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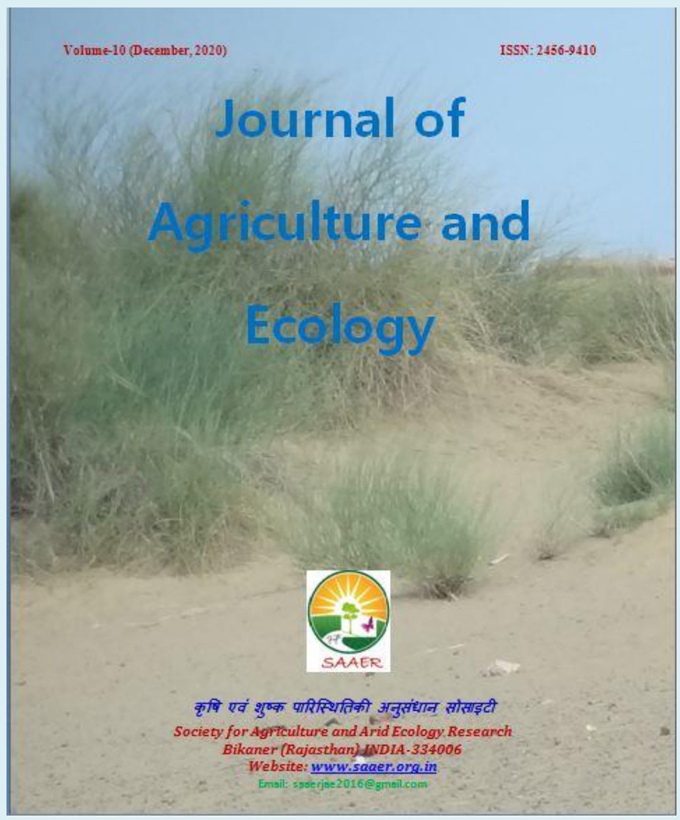

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Cost benefit ratio of bio-control agents, botanicals and fungicide in the management of white rot of onion caused by *Sclerotium rolfsii* Sacc. in Manipur

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Abstract

The research investigation was undertaken to evaluate the economics of the management of white rot of onion by *Trichoderma harzianum*, *Trichoderma viride*, garlic (*Allium sativum* L.), turmeric (*Cucurma longa* L.), sweet flag (*Acorus calamus* L.) and Carbendazim (50% WP). Carbendazim recorded highest gross return followed by *T. harzianum* and *T. viride* respectively. Carbendazim also recorded highest net return followed by *T. harzianum* and garlic respectively. Among the treatments, Carbendazim gave the highest net return cost benefit ratio of 1:3.25. Garlic extract gave cost benefit ratio of 1:2.96. *T. harzianum* gave cost benefit ratio of 1:2.89.

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Introduction

Onion (*Allium cepa* L.) is a vegetable and spice crop of economic importance in Manipur. It was originated in Central Asia (Vavilov 1951). It is included under the family *Amaryllidaceae.* It is also used as medicines since it is rich in antioxidant enzymes and antimicrobial compounds (Stajner & Varga 2003; Santas et al. 2010). Onion is often used in the preparation of cuisine including salad, gravy, sauce, pickles, curry, chutney and many more. Onion contains organic disulphides including allyl propyl disulphides, methyl cis-propenyl disulphides, methy trans-propenyl disulphides, cis-propenyl propyl disulphides, trans- propenyl propyl disulphides, methyl propenyl trisulphides and propenyl propyl trisulphides (Brodnitz et al. 1969; Augusti & Benaim 1975). The varying colour of onion skin is due to anthocyanin and flavonol like quercetin glucoside (Downes et al. 2009). It is being referred to as queen of the kitchen (Selvaraj 1976). In Manipur, bulb onion is mostly cultivated as a cool season crop. Onion suffers from numerous diseases and white rot of onion caused by *Sclerotium rolfsii* Sacc. is one of important diseases which reduces onion production to a significant extent. The disease is characterized by yellowing of leaves from tips which extend downwards and is subsequently accompanied by blighting, drooping and wilting of aerial part of the plant. Infected bulbs are soft, watery, decayed and white fluffy mycelium with small circular white, brown to black colour sclerotia of the fungus are present on the infected bulb scales and basal plate and roots. The fungus have a very large host range of about 500 plant species and attack both monocots and dicots (Aycock 1966; Punja 1985). The fungus produced sclerotia which remains viable for long period (Punja 1985). The fungus survives as sclerotia, hymenial layers, and also as mycelium in infected plants, plant debris and on dead organic materials (Mullen 2001). Sclerotia are differentiated into thick walled rind cells which are rich in melanin pigment, thinner walled cortex and extremely thick walled medulla which are full of reserve materials and this arrangement in turn make sclerotia resistance to biological degradation (Chet et al. 1969). There are variability among isolates of *S. rolfsii* obtained from different hosts and locations (Sarma et al. 2002). Therefore, the utilization of eco-friendly biocontrol agents and botanicals are essential as the continuous use of fungicides are harmful to human health, environment, confers phytotoxic effect, non target effect on unrelated microorganism and development of resistance of the pathogen against fungicides (Franke et al. 1998; Dias 2012; Nettles et al. 2016). However, the use of fungicides is also essential as it cost less compared to biocontrol agents and botanicals. Moreover, fungicides are often considered as the last line of defence in integrated disease management practices that protect an inherent yield potential (Poole and Arnaudin 2014). Hence, the present study was conducted to evaluate the cost benefit ratio of the management of white rot of onion caused by *Sclerotium rolfsii* Sacc. by biocontrol agents namely, *Trichoderma harzianum* and *Trichoderma viride* and aqueous extract (1:1 w/v) of botanicals namely, clove of garlic (*Allium sativum* L.), rhizome of turmeric (*Cucurma longa* L.) and rhizome of sweet flag (*Acorus calamus* L.) and fungicide namely, Carbendazim (50% WP) in Manipur as it was crucial to evaluate the economic for sustainable management of this disease.

Materials and Methods

Collection, identification and maintenance of the pathogen

The diseased onion bulbs which were cultivated in the experimental site in the previous crop season were collected. The infected bulb scales were cut into small pieces and were surface sterilised with 1% sodium hypochloride solution. The sterilised pieces were blot dried and inoculated on potato dextrose agar and were incubated at 28 ± 1^{0}C for 4 days. The pathogen was purified by hyphal tip cut method and re-isolated on PDA and identified by comparison with relevant monographs.

Application of treatment

Seedlings dipping and sprayings at the base of the onion plants were adopted for each treatment. Onion seedlings were dipped in suspension of each treatment of both

Trichoderma harzianum and *T. viride* (10g/L), garlic (3mL/L), turmeric (10mL/L), sweet flag (10mL/L), and carbendazim (1g/L). Basal spraying at the base of onion plants were given thrice after one month of transplanting at 30 days intervals by suspension of all the treatments at the same concentrations used for seedlings dipping. Control plots were not subjected to treatment. Three replications were adopted for each treatment.

Assessment of economics

The research investigation was conducted at College of Agriculture, Central Agricultural University, Imphal, India during 2015-2016. Imphal have a sub-tropical climate. The soil of experimental site is clayey in texture and acidic in reaction ranging from $p^{H\ 5.6}$ to p^{H}5.8. The experiment was carried out in rabi season using randomized block design (RBD) with three replications. The plot measures 2m X 1.5m and a spacing of 10cm X 10cm was adopted. There were a total of 266 plants on a single plot. Nasik Red N-53 was used for the investigation. Economics of individual treatment were worked out using the following indices:

Cost of cultivation

It was calculated by taking into account the inputs, labour and operational costs.

Gross return

The total monetary values of the economic produce, which in this investigation is fresh onion bulb obtained was calculated based on the price of local market and is expressed on unit area basis.

Net return

It is also referred to as net profit. It was calculated by subtracting the total cost of cultivation for the various treatments from their respective gross returns.

Cost benefit ratio (Return per rupee invested)

It is also referred to as input-output ratio and cost benefit ratio. It was calculated by using the formula

$$\text{Cost benefit ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

This index provides an estimate of the benefit, derived from the expenditure incurred in adopting a particular system.

Results and Discussion

The fungus was identified as *Sclerotium rolfsii* Saccardo based on morphological characteristics and taxonomic keys available in the literatures (Saccardo 1913; Mordue 1974; Punja 1985). Carbendazim gave highest bulb yield of 191.2 q/ha.

Cost of Cultivation

The total capital investments in the production of onion bulb with different treatments are presented in Table 1 and Table 2. The maximum capital investments of ₹1,53,400/ha was needed for *Trichoderma harzianum* and *T. viride* for the management of white rot of onion. While minimum capital investment of ₹1,47,000/ha was needed in plots sprayed with Carbendazim.

Gross Return

Gross return presented in Table 3 showed that maximum gross income of Rs. 4,78,000/ha was recorded from plot sprayed with Carbendazim which was followed by *T. harzianum* recording ₹4,44,750/ha. The lowest gross income of Rs. 4,09,250/ha was obtained from plots sprayed with sweet flag extract.

Net Return

Data presented in Table 3 revealed that among the different treatments, maximum net income of Rs. 3,31,000/ha was recorded from plot sprayed with Carbendazim, and was followed by garlic extract which gave net return of Rs. 2,89,850/ha. However, the lowest net income of Rs. 2,59,250/ha was obtained from the plots sprayed with sweet flag extract.

Cost benefit ratio (Return per rupee invested)

Data presented in Table 3 revealed that the maximum cost benefit ratio of 1:3.25 was recorded with Carbendazim followed by cost benefit ratio of 1:2.96 with garlic extract. *Trichoderma harzianum* and *T. viride* gave cost benefit ratio of 1:2.89 and 1:2.86. Least cost benefit ratio was observed from the plots sprayed with sweet flag extract (1:2.72). The present findings are in conformity with that of Raut and Patil (2005) who reported that the cost benefit ratio of 1:2.15 was highest in plots treated with 1% Bavistin (Carbendazim), followed by *T. viride* (1:1.47), 0.1% garlic extract (1:1.38) in management of foot rot and wilt of tomato caused by *Fusarium oxysporum* and *Rhizoctonia bataticola*. Jadav et al. (2016) reported that application of *Trichoderma* species for the management of stem rot of groundnut caused by *S. rolfsii* gave an average cost benefit ratio of 1:1.89. Similarly, Laksman et al. (2018) stated that treatment of sunflower wilt caused by *S. rolfsii* with *T. viride* during 2014-15 and 2015-16 gave benefit cost ratio of 1.23 and 1.28 respectively while treatment with *T. harzianum* during 2014-15 and 2015-16 gave benefit cost ratio of 1.26 and 1.31 respectively. Siddique et al. 2018 reported that highest benefit cost ratio of 1.89 was obtained from Carbendazim in the management of foot and root rot of brinjal caused by *S. rolfsii* and treatment with *T. harzianum* gave a benefit cost ratio of 1.34 respectively. Daunde et al. (2020) also reported that Carbendazim (50WP), *T. harzianum* and *T. viride* gave a cost benefit ratio of 1:2.79, 1:2.38 and 1:2.32 in the management of collar rot of chilli caused by *S. rolfsii*. The present findings are also in conformity with the findings of Sunkad (2012) and Jadon et al. (2017).

Table 1. Cost of cultivation of onion (Nasik Red N-53) per hectare

Serial number	Particulars	Quantity/unit	Rate(Rs)	Total(Rs)
1.	Land preparation			
	a) Tractor	5 hrs	500/hr	2500
	b) Power tiller	6hrs	700/hr	4200
2	Seed (12Kg/ha)	12kg	1100/kg	13200
3	Fertilizer			
	a) Urea (125kg/ha)	125kg	11/kg	1375
	b) SSP (60kg/ha)	60kg	15/kg	900
	c) MOP (100kg/ha)	100kg	28/kg	2800

4	FYM (20t/ha)	20,000kg	5/kg	1,00,000
5	Labour cost			
	a) Nursery bed preparation	2 men/day	225/man/day	450
	b) Levelling	15 men/day	225/man/day	3375
	c) Seed sowing	1 men/day	225/man/day	225
	d) Transplanting	20 men/day	225/man/day	4500
	e) Gap feeling	3 men/day	225/man/day	675
	f) Intercultural operation	20 men/day	225/man/day	4500
	g) Irrigation	8 men/day	225/man/day	1800
	h) Harvesting and handling	20 men/day	225/man/day	4500
Total A (Rs)				1,45,000

Table 2. Cost of cultivation for each treatment

Treatment	Quantity/ha	Rate of treatment (Rs/kg)	Total cost of treatment (a) (Rs/ha)	Total number of application (b)	Total B (a X b) (Rs)	Total cost of cultivation A+B (Rs)
Trichoderma harzianum	2.1kg/ha	1000	2100	4	8400	1,53,400
T. viride	2.1 kg/ha	1000	2100	4	8400	1,53,400
Garlic	5 kg/ha	120	600	4	2400	1,47,400
Turmeric	50 kg/ha	30	1500	4	6000	1,51,000
Acorus	50 kg/ha	25	1250	4	5000	1,50,000
Carbendazim	1kg/ha	500	500	4	2000	1,47,000

Table 3. Effect of bio control agents, botanicals and fungicide on bulb yield, gross return, net return and cost benefit ratio

Treatment	Yield (quintal/ ha)	Gross return @ Rs 25/kg (Rs/ha)	Total cost of cultivation (Rs/ha)	Net return Rs/ha	Cost benefit ratio
Trichoderma harzianum	177.9	4,44,750	1,53,400	2,91,350	1:2.89
T. viride	175.6	4,39,000	1,53,400	2,85,600	1:2.86
Garlic	174.9	4,37,250	1,47,400	2,89,850	1:2.96

Turmeric	166.6	4,16,500	1,51,000	2,65,500	1:2.75
Sweet flag	163.7	4,09,250	1,50,000	2,59,250	1:2.72
Carbendazim	191.2	4,78,000	1,47,000	3,31,000	1:3.25
Control	130.4	3,26,000	1,45,000	1,81,000	1:2.25

Conclusion

Utilization of fungicide in the management of white rot of onion gave a highest net return and cost benefit ratio. However, the constant use of fungicide is disastrous to environment and living organisms. Therefore, alternatives for fungicides such as biocontrol agents and locally available botanicals should also be considered although it is not as beneficial in terms of economics. Fungicide can be employed in integrated disease management strategies so as to raise the net return and cost benefit of the crop productivity. Biocontrol agents and botanicals can be employed in organic farming and can also be utilized in integrated disease management alongside with fungicide. Hence, consideration of not only cost benefit ratio of the crop's production but also that of environment and its biodiversity is very crucial.

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