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Cultural and Biological Control Measures Against Corm Rot Disease of Tannia (*Xanthosoma sagittifolium* (L.) Schott): Impact on Growth and Yield

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Abstract

Tannia (*Xanthosoma sagittifolium* (L.) Schott), a backyard tuber crop and a low subsistence staple food, is now an important commercial crop in Sri Lanka. It is a shade loving crop relatively free from pest problems. However, corm rot (leaf yellowing) disease caused by *Rhizoctonia* spp. is one of the major constraints in the profitable cultivation of the crop. At present this disease has reached an epidemic level in most of the tannia cultivated areas. The main symptoms of the disease are yellowing of leaves, stunted plant growth and rotting of tubers. Experiments were conducted at Horticultural Crops Research and Development Institute (HORDI), Gannoruwa for three consecutive seasons (2006-2009) for the management of soil borne disease, corm rot (leaf yellowing) in tannia. Four cultural practices (planting on ridges, pits, flat land and intercropping with maize) and three soil treatments with *Trichoderma* (at the time of planting, one and two months after planting) were evaluated. The disease incidence was very low in soils treated with *Trichoderma* based biocontrol agent. The results revealed that soil treatment with *Trichoderma* gave significantly higher yields (13.5 t ha^{-1}) and mean number of cormels per plant and mean cormel weight. Therefore, *Trichoderma* based biocontrol agent was found to be effective for the management of soil borne diseases like corm rot and getting higher productivity.

Key words: Tannia, *Trichoderma,* biocontrol agent, corm rot (leaf yellowing) disease, productivity

Introduction

Tannia, locally known as Kiri ala (*Xanthosoma sagittifolium* (L.) Schott) belonging to the family Araceae, is believed to have originated in Tropical America (Purseglove,1972). Tannia has been cultivated since ancient times in South America and West Indies. It has become widespread in the tropics in the mid nineteenth century (Leslie Cobley, 1976). The young leaves are used as vegetables and the corms are more nutritious than taro (*Colocasia).* Currently it is a major horticultural export commodity, which is second to the export of cassava, among root and tuber crops. Tannia is grown as a large scale commercial crop in open lands and in marginal rice lands in the dry and intermediate zones with irrigation, in lands with fluctuating water table and irregular sloppy lands in the wet zone. It is a viable intercrop to increase the land use efficiency and cropping intensity in coconut and banana plantations in the wet and intermediate zones. In addition, cultivation is made in newly cleared lands on a fairly large scale in Moneragala and Badulla districts of Sri Lanka.

Corm rot (leaf yellowing) disease is one of the major constraints in the profitable cultivation of tannia. In the recent past, tannia production in Kandy, Kegalle, Galle, Gampaha, Kurunegala and Colombo in Sri Lanka areas suffered heavily due to the incidence of corm rot. At present this disease has reached epidemic level in most of the areas, which causes significant reduction of yield in tannia. The crop requires well-drained soil and does not tolerate permanent water logging (Hernando Bermejo and Leon, 1994). The disease tends to occur in fields with poor drainage, where water accumulates in the field or on the lower sections of gentle slopes and causes heavy damage (Nzietchueng, 1984). The main symptoms observed in the infected plants are poor plant growth, yellowing at the margin of the leaves and finally drying of the entire leaf and rotting of the corm (Fig.1). Isolation of causal organisms was done from diseased tannia plants obtained from different locations. The isolates of fungi were identified by comparison of their colony characters and morphology on potato dextrose agar (PDA) and corn meal agar (CMA) with published data. The causal agents of this disease were identified as *Rhizoctonia solani, Fusarium oxysporum* and *Pythium* species in the Pathology Division, HORDI, Gannoruwa. Among these *Rhizoctonia solani* was commonly isolated from rotten corms collected from all locations (Anon., 2003). The control measures recommended were use of disease free planting material, crop rotation with non host crops like sweet potato, cassava and maize and dipping planting materials in fungicides like Homai WP 18g 10 l^{-1} or Thiram 80 WP 50g 10 l^{-1} for 15-30 min before planting. However, significant reduction of the disease could not be achieved by fungicide treatments under field conditions. Parasitic activity of members of the genus *Trichoderma* to fungal pathogens such as *Rhizoctonia solani, Pythium* and *Fusarium* species has been reported by earlier researchers (Hornby, 1990; Shalini-Verma and Dohroo, 2003; El-Mohamedy and El-Mougy, 2009; Ruano-Rosa and Lopez-Herrera, 2009; Saddiq, 2009) in several crops. Hence attempts were made at HORDI, Gannoruwa to identify suitable *Trichoderma* based biocontrol agents for managing corm rot (leaf yellowing) of tannia. Therefore, the objective of the present study was to test the effect of *Trichoderma* based biocontrol agent conjoint to manage corm rot disease and thereby increase the yield.

Fig.1. Leaf yellowing symptoms of affected plant

Materials and Methods

Site description

An experiment was conducted at Horticultural Crops Research and Development Institute (HORDI), Gannoruwa for three consecutive seasons during October - June in 2006-2009. This area is in mid country wet zone of Sri Lanka. The annual rainfall in this region ranges from 2000 to 3000 mm. The average temperature ranges from 20°C to 28°C. The day time relative humidity generally ranges from 55% to 80% whereas night time ranges from 75% to 85 %. The soil type of the experimental site is reddish brown latosols (Panabokke, 1967). The soil is moderately fine textured and slightly acidic. The initial pH of the soil was 5.2, organic C content 1.83% available N 0.32% available P 2.1 mg kg^{-1} and availabe K 13.81 mg kg^{-1}. Base saturation was 20-30%. Cation exchange capacity was 12-20 meq 100 g^{-1}. Moderately high responses to N, P and K fertilizers could be obtained in this soil. It was also fairly well supplied with Ca and Mg.

Culturing of *Trichoderma harzianum*

A saw dust based carrier medium was developed by HORDI Scientists and used for bulk production. Saw dust filled polypropylene bags were autoclaved at 121°C for 20 min under 15 Psi (Fig. 2) . *Trichoderma harzianum* isolates (HORDI 1) cultured on PDA were incubated at room temperature (25-28°C) for two weeks until well sporulated. Conidial suspensions (10^7 conidia ml^{-1} water) were prepared from culture plates of *Trichoderma* isolates. Ten ml of conidial suspension was added to the carrier material of the bags under aseptic condition and incubated for 3-4 weeks in room temperature.

Design, test variety and treatments

Field experiments were conducted consecutively for three years during October to June in 2006-2009 in an

Fig. 2. *Trichoderma* inoculum bag

area infected with corm rot fungi, wherein the crop was grown in an open land. The experiment was laid out in randomised block design with five treatments and three replications. The recommended variety Rathu iri Kiri ala – Isuru, which is moderately susceptible to the disease, was the test variety. Healthy tannia suckers with 4-5 leaves were transplanted in 4.5 x 4.5 m^2 plots at a plant spacing of 90 x 90 cm. Irrigation was done once in 3 or 4 days. Two or three weedings were carried out during each season. Cattle manure @ 10 t ha^{-1} was applied two weeks before planting. Chemical fertilizers were applied according to the recommendation of Department of Agriculture to supply NPK @ 15:55:35 kg ha^{-1} as basal dressing. At 1.5-2 months and 3-3.5 months, N @ 30 kg ha^{-1} and K @ 35 kg ha^{-1} were applied as top dressing. At 5.5-6.5 months, K @ 25 kg ha^{-1} was applied as top dressing. Treatments comprised four cultural practices (planting on ridges, pits, flat land and intercropping with maize) and soil treatment with *Trichoderma* in pits (at the time of planting, one and two months after planting). In pit method, pits of size 45 cm^3 were made. In plots intercropped with maize, two rows of maize (spacing 90 x 45 cm) were planted between three rows of tannia. Saw dust based *Trichoderma* inoculum was incorporated into the soil two weeks before planting (500 g m^{-2} bag^{-1}) and then re-inoculated again into the soil one and two months after planting. The average spore concentration in *Trichoderma* bags was around 10^6 spores g^{-1} of inoculum. The disease development was observed during crop growth and percentage of disease incidence was recorded. The crop was rainfed with supplementary irrigation. The causal agents of corm rot were identified as *Rhizoctonia solani, Fusarium oxysporum* and *Pythium* species in the laboratory of Pathology Division, HORDI. Harvesting was done 8-9 months after planting. The mean plant height, number of leaves per plant, leaf length and leaf breadth were recorded. The cormel yield, number of cormels per plant, cormel weight per plant, cormel length and cormel girth were recorded. The data were analyzed by ANOVA and mean separation were done by Duncan's Multiple Range Test. SAS software programme was used for the analysis of data.

Results and Discussion

The effect of treatments on growth parameters of tannia is given in Table 1. The pit method, method of intercropping with maize and soil treated with *Trichoderma* produced taller plants. Leaf production was also high in the pit method and under *Trichoderma* treatment. The plant growth was poor when planted on ridges and flat land. Therefore planting the tannia plants on ridges and flat land were not suitable for crop growth. Generally leaf length/breadth ratio of more than one is an indicator of good growth. This was observed in all the treatments, except, for ridge planting.

The mean disease incidence and cormel yield of different treatments are given in Table 2.

Table1. Effect of treatments on growth parameters of tannia

Treatment	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Leaf breadth (cm)	Leaf length / breadth ratio
Pit	68.1^{ab}	5.0^{a}	33.2^{a}	30.8^{a}	1.07
Planting on ridges	61.1^{b}	4.2^{b}	28.7^{c}	29.8^{b}	0.96
Intercropping with maize	71.5^{a}	4.4^{b}	33.8^{a}	30.9^{a}	1.09
Soil treatment with *Trichoderma*	66.3^{ab}	5.1^{a}	31.7^{b}	30.1^{b}	1.05
Flat land	63.8^{b}	4.5^{ab}	32.1^{ab}	30.6^{a}	1.04
CD (0.05)	5.5	0.5	1.8	0.7	

Values with the same superscript in a coloumn are not significantly different

Table 2. Effect of treatments on disease incidence and cormel yield of tannia

Treatment	Disease incidence (%)				Tuber yield (t ha^{-1})			
	2006-2007	2007-2008	2008-2009	Mean	2006-2007	2007-2008	2008-2009	Mean
Pit	60	55	55	56.7	10.5^{ab}	8.7^{b}	8.5^{bc}	9.2
Planting on ridges	60	55	50	55.0	7.1^{c}	6.5^{b}	7.0^{c}	6.9
Intercropping with maize	55	30	20	35.0	10.3^{abc}	9.5^{b}	11.1^{b}	10.3
Soil treatment with *Trichoderma*	50	20	10	26.7	11.7^{a}	13.4^{a}	15.4^{a}	13.5
Flat land	60	55	55	56.7	8.3^{bc}	7.6^{b}	7.3^{c}	7.7
CD (0.05)					3.19	3.42	3.84	

Values with the same superscript in a coloumn are not significantly different

The results revealed that in the first season the disease incidence was similar in all the treatments (Table 2). However, in the consecutive seasons drastic reduction in the incidence of disease was observed in the *Trichoderma* incorporated treatment. The disease incidence was reduced to 20% in the second year and 10% in the third year in soil treated with *Trichoderma*. The highest yield was obtained from the *Trichoderma* incorporated treatment in all the three years. In the first year, the yield obtained from the *Trichoderma* incorporated treatment was on par with the treatments such as intercropping with maize and planting in pits. In the subsequent years, soil treatment with *Trichoderma* proved significantly superior (Figs. 3 and 4).

Reduction in disease incidence and yield enhancement due to *Trichoderma* based biocontrol agent had been successfully reported by several workers. Pieta and Pastuch (2009) reported the protective effect of the microbiological material *Trichoderma harzianum* G 220 and *Gliocladium fimbriatum* S 151 and their post-culture liquids against soil borne pathogenic fungi such as *Alternaria alternata*, *Botrytis cinerea*, *Fusarium solani*, *Pythium irregulare*, *Rhizoctonia solani* and *Sclerotinia sclerotiorum*. They found that the use of biocontrol agents improved the emergence, health and yield of pea plants. Sallam et al. (2008) reported that in greenhouse and field experiments, soil treatment with a powder formulation of *Trichoderma* spp. two weeks before planting or at the time of planting reduced significantly the incidence of damping-off and wilt diseases caused by *Rhizoctonia solani* and *Fusarium oxysporum* on Giza 3 bean cultivar. The formulation of *Trichoderma* not only suppressed both damping-off and wilt diseases but also enhanced green pod yield of bean plants compared to

Fig.3. Cormels of affected plants

Fig.4. A plant with high yield in *Trichoderma* incorporated treatment

the infected control.

Juber and Hassoun (2008) evaluated the effect of biological control agents, namely *Trichoderma harzianum* and *Bacillus subtilis* against potato stem canker disease caused by *Rhizoctonia solani* AG3 isolate RS6. The disease incidence and severity was lower and yield higher in the biocontrol treatment.

Tannia intercropping with maize also showed reduction in disease incidence (up to 20% in the third year) and higher yield in consecutive seasons. Planting on ridges and flat bed were not effective to control the disease or enhancing the yield. The establishment rate, crop growth, corm size and weight were poor when the crop was planted on ridges.

Greater cormel yield was observed in the *Trichoderma* based biocontrol agent application due to favourable effects on yield attributes viz., number of cormels per plant, cormel girth and cormel weight (Table 3). The cormels in this treatment had greater girth than length, which is a preferred character to obtain the correct cormel shape (flask shape) for export market. Though the cormel number was significantly higher due to planting on ridges, cormel length, cormel girth and cormel weight were low in this treatment. Soil incorporation of *Trichoderma harzanium* significantly increased tannia yield due to the control of corm rot and improvement of growth parameters.

Table 3. Effect of treatments on yield attributes of tannia

Treatment	Mean number of cormels per plant	Mean cormel weight (g)	Mean cormel length (cm)	Mean cormel girth (cm)
Pit	8.7^{ab}	120.4^{a}	16.6	16.7
Planting on ridges	9.9^{a}	70.5^{c}	13.1	15.8
Intercropping with maize	8.8^{ab}	116.2^{a}	16.1	16.4
Soil treatment with *Trichoderma*	10.7^{a}	118.6^{a}	16.0	17.9
Flat land	7.8^{b}	108.3^{b}	16.3	16.3
CD (0.05)	1.6	9.5		

Values with the same superscript in a coloumn are not significantly different

Conclusion

Incorporation of *Trichoderma harzianum* into the soil and intercropping with maize can be successfully practiced to manage corm rot and enhance yield in tannia.

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