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Evaluation of integrated crop management strategies to combat collar rot (*Sclerotium rolfsii*) in elephant foot yam

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Abstract
Root and tuber crops are important food crops that are climate resilient. Elephant foot yam is an important tuber crop with high yield potential. The experiment was conducted over six years at the Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The aims were to evaluate different management strategies to control collar rot disease in elephant foot yam. The results showed that out of seven treatment combinations treatment T_3 recorded significantly the highest corm yield per plant (2.58 kg) and corm yield per hectare (38.67 t) with high benefit-cost ratio (2.13). The lowest values for yield per plant (1.81 kg), corm yield per hectare (25.60 t) and benefit cost ratio (1.30) was recorded inT_3-control. This indicate that, for soil-borne diseases in elephant foot yam, integrated crop management practices play a key role when the crops are under biotic stress.

Keywords: Elephant foot yam, collar rot, ICM, yield, BCR

Introduction
Root and tubers are the most important food crops since time immemorial in the tropics and subtropics (Behera*et al*., 2009) [4]. Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) is regarded as "King of tuber crops" due to its higher biological efficiency as a food producer and possesses higher productivity in a short growing season as well as confers high returns (Mukhopadhyay and Sen, 1999; Nath*et al*., 2007; Nedunchezhiyan, 2014) [11, 13, 14]. It has long been used as a local staple food in many countries such as Philippines, Indonesia, Bangaladesh, India, China and other South eastern Asian countries. It is a cheap source of carbohydrate, rich in mineral and vitamin A and B. The corm is used as vegetable and also for preparing curries and pickles.

One of the greatest challenges of the 21st century will be to feed the burgeoning population with nutritional qualities so as to achieve food security in India as well as in many parts of the globe. Elephant foot yam is the crop having the potential to meet the nutritional requirements of the fast growing population of the developing countries. The crop is attacked by bacteria, fungi and viruses. These diseases reduce the yield and quality of corms making them unappealing to the consumers. In India, the root rot/collar rot caused by *Sclerotium rolfsii* wasfirst time reported by Shaw and Ajrekar (1915) [23] who had isolated the pathogen from rotting potatoes which they identified as *Rhizoctonia destruens* Tassi. Later studies convinced Ajrekar that the fungus involved in rotting of potato as *Sclerotium rolfsii* but not *Rhizoctonia destruens*(Ramakrishna, 1930) [20]. During 1985 the collar rot to chilli caused by *Sclerotium rolfsii* was observed in Maharshtra at Vidarbha region (Wangihar *et al*. 1988) [29]. Higher precipitation, relative humidity and temperature aggravate intensity/severity of the disease. The pathogen, *Sclerotium rolfsii* Sacc. is a polyphagous soil-borne pathogen causing heavy yield loss worldwide.The symptoms include appearance of water soaked lesions on the collar region of stem and yellowing of leaves. In later stages, the yellowing spreads and the petiole (Pseudo stem) collapses.

The crop is susceptible to *Sclerotium rolfsii* Sacc. which causes collar rot, a destructive disease often afflicting heavy loss to the crop (Sivaprakasam *et al*., 1982) [25]. Since, *S. rolfsii* is a non-specialized soil borne fungal pathogen of world-wide importance and management of this pathogen is extremely ambiguous. The pathogen, *S. rolfsii* is distributed in tropical and sub-tropical regions of the world where high temperatures prevail. The fungus has a wide host range of 500 species in about 100 families including groundnut, green bean, lima bean, onion, garden bean, pepper, potato, sweet potato, tomato and water melon (Aycock, 1966) [2]. The pathogen caused a great economic loss in various crops. In groundnut, it caused 25 per cent of seedling mortality (Ingale and Mayee, 1986) [8]. Thiribhuvanamala *et at*. (1999) [26] observed that 30 per cent of crop losses in tomato was due to *S. rolfsii*. It is more destructive during rainy season followed by warm dry weather. Injury to collar region during intercultural operation, poor drainage and water logging acts as predisposing factors for infection by *S. rolfsii*. Soft and tender pseudostems are more vulnerable to this disease. Hence, the present investigation was designed to incur the data regarding effect of different treatment combination on incidence of collar rot and its subsequent effect on yield of elephant foot yam.

Materials and Methods

The field experiment was carried out for consecutive two years during 2017 and 2018 at Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The experimental site is characterized with clay loamy soil texture rich in organic matter content. Coimbatore receives on an average 650- 700 mm rainfall annually and is situated at an elevation of 426 M (longitude: 77°E and latitude: 11ºN). The average annual temperature ranges from 25ºC-38ºC. The experimental land was ploughed and pulverized 2-3 times by tractor-driven mold board plough followed by laddering to obtain a fine tilth. Stubbles and weeds were removed from the field. The experimental plot was divided into 21 plots. Each plot measuring 4.5 × 4.5m, having 50 cm wide irrigation cum drainage channel between each plot was laid out. The corms of 500 g weight were planted on the ridges or hills with plant to plant spacing of 90 cm and ridge to ridge spacing of 90 cm. The experiment was laid out in randomized block design with three replications.

Treatment details

Treatment		Treatment details
T1	:	Dip the corms in Sprint 0.1% (Mancozeb+ carbendazim)– before storing the corms; Treat the corms in cow dung slurry +*Trichoderma* @5g/kg corm- 3 days before planting; Drench twice with 0.2% Sprint- after intercultural operations; Remove infected plants carefully and give an additional application (drenching with 0.2% Sprint) to the surrounding plants
T2	:	Treat the corms in cow dung slurry +*Trichoderma* @5g/kg corm- 3 days before planting; Drench twice with 0.2% Sprint- after intercultural operations
T3	:	Dip the corms in Saaf 0.1%(Mancozeb+ carbendazim) – before storing the corms; Treat the corms in cow dung slurry +*Trichoderma* @5g/kg corm- 3 days before planting; Drench twice with Saaf (0.2%) - after intercultural operations; Remove infected plants carefully and give an additional application (drenching with Saaf (0.2%)) to the surrounding plants
T4	:	Treat the corms in cow dung slurry +*Trichoderma* @5g/kg corm- 3 days before planting; Drench twice with Saaf (0.2%) - after intercultural operations
T5	:	Dip the corms in 0.7% Nanma for 10 minutes – before storing the corms; Treat the corms in cow dung slurry +*Trichoderma* @5g/kg corm- 3 days before planting; Apply **Trichoderma* enriched FYM @2.0-2.5 kg/pit at the time of planting; Apply twice *Trichoderma* + vermicompost (150-200g) after intercultural operations; Remove infected plants carefully and give an additional application (*Trichoderma* + vermicompost (150-200g)) to the surrounding plants
T6	:	Treat the corms in cow dung slurry +*Trichoderma* @5g/kg corm- 3 days before planting; Apply *Trichoderma* enriched FYM @2.0-2.5 kg/pit at the time of planting; Apply twice *Trichoderma* + vermicompost (150-200g)- after intercultural operations
T7	:	Control (Treat the corms in cow dung slurry 3 days before planting; Apply FYM @2.0-2.5 kg/pit at the time of planting)

* FYM: Neem cake mixture (10:1) inoculated with *Trichoderma* @ 2.5 kg per tonne of FYM + neem cake mixture. Cover with a polythene sheet after heaping the inoculated FYM to maintain humidity. After 7 days, fungal growth will be visible.

The collar rot incidence was recorded from 2 months of planting until harvest. The observations were recorded on initiation of the disease (DAP), Number of plants affected, Number of days taken from initial symptom to death, Number of plants yellowing to collapse of the plant, Number of plants shown sudden collapse. Yield attributes and BCR were recorded at harvest.

Cost benefit analysis

Total cost of cultivation and gross returns were calculated from average input cost and average market price of the produce during the period of investigation. Based on this net income was computed as follows:

Net income Indian (Rupees ha^{-1}) = Gross income - cost of cultivation

Data Analysis

According to the statistical techniques given by Panse and Sukhatme (1976) [15], the quantitative data was subjected to analysis of variance (ANOVA) using AGRES statistical software for the relevant experimental design. Following the significance of mean squares, the comparisons of the mean performance of treatments were made using the Least Significant Difference (LSD) at the 5% probability level.

Results and Discussion

The result of the two-year investigation on the effect of different treatments on initiation of disease, the number of plants affected and the number of days taken from initial symptom to death are presented in Table 1.Collar rot incidence was meager when both bio-control agents and chemicals were applied. Papavizas (1985) [16] emphasized the importance of the integration of *Trichoderma* or *Gliocladium* with compatible fungicides or other practices in controlling soil-borne pathogens. The treatment T^3 resulted in significantly lower collar rot incidence. The number of plants that expressed sudden collapse was also much in T^3. This may be due to a synergistic effect of the disease controlling microbial consortia and chemical treatment which might arrest the collar rot spread. The treatment was the next best treatment. The treatment T^7resulted INA higher incidence of collar rot. A study

conducted by Praveen Kumar (2012) [19] revealed that the combination involving soil drenching with vitavax @ 0.2%+ soil application of FYM-enriched *Trichoderma hazianum* @ 5q/ha showed minimum disease severity (16.75%) and gave 69.40 per cent disease control and 58.24 t/ha corm yield. Results of studies conducted by Vishal Gandhi *et al*. (2017) [28] revealed that seed treatment with Captan 50 WP @ 3 g/kg seed was found most effective treatment in controlling the disease incidence (73.38%). Among the different bio-agents evaluated, *Pseudomonas fluorescens* as soil dressing gave maximum disease control (55.11%) of collar rot in sunflower and obtained maximum seed yield.

The effect of different treatments on yield and economics elephant foot yam are presented in Table 2. The results showed that, out of seven treatment combinations treatment T_3 [Dip the corms in Saaf 0.1%(Mancozeb+ carbendazim) – before storing the corms; Treat the corms in cow dung slurry +*Trichoderma* @5g/kg corm- 3 days before planting; Drench twice with Saaf (0.2%) - after intercultural operations; Remove infected plants carefully and give an additional application (drenching with Saaf (0.2%) to the surrounding plants] recorded significantly highest corm yield per plant (2.58 kg) and corm yield per hectare (38.67 t) with highest benefit-cost ratio (2.13). The lowest values for yield per plant (1.81 kg), corm yield per hectare (25.60 t) and benefit-cost ratio (1.30) were recorded in T7 -control [Treat the corms in cow dung slurry 3 days before planting; Apply FYM @2.0-2.5 kg/pit at the time of planting]. Gogoi *et al*. (2002) [7] reported the efficacy of *T.harzianum* + 0.2% Captan against collar rot caused by *S. rolfsii* in elephant foot yam. They also reported disease suppression and increased yield in the corm of Elephant footy yam.

Dutta and Das (2002) [5]studied the efficacy of three *Trichoderma* spp. and two seed dressing fungicides for the management of collar rot. He also reported the efficacy of *T. harzianum*, *T. viride* & *T. koningii* & 2 seed dressing fungicides [0.1% thiram& 0.1% Dithane M-45 (Mancozeh)] for the management of collar rot of tomato caused by *Sclerotium rolfsii* under laboratory & field condition. Gogoi *et al*. (2002) [7] also reported the efficacy of *Trichoderma harzianum* and *Bacillus subtilis* (alone & in combination with 0.2% Captan) against collar rot of EFY caused by *S. rolfsi*i. Soil drenching with Captan exhibited the lowest disease incidence (12.9%) among all the treatments. The combination of corm+soil treatment with Captan was satisfactorily at par with corm+ soil treatment with *T. harzianum*. Corm treatment with *T. harzianum* followed by soil drenching with Captan inhibited the growth of the antagonist. In all the treatments the population density of *S. rolfsii* significantly decreased compared to the control.

Various workers have worked out integrated management modulus for effective control of *S. rolfsii* in various crops *viz.*, groundnut (Patibanda*et al*., 2002; Muthamilan and Jeyarajan, 1996; Saralamma and Reddy, 2005; Ganesan *et al*., 2007; Sai *et al*., 2010; Vikram and Hamzehzarghani, 2011) [17, 12, 22, 6, 21, 27], tomato (Banyal*et al*., 2008) [3], Soybean (Singh and Thpliyal, 1998; Prabhu and Patil, 2004; Ansari and Agnihotri, 2000) [24, 18, 1], Strawberry (Khosla and Kumar, 2005) [10] and tuberose (Islam & Bhuiyan, 2006) [9]. Hence, instead of following fully organic methods, integrated crop management practices will reduce the disease incidence and also increase the income per unit area.

Table 1: Effect of ICM packages on the incidence of *S. Rolfsii*

Treatments	Initiation of the disease (DAP)	Number of plants affected	Number of days taken from initial symptom to death	Number of plants shown yellowing to collapse of the plant	Number of plants shown sudden collapse
T_1	92.67	5.67	14.33	3.67	2.00
T_2	81.00	6.00	13.04	3.33	2.67
T_3	94.67	4.33	17.90	2.67	1.67
T_4	83.67	5.67	14.24	3.33	2.33
T_5	78.67	6.67	11.98	3.33	3.33
T_6	78.00	7.00	11.28	4.00	3.00
T_7	77.00	9.67	9.55	5.00	4.67
CD	2.97	1.63	2.04	1.08	1.22
SeD	1.49	0.82	1.02	0.54	0.61
CV	11.63	3.86	4.93	4.95	2.82

*DAP- Days after planting

Table 2: Effect of different treatments on Yield and Economics elephant foot yam

Treatments	Corm Yield/plant (tha^{-1})	Corm Yield(tha^{-1})	Cost of cultivation (Rs.ha^{-1})	Gross return (Rs.ha^{-1})	Net return (Rs.ha^{-1})	B:C ratio
T_1	2.55	38.40	158860	460846	311517.6	2.09
T_2	2.33	35.78	151340	429408	287148.4	2.02
T_3	2.58	38.67	157920	464026	315581.2	2.13
T_4	2.39	36.29	152280	435456	292312.8	2.04
T_5	2.16	33.96	160740	407549	256453.4	1.70
T_6	2.01	31.25	155100	374986	229192	1.57
T_7	1.81	25.60	136300	295231	167109	1.30
CD	0.62	2.56				
SeD	0.31	1.28				
CV	7.97	7.45				

Conclusion

The systematic investigation revealed that elephant foot yam was found to be infected with *S. rolfsii* 70 days after planting. Different treatment combinations were studied for the integrated management of EFY and it is evident from the finding that T_3> T1 were the better treatments compared to the evaluated counterparts. It can be concluded that *S. rolfsii* causing collar rot of elephant foot yam can be managed by an integrated management option i.e. T_3 recorded77.32% disease control with a good benefit-cost ratio of 2.13.

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