumar, 2017) [16].

$$\text{Weight Loss (\%)} = \frac{\text{Fresh weight of stored tubers} - \text{Weight of tubers after one Month storage}}{\text{Fresh weight of stored tubers}} \times 100$$

For calculating rotting percent in storage, the numbers of rotten tubers of different treatments were counted separately and it was expressed in percent (Sarita Sahu and Kumar, 2017) [16].

$$\text{Rotting (\%)} = \frac{\text{Number of rotten tubers}}{\text{Total number of stored tubers}} \times 100$$

For calculating sprouting percent in storage, the numbers of sprouted tubers of different treatments were counted separately and it was expressed in percent (Sarita Sahu and Kumar, 2017) [16].

$$\text{Sprouting (\%)} = \frac{\text{Number of sprouted tubers}}{\text{Total number of stored tubers}} \times 100$$

Results and Discussion

Sclerotium rolfsii (Plate 1), *Aspergillus flavus* (Plate 2) and *Rhizopus stolonifer* (Plate 3) were isolated from rotten tubers of elephant foot yam, *Fusarium solani* (Plate 4) was isolated from lesser yam and *Rhizopus stolonifer* (Plate 5) was isolated from greater yam. Isolated and identified fungi associated with the samples. Pathogenicity test revealed that all the isolated fungus were pathogenic on tuber crops.

Plate 1: Colony growth and microscopic view of *Sclerotium rolfsii*

Plate 2: Colony growth and microscopic view of *Aspergillus flavus*

Plate 3: Colony growth and microscopic view of *Rhizopus stolonifer*

Plate 4: Colony growth and microscopic view of *Fusarium solani*

Plate 5: Colony growth and microscopic view of *Fusarium solani*

Plate 6: Pathogenicity test of *Sclerotium rolfsii* on elephant foot yam

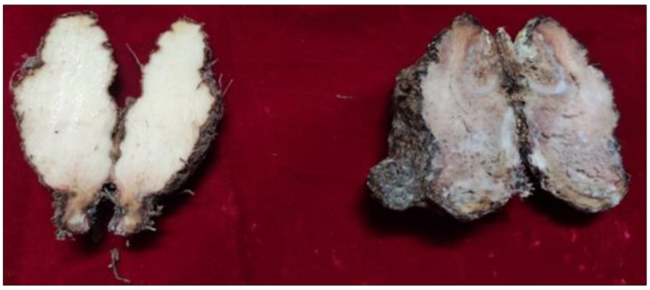

Plate 10: Pathogenicity test of *Rhizopus stolonifer* on greater yam

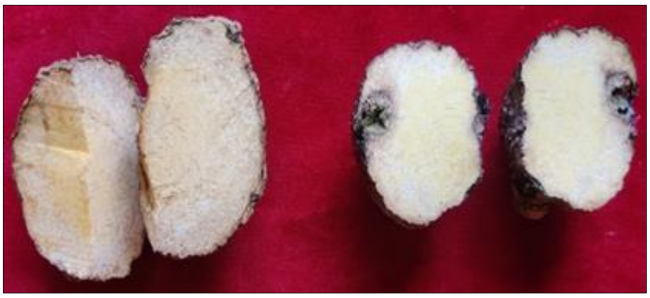

Plate 7: Pathogenicity test of *Aspergillus flavus* on elephant foot yam

Plate 8: Pathogenicity test of *Rhizopus stolonifer* on elephant foot yam

Plate 9: Pathogenicity test of *Fusarium solani* on lesser yam

In a plate, three different fungal mycelial growth was observed around the inoculated rotten tuber tissue of elephant foot yam. *Sclerotium rolfsii*, *Aspergillus flavus* and *Rhizopus stolonifer* were isolated from elephant foot yam. *Sclerotium rolfsii* showed milky white and thick mycelial growth with good sclerotia formation. Sclerotia produced were initially whitish and finally brown coloured. *Rhizopus stolonifer* was showed rapid and fast growth on PDA. Growth appears as black pin-head, similar to cotton wool (white in colour). *Aspergillus flavus* also showed rapid growth as green in colour surrounded by a clear white zone on PDA. Upper view showed yellowish green colour and reverse view shows pale yellow colour. Colony texture was powdery.

Fusarium solani was isolated from rotten tissues of lesser yam. Upper view showed cottony white structure. The microscopic observations showed branched, septate and hyaline hyphae. The fungus produced microconidia, macroconidia and chlamydospores.

From rotten tubers of greater yam *Rhizopus stolonifer* was isolated. Fungus showed rapid and fast growth on PDA. Colony texture was fluffy. Upper view showed greyish colour. Growth similar to cotton wool.

In the present study, fungi associated with the rot of elephant foot yam are *Sclerotium rolfsii*, *Aspergillus flavus* and *Rhizopus stolonifer*. Also, *Fusarium solani* associated with lesser yam (*Dioscorea esculenta*) and *Rhizopus stoloifer* associated with greater yam (*Dioscorea alata*). Earlier work was carried out by Okigbo an Emeka (2010) [14] from Nigeria, who were isolated *B. theobromae*, *A. niger*, *A. flavus*, *Rhizopus stolonifer* from *D. alata*. Yeni (2011) [17] also isolated *A. niger*, *F. oxysporum*, *A. flavus*, *B. theobromae*, *R. stolonifer* and *F. solani* from rot affected tissue of *D. alata*. In similar way, Ogunleye and Ayansola (2014) [13] isolated and identified *S. rolfsii*, *R. stolonifer*, *A. flavus*, *A. niger*, *F. oxysporum* from rotten yam (*Dioscorea* spp.) tubers on PDA medium. Similarly, Gwa and Akombo (2016) [6] isolated *A.*

flavus from rotten white yam (*D. rotundata*) on PDA medium. Aidoo *et al.* (2020) [4] from Ghana isolated *A. alternata*, *A. niger*, *A. flavus*, *R. stolonifer* and *F. oxysporum* from tissues of rotten yam tubers.

Elephant foot yam (EFY) – A. Effect of treatments on weight loss under storage in EFY.

The table 1, indicated the significant differences among different treatments in relation to weight loss percent in storage under ambient condition. Data shows that, there was progressive increase in average weight loss percent of tubers up to 120 Days. Minimum weight loss recorded in treatment T_4 - SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) is 36.00% at 120 days of storage, while it was at par with treatment T_1.

Table 1: Effect of treatments on weight loss under storage in elephant foot yam

Tr. No.	Treatments	Initial Weight (g)	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT a(%)
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	429.11	9.90 (18.33)	22.25 (28.14)	32.27 (34.61)	36.99 (37.46)
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	485.22	10.14 (18.56)	23.16 (28.76)	33.03 (35.08)	38.90 (38.58)
T_3	SNRE (20%) + Captan 50% WP (0.1%)	456.00	10.71 (19.09)	23.96 (29.31)	34.60 (36.03)	41.29 (39.98)
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	469.00	8.95 (17.40)	21.76 (27.80)	31.71 (34.27)	36.00 (36.87)
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	454.78	10.06 (18.49)	22.82 (28.53)	32.83 (34.96)	38.66 (38.45)
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	439.89	10.27 (18.69)	23.79 (29.19)	34.26 (35.82)	41.05 (39.85)
T_7	Control	426.78	11.37 (19.71)	24.24 (29.50)	35.38 (36.54)	43.19 (41.09)
	S.E.(m) ±		0.31	0.29	0.30	0.24
	C.D. at 1%		1.30	1.22	1.27	0.99

SNRE: Soap Nut Rind Extract, DAT: Days after Treatment, Figures in parenthesis are arc sine transformed values.

b. Effect of treatments on rotting under storage in elephant foot yam

In table 2, among all treatments, T_4- was found the best effective. The rotting percent in corms was recorded in T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) at 120 days of storage. i. e. 13.33, while it was at par with treatment T_1 and T_5.

Table 2: Effect of treatments on rotting under storage in elephant foot yam

Tr. No.	Treatments	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT (%)	% ROC
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	0.00	8.89 (17.12)	13.33 (21.41)	15.56 (23.13)	58.81
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	0.00	11.11 (19.26)	17.78 (24.85)	20.00 (26.57)	47.06
T_3	SNRE (20%) + Captan 50% WP (0.1%)	0.00	13.33 (21.41)	22.22 (28.07)	24.44 (29.58)	35.31
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	0.00	6.67 (14.97)	11.11 (19.26)	13.33 (21.41)	64.72
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	0.00	8.89 (17.12)	15.56 (23.13)	17.78 (24.85)	52.94
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	0.00	11.11 (19.26)	20.00 (26.57)	22.22 (28.07)	41.19
T_7	Control	0.00	20.00 (26.57)	35.56 (36.52)	37.78 (37.91)	-
	S.E.(m) ±	0.00	1.62	1.70	1.32	
	C.D. at 1%	0.00	6.84	7.14	5.56	

SNRE: Soap Nut Rind Extract, DAT: Days after Treatment, Figures in parenthesis are arc sine transformed values

Effect of treatments on sprouting under storage in elephant foot yam

Treatment T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) was the best effective treatment, while this treatment at par with T_1 and T_5. Table 3 revealed that, sprouting percent was more in T_4-SNRE (20%) + carbendazim 12%WP + mancozeb 63% WP (0.2%) at 120 days of storage is 86.67.

Table 3: Effect of treatments on sprouting under storage in elephant foot yam

Tr. No.	Treatments	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT (%)
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	0.00	64.44 (53.41)	84.44 (66.87)	84.44 (66.87)
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	0.00	60.00 (50.77)	77.78 (61.93)	80.00 (63.43)
T_3	SNRE (20%) + Captan 50% WP (0.1%)	0.00	55.56 (48.25)	73.33 (59.03)	75.56 (60.42)
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	0.00	64.44 (53.41)	86.67 (68.59)	86.67 (68.59)
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	0.00	62.22 (52.09)	82.22 (65.15)	82.22 (65.15)
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	0.00	60.00 (50.81)	75.56 (60.42)	77.78 (61.93)
T_7	Control	0.00	44.44 (41.80)	62.22 (52.09)	62.22 (52.09)
	S.E.(m) ±	0.00	1.84	1.63	1.32
	C.D. at 1%	0.00	7.76	6.85	5.56

SNRE: Soap Nut Rind Extract, DAT: Days after Treatment, Figures in parenthesis are arc sine transformed values.

Lesser yam

Effect of treatments on weight loss under storage in lesser yam

The table 4, showed the significant differences among different treatments in relation to weight loss percent in storage. Data shows that, there was progressive increase in average weight loss percent of tubers up to 120 Days. Minimum weight loss recorded in T_4 - SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) is 34.20%, which was found effective at 120 days of storage.

Table 4: Effect of treatments on weight loss under storage in lesser yam

Tr. No.	Treatments	Initial Weight (g)	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT (%)
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	75.22	5.49 (13.54)	20.19 (26.70)	29.53 (32.92)	35.67 (36.67)
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	79.56	6.56 (14.84)	23.19 (28.79)	32.41 (34.70)	38.56 (38.39)
T_3	SNRE (20%) + Captan 50% WP (0.1%)	79.67	8.50 (16.95)	25.19 (30.13)	33.31 (35.25)	40.94 (39.78)
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	86.78	4.63(12.42)	17.45 (24.69)	26.91 (31.25)	34.20 (35.79)
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	77.78	6.42 (14.67)	21.15 (27.38)	30.31 (33.41)	37.27 (37.63)
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	81.11	7.39 (15.77)	21.33 (27.50)	30.85 (33.74)	38.98 (38.63)
T_7	Control	70.67	11.17 (19.52)	30.05 (33.24)	37.74 (37.90)	44.35 (41.76)
	S.E.(m) ±		0.20	0.27	0.27	0.28
	C.D. at 1%		0.83	1.15	1.14	1.18

SNRE: Soap Nut Rind Extract, DAT: Days after Treatment, Figures in parenthesis are arc sine transformed values

Effect of treatments on rotting under storage in lesser yam.

Among all treatments, T_4- was found the best effective. In treatment T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) at 120 days of storage 17.78% rooting was recorded, which showed at par with treatment T_1 and T_5.

Table 5: Effect of treatments on rotting under storage in lesser yam

Tr. No.	Treatments	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT (%)	% ROC
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	2.22 (4.99)	13.33 (21.41)	15.56 (23.13)	22.22 (28.07)	37.51
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	6.67 (14.97)	15.56 (23.13)	20.00 (26.57)	24.44 (29.58)	31.27
T_3	SNRE (20%) + Captan 50% WP (0.1%)	8.89 (17.12)	15.56 (23.13)	24.44 (29.58)	28.89 (32.48)	18.76
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	0.00 (0.00)	8.89 (17.12)	13.33 (21.41)	17.78 (24.85)	50.00
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	4.45 (9.98)	13.33 (21.41)	17.78 (24.85)	22.22 (28.07)	37.51
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	8.89 (17.12)	15.56 (23.13)	22.22 (28.07)	26.67 (31.09)	25.00
T_7	Control	13.33 (21.41)	22.22 (28.07)	28.89 (32.48)	35.56 (36.59)	-
	S.E.(m) ±	2.90	1.50	1.33	1.39	
	C.D. at 1%	12.22	6.31	5.60	5.84	

SNRE: Soap Nut Rind Extract, DAT: Days after Treatment, Figures in parenthesis are arc sine transformed values.

Effect of treatments on sprouting under storage in lesser yam

Over all, Treatment T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) was the best effective. Table 6 indicated that sprouting percent was more in T_4- SNRE (20%) + carbendazim 12%WP + mancozeb 63% WP (0.2%) at 120 days of storage was 82.22%, while it was at par with treatment T_1 and T_5.

Table 6: Effect of treatments on sprouting under storage in lesser yam

Tr. No.	Treatments	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT (%)
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	0.00	66.67 (54.80)	77.78 (61.93)	77.78 (61.93)
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	0.00	60.00 (50.77)	68.89 (56.13)	75.56 (60.42)
T_3	SNRE (20%) + Captan 50% WP (0.1%)	0.00	57.78 (49.48)	66.67 (54.74)	71.11 (57.52)
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	0.00	71.11 (57.52)	80.00 (63.43)	82.22 (65.15)
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	0.00	64.44 (53.41)	71.11 (57.52)	77.78 (61.93)
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	0.00	62.22 (52.09)	66.67 (54.74)	73.33 (58.91)
T_7	Control	0.00	51.11 (45.65)	60.00 (50.77)	64.44 (53.41)
	S.E.(m) ±	0.00	1.65	0.94	1.39
	C.D. at 1%	0.00	6.96	3.94	5.84

SNRE: Soap Nut Rind Extract, DAT: Days after Treatment, Figures in parenthesis are arc sine transformed values.

Greater yam

Effect of treatments on weight loss under storage in greater yam

The table 7, showed the significant differences among different treatments in relation to weight loss percent in storage. Data shows that, there was progressive increase in average weight loss percent of tubers up to 120 Days. Minimum weight loss recorded in treatment T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) was 23.15%. Treatment T_1- SNRE (20%) + mancozeb 75% WP (0.2%) was recorded next best treatment.

Table 7: Effect of treatments on weight loss under storage in greater yam

Tr. No.	Treatments	Initial Weight (g)	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT (%)
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	308.44	6.04 (14.22)	11.81 (20.09)	16.66 (24.08)	25.54 (30.35)
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	309.69	6.58 (14.85)	13.39 (21.46)	18.37 (25.37)	26.26 (30.82)
T_3	SNRE (20%) + Captan 50% WP (0.1%)	315.78	7.29 (15.64)	14.31 (22.22)	18.90 (25.77)	27.01 (31.31)
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	300.11	5.71 (13.81)	10.36 (18.77)	15.72 (23.36)	23.15 (28.75)
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	309.78	6.16 (14.35)	12.64 (20.82)	17.53 (24.75)	25.82 (30.54)
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	317.33	7.21 (15.57)	14.15 (22.09)	18.64 (25.58)	26.91 (31.24)
T_7	Control	301.11	8.28 (16.70)	17.07 (24.40)	24.87 (29.91)	32.04 (34.47)
	S.E.(m) ±		0.48	0.29	0.31	0.46
	C.D. at 1%		2.04	1.22	1.32	1.92

SNRE: Soap Nut Rind Extract, DAT: Days After Treatment, Figures in parenthesis are arc sine transformed values.

Effect of treatments on rotting under storage in greater yam.

Among all treatments, T_4 was the best effective, while it was at par with treatment T_1 and T_5. The rotting percentage in corms was recorded in T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) at 120 days of storage. i. e. 11.11% and it was at par with treatment T_1 and T_5.

Table 8: Effect of treatments on rotting under storage in greater yam

Tr. No.	Treatments	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT (%)	% ROC
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	0.00	8.89 (17.12)	13.33 (21.41)	13.33 (21.41)	50.02
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	0.00	11.11 (19.26)	17.78 (24.85)	17.78 (24.85)	33.33
T_3	SNRE (20%) + Captan 50% WP (0.1%)	0.00	13.33 (21.41)	17.78 (24.85)	20.00(26.57)	25.01
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	0.00	6.67 (14.97)	8.89 (17.12)	11.11 (19.26)	50.02
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	0.00	8.89 (17.12)	15.56 (23.13)	15.56 (23.13)	41.66
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	0.00	11.11 (19.26)	17.78 (24.85)	20.00 (26.57)	25.01
T_7	Control	0.00	20.00 (26.57)	24.44 (29.58)	26.67 (31.09)	-
	S.E.(m) ±	0.00	1.62	1.63	1.23	
	C.D. at 1%	0.00	6.84	6.88	5.16	

SNRE: Soap Nut Rind Extract, DAT: Days after Treatment, Figures in parenthesis are arc sine transformed value.

Effect of treatments on sprouting under storage in greater yam

Treatment T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) was found best effective, while it was at par with T_1 and T_5. Table 9 indicated that sprouting percent was more in T_4- SNRE (20%) + carbendazim 12%WP + mancozeb 63% WP (0.2%) at 120 days of storage is 88.89%.

Table 9: Effect of treatments on sprouting under storage in greater yam

Tr. No.	Treatments	30 DAT (%)	60 DAT (%)	90 DAT (%)	120 DAT (%)
T_1	SNRE (20%) + Mancozeb 75% WP (0.2%)	0.00	64.44 (53.41)	82.22 (65.15)	86.67 (68.59)
T_2	SNRE (20%) + Carbendazim 50% WP (0.1%)	0.00	60.00 (50.81)	77.78 (61.93)	82.22 (65.15)
T_3	SNRE (20%) + Captan 50% WP (0.1%)	0.00	57.78 (49.48)	68.89 (56.13)	80.00 (63.43)
T_4	SNRE (20%) + Carbendazim 12% WP + Mancozeb 63% WP (0.2%)	0.00	68.89 (56.19)	84.44 (66.87)	88.89 (70.74)
T_5	SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (Cow dung 50% + Water 50%)	0.00	62.22 (52.09)	80.00 (63.64)	84.44 (66.87)
T_6	SNRE (20%) + Cow dung slurry (Cow dung 50% + Water 50%)	0.00	57.78 (49.48)	75.56 (60.42)	80.00 (63.43)
T_7	Control	0.00	48.89 (44.36)	64.44 (53.41)	73.33 (58.91)
	S.E.(m) ±	0.00	1.73	1.77	1.23
	C.D. at 1%	0.00	7.27	7.46	5.16

SNRE: Soap Nut Rind Extract, DAT: Days after Treatment, Figures in parenthesis are arc sine transformed values

Plate 13: General view of EFY, Lesser yam and Greater yam tubers in storage

In storage, treatment T_4- SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%) was performed the most effective treatment in all tuber crops. This treatment showed less weight loss percent, less rotting percent and more sprouting percentages at 120 days of storage. After that, T_1- SNRE (20%) + mancozeb 75% WP (0.2%), T_5- SNRE (20%) + *Trichoderma harzianum* (5 g/kg of corms) in cow dung slurry (cow dung 50% + water 50%), T_2- SNRE (20%) + carbendazim 50% WP (0.1%), T_6- SNRE (20%) + cow dung slurry (Cow dung 50% + Water 50%) were noticed the next best treatments and T_3- SNRE (20%) + captan 50% WP (0.1%) was the less effective treatment in all tuber crops.

Discussion

In the present study, fungi associated with the rot of elephant foot yam are *Sclerotium rolfsii*, *Aspergillus flavus* and *Rhizopus stolonifer*. Also, *Fusarium solani* associated with lesser yam (*Dioscorea esculenta)* and *Rhizopus stoloifer* associated with greater yam (*Dioscorea alata*). Earlier work was carried out by Okigbo an Emeka (2010) [14] from Nigeria, who were isolated *B. theobromae*, *A. niger*, *A. flavus*, *Rhizopus stolonifer* from *D. alata*. Yeni (2011) [17] also isolated *A. niger*, *F. oxysporum*, *A. flavus*, *B. theobromae*, *R. stolonifer* and *F. solani* from rot affected tissue of *D. alata*. In similar way, Ogunleye and Ayansola (2014) [13] isolated and identified *S. rolfsii*, *R. stolonifer*, *A. flavus*, *A. niger*, *F. oxysporum* from rotten yam (*Dioscorea* spp.) tubers on PDA medium. Similarly, Gwa and Akombo (2016) [6] isolated *A. flavus* from rotten white yam (*D. rotundata*) on PDA medium. Aidoo *et al.* (2020) [4] from Ghana isolated *A. alternata*, *A. niger*, *A. flavus*, *R. stolonifer* and *F. oxysporum* from tissues of rotten yam tubers.

The results of the present study are in accordance with Ibrahim *et al.* (2014) who proved pathogenicity of *R. stolonifer*, *A. niger*, *A. flavus*, *F. oxysporum* on Irish potato. Pathogenicity of *A. niger*, *S. rolfsii*, *R. stolonifer*, *F. oxysporum*, *A. flavus*, *Penicillium* spp. also proved on yam by using method of Okafor (Ogunleye and Ayansola, 2014) [13]. Agu *et al.* (2015) [3] also carried out pathogenicity test of *A. fumigatus*, *A. niger* and *R. stolonifer* on Sweet Potato. Similarly, Gwa and Akombo (2016) [6] proved pathogenicity *A. flavus* on white yam. Pathogenicity test carried out using the six fungal isolates (*F. solani*, *S. rolfsii*, *L. theobromae*, *A. flavus*, *A. niger* and *A. ochraceus*) on fresh and healthy sweet potato tubers showed that all the six fungal isolated were pathogenic in causing rot (Gyasi *et al*., 2022) [7].

In present experiment, T_6- SNRE (20%) + cow dung slurry (cow dung 50% + water 50%) showed 34.26% weight loss in elephant foot yam and 30.85% weight loss in lesser yam at 90 days of storage. The results of present experiment are in accordance with the results obtained by Sarita Sahu and Kumar (2017) [16], who were reported that treatment cow dung slurry (cow dung 50% + water 50%) was showed 30.96% of weight loss at 90 days of storage in elephant foot yam. Treatment T_2- SNRE (20%) + carbendazim 50% WP (0.1%) showed 11.11% rotting in elephant foot yam, 15.56% rotting in lesser yam and 11.11% rotting in greater yam at 60days of storage. Remadi *et al.* (2006) demonstrated that fungicides individually or in combination were effective against dry rot of potato in which carbendazim application showed 16.66% rotting at 60 days of storage. In another study, experiment conducted at AAU, Jorhat (ICAR-CTCRI TC, 2022), noticed that T_5- carbendazim 12% WP + mancozeb 63% WP (0.2%) was the effective treatment which showed 9.56% rotting at 90 days of storage in elephant foot yam. Also, in storage BAU, Ranchi (ICAR-CTCRI TC, 2022) showed that T_5- carbendazim 12% WP + mancozeb 63% WP (0.2%) was the effective treatment which showed 18.30% rotting in elephant foot yam. Similarly, Dr. YSRHU, Kovvur (ICAR-AICRP TC Annual report, 2022) revealed that among all the treatments, minimum rotting of corms was observed in elephant foot yam, when the corms were treated with combination fungicide containing mancozeb + carbendazim (saaf).

Conclusion

From the results of present experiment, it is concluded that storage rot of tuber crops incited by *Sclerotium rolfsii*, *Aspergillus flavus*, *Rhizopus stolonifer*, *Fusarium solani* can be effectively controlled by treatment SNRE (20%) + carbendazim 12% WP + mancozeb 63% WP (0.2%). This treatment showed less weight loss percent, less rotting percent and more sprouting percentage.

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