Original Research Article

Evaluation of fungicides and their compatibility with *Trichoderma asperellum* for management of *Rhizoctonia bataticola* (Taub) Butler in groundnut

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ABSTRACT

The efficacy of four systemic and combination fungicides, namely Carbendazim 12% + Mancozeb 63% WP, Tebuconazole 25% WG, Hexaconazole 4% + Zineb 68% WG, and Tebuconazole 50% + Trifloxystrobin 25% WG, against *Rhizoctonia bataticola*, the causal agent of dry root rot in groundnut was evaluated using the poison food technique. Among the tested fungicides, Hexaconazole 4% + Zineb 68% WG exhibited the highest efficacy, with 100% inhibition of mycelial growth at all concentrations tested.Tests of compatibility of these fungicides with *Trichodermaasperellum* revealed that Hexaconazole 4% + Zineb 68% WG caused 38.88% of growth inhibition in *T.asperellum* while the other fungicides tested were totally incompatible with100 percent inhibition.

Keywords: Dry root rot, Rhizoctoniabataticola, Trichoderma, Fungicides,poisoned food technique, compatibility,

1. INTRODUCTION

Worldwide the leading producer of groundnut (*Arachishypogaea* L.) is China, with a production of **17.57 MILLION TONNES, FOLLOWED BY INDIA WITH 6.73 MILLION TONNES IN 2019-20 (AGRICULTURAL MARKET INTELLIGENCE CENTRE, PJTSAU, 2022).IT** is the most cultivated oil seed crop in India and second to soybean in production. **DESPITE ITS IMPORTANCE, GROUNDNUT PRODUCTIVITY IN MANY DEVELOPING COUNTRIES REMAINS LOW DUE TO VARIOUS PRODUCTION CONSTRAINTS, INCLUDING BOTH BIOTIC AND ABIOTIC STRESSES.**Among biotic factors, pathogens on groundnut plants cause significant yield losses in the field as well as reduce seed quality during post-harvest storage. One such pathogen is *Rhizoctonia bataticola*, a soil-borne fungus responsible for causing dry root rot in groundnut plants. The disease, also known as "dry wilt," is particularly severe in regions like Rajasthan, Uttar Pradesh, Tamil Nadu, Andhra Pradesh, and Maharashtra, where dry conditions prevail during the rain-fed season. The pathogen can survive on or within seeds and persists in the soil in the form of black sclerotia, which are abundantly produced on infected tissues and disseminated during tillage operations.

Chemical fungicides are commonly used to control *R. bataticola* and manage the disease. However, the use of fungicides may have negative effects on beneficial soil microorganisms (BCAS), such as *Trichoderma* spp., which are crucial for sustainable agriculture. By utilizing compatible fungicides with BCAS, the management of dry root rot in groundnut can be improved, reducing the reliance on hazardous chemicals and promoting more environmentally friendly and effective disease control practices.

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MATERIAL AND METHODS

2.1Isolation of pathogen

The test pathogen *R. bataticola* was isolated from roots of the dry root rot affected plants using the tissue segment method (Rangaswamy and Mahadevan,1999) on Potato Dextrose Agar media and was identified based on morphological characters.Upon observation, the fungus that emerged from the root bits exhibited a prolific aerial mycelium that gradually changed colour from greyish brown to black. Pure cultures were obtained using the single hyphal tip method, maintaining the isolates on PDA medium through regular sub culturing during the study.

2.2Isolation of *Trichoderma asperellum* from rhizosphere soil

Composite soil samples were collected from the rhizosphere of healthy groundnut plants and isolationof *Trichoderma* was done through the serial dilution technique (Johnson and Curl in (1972) on *Trichoderma* selective media..The culture plates were subsequently incubated at a temperature of 28 ± 2°C for a period of 72 hours, during which colony development was regularly monitored. The isolated *Trichoderma* sp. was identified as *Trichoderma asperellum* under the accession number OR357655.

2.3Fungicides

In the present investigation foursystemic fungicides*viz* Carbendazim 12%+ Mancozeb 63% WP, Tebuconazole 25% WG, Hexaconazole 4% + Zineb 68 % WG, Tebuconazole 50%+Trifloxystrobin25% WG were used to test their efficacy against *R. bataticola*at four different concentrations (100, 250, 500, 1000ppm) using poison food technique ((Nene and Thapliyal,1993).

Percent inhibition of mycelial growth of dry root rot pathogen=C-T/C*100

WhereC=mycelial growth in control (cm)

T=mycelial growth in treatment (cm)

2.4 Efficacy of fungicides against *R. bataticola* and compatibility with *Trichoderma asperellum*

For each treatment, the specified concentration of fungicide was dissolved in 30 ml of sterile distilled water at lukewarm temperature. The fungicide solution was thoroughly mixed with 30ml of autoclaved PDA medium. This poisoned medium was then evenly distributed into three petri plates to solidify, which were considered as three replications. A disc (6mm) of*R. bataticola*, from the periphery of an actively growing colony was transferred to the center of each petri plate containing the poisoned medium. To maintain a control, fungal discs were placed in petri plates containing untreated medium without any chemical. The inoculated petri plates were incubated at a temperature of 28±2°C, and observations were recorded to determine the percentage inhibition when *R. bataticola* completely covered the plate in the control.

3. RESULTS AND DISCUSSION

3.1 *In vitro* evaluation of fungicides against *R.bataticola*:

All the fungicides were completely inhibitory to *R.bataticol*a at concentrations from 250-1000ppm.Of the four fungicides tested, Hexaconazole 4% + Zineb 68 % WG as well as Tebuconazole 50% +Trifloxystrobin25% (100, 250, 500, 1000 ppm) exhibited complete inhibition of the mycelial growth of the pathogen recording more than 95% effiacy. This indicates that the fungicide was highly effective in suppressing the growth of *R.bataticola* at all concentrations tested. Carbendazim 12%+ Mancozeb 63% exhibited the highest inhibition of 95.56 and100 per cent at 500 and 1000 ppmrespectively while Tebuconazole 25% at 250, 500, and 1000 ppmrecorded complete inhibition (100%) of the mycelial growth of *R. bataticola* (Table 1).Similar results from the study conducted by Maruti *et al*. (2017) provided insights into the efficacy of various fungicides against *R. bataticola* causing dry root rot of pigeon peaunder *in vitro* conditions. Furthermore, the study investigated the effectiveness of systemic fungicides against *R. bataticola*. Tebuconazole showed 100 per cent inhibition at a concentration of 0.1%, while propiconazole, difenaconazole, carbendazim, and hexaconazole showed cent per cent inhibition at a slightly higher concentration of 0.15%.

Similarily, Agale *et al.* (2018) evaluated the efficacy of several fungicides against *R. bataticola* of soy bean using *in vitro* poisoned food technique. All fungicides tested showed significant inhibition of mycelial growth compared to the untreated control. The most effective fungicides, with 100 per cent mycelial growth inhibition, were carbendazim 50% WP at 500 ppm, carboxin 37.5% + thiram 37.5% WP at 1500 ppm, and carbendazim 12% WP + mancozeb 63% WP at 2000 ppm. Additionally, thiophanate methyl 70% WP showed 93.57 per cent inhibition, captan 50% WP showed 89.48 per cent inhibition, and hexanconazole 5% EC showed 87.62 per cent inhibition of mycelial growth.

In the similar studies Tekade *et al*. (2021) proved that cent per cent inhibition of *R. bataticola* obtained in Carbendazim, Curzet M-8, Ridomil – MZ, Propiconazole, Dithane M-45, Thiram, Carbendazim +Mancozeb, and Zineb + Hexaconazole. Next in order of merit fungicides like Tricyclozole + Mancozeb and Tridemorph recorded 98.50 per cent and 93.79 per cent inhibition respectively.

In the present investigation all the four fungicides were proved to be effective on mycelial growth inhibition. Similar results were provided by Bharani Deepan *et al.* (2018) who investigated on the mode of action of different combination fungicides and they revealed that tebuconazole and hexaconazole interfere with biosynthesis of sterols in cell membranes.

They also reported that zineb in zineb 68% + hexaconazole 4% and mancozeb in mancozeb 50% + carbendazim 25% combination fungicide inactivates sulphahydryl groups in enzymes block metabolism at krebs cycle whereas carbendazim disrupts spindle formation during cell division. Suthin *et al.* (2016) revealed that demethylation of C-14 by hexaconazole during ergosterol biosynthesis leads to accumulation of C-14 methyl sterols which controlled *Rhizoctonia solani* causing sheath blight of rice

Table 1 *IN VITRO* EVALUATION OF FUNGICIDES AGAINST *R. BATATICOLA*:

SNo.	Fungicide	Concentration (ppm)	Mycelial growth (cm)	Per cent inhibition[#]	
1	Carbendazim 12%+ Mancozeb 63% WP	100	2.766	69.26	(56.33)
		250	1.66	81.48	(64.51)
		500	0.4	95.56	(77.83)
		1000	0	100.0	(90.00)
2	Tebuconazole 25% WG	100	1.5	83.33	(65.91)
		250	0.4	95.56	(77.83)
		500	0	100.00	(90.00)
		1000	0	100.00	(90.00)
3	Hexaconazole 4% + Zineb 68 % WG	100	0	100.00	(90.00)
		250	0	100.00	(90.00)
		500	0	100.00	(90.00)
		1000	0	100.00	(90.00)
4	Tebuconazole 50% +Trifloxystrobin25% WG	100	0.83	90.74	(72.28)
		250	0	100.00	(90.00)
		500	0	100.00	(90.00)
		1000	0	100.00	(90.00)
7	Control	---	9.00	0.00	(0.00)

*Figures in parenthesis are arc sine transformed values. # Mean of three replications

	C.D.	SE(d)	SE(m)
Fungicide	1.682	0.828	0.585
Concentration	1.504	0.740	0.523
Fungicide × concentration	3.364	1.655	1.170

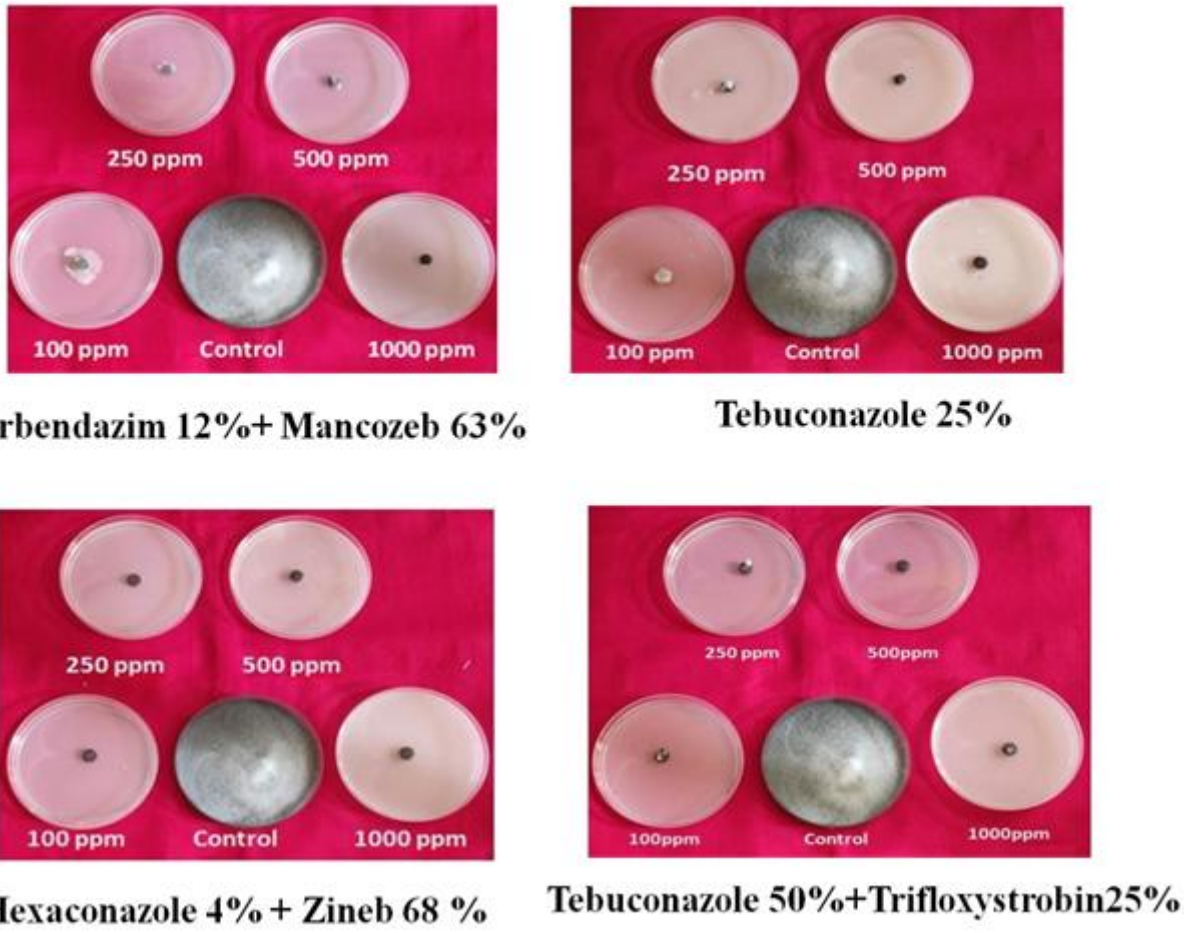

Plate1:Effect of fungicides on the mycelial growth of *Rhizoctoniabataticola*

3.2COMPATIBILITY OF FUNGICIDES WITH POTENTIAL *TRICHODERMA ASPERELLUM*

Moderate compatibility of Hexaconazole 4% + Zineb 68 % at 100 ppm with the bioagent was observed as the "compatibility" value at this concentration was 61.12%. However, the compatibility value at 500 ppm was 5.56%, indicating lower compatibility and stronger inhibitory effects.All other fungicides tested at all four concentrations completely arrested (100%) mycelial growth of the bioagentindicating incompatibility.

Kumar *et al.*(2017) reported that Carbendazim 12% + Mancozeb 63% has completely inhibited mycelial growth of *T.asperellum*and had inhibited to cent per cent at 100,200,400 and 800 ppm.

Singh *et al.* (2021) studied about the compatibility of different fungicides *viz*., Hexaconazole, Tebuconazole 50%+ Trifloxystrobin 25% WG, propiconazole and tebuconazole at 10, 15, 20 and 25 ppm for their compatibility with *T. harzianum* strain IRRI-1 using poisoned food technique. All the four concentrations of Tebuconazole 50%+ Trifloxystrobin 25% WG were highly compatible with low toxic effect against *T. harzianum* strain IRRI-1 *in vitro*. Nativo and Propiconazole were comparatively safer, than Hexaconazole and Tebuconazole which exhibited acute toxicity for the growth of *T. harzianum* strain IRRI-1.

Similarily Sharma *et al.* (2016) found that *Trichoderma harzianum* strain TCMS-14 was found to be completely compatible with sulphur (at 625ppm, 1250ppm and 2500 ppm), zineb (375ppm, 750ppm and 1500ppm).

These findings are in accordance with Bindu Madhavi *et al.* (2011) who reported that lower compatibility of *Trichoderma* with carbendazim + mancozeb (0.2%) as 67.4 per cent mycelial inhibition. Durga *et al.* (2014) also opined that Avtar (Zineb + Hexaconazole) was compatible with *T. koningi* at 0.25 per cent. Teertha *et al.* (2017) also reported that Avtar (Zineb 68% + Hexaconazole 4%) tested at 100 ppm inhibited *T. asperellum* to 76.4 per cent with 23.60 compatibility. Further, they reported that ,complete inhibition of radial growth of *T. asperellum* was recorded with tebuconazole 50% + trifloxystrobin 25% WG, azoxystrobin 18.2% + difenoconazole 11.4% SC, carbendazim 12% + mancozeb 63% at different concentrations of 1000ppm .Maheswary *et al.*(2020)and Vineela *et al.* (2017) reported that carbendazim 12% + mancozeb 63% has inhibited radial growth of *T. viride, T. harzianum* and *T. hamatum* completely (100% inhibition) and was found to be incompatible with *Trichoderma.*

Table 2 COMPATIBILITY OF FUNGICIDES WITH POTENTIAL *TRICHODERMA ASPERELLUM*

S.no	Fungicide	Concentration (ppm)	Mycelial growth(cm)	#Per cent inhibition
1	Carbendazim 12%+ Mancozeb 63% WP	100	0	100
		250	0	100
		500	0	100
		1000	0	100
2	Tebuconazole 25% WG	100	0	100
		250	0	100
		500	0	100
		1000	0	100
3	Hexaconazole 4% + Zineb 68 % WG	100	8	38.88
		250	2.66	79.62
		500	0.83	94.44
		1000	0	100
4	Tebuconazole 50% +Trifloxystrobin25% WG	100	0	100
		250	0	100
		500	0	100
		1000	0	100
7	Control	---	9	0

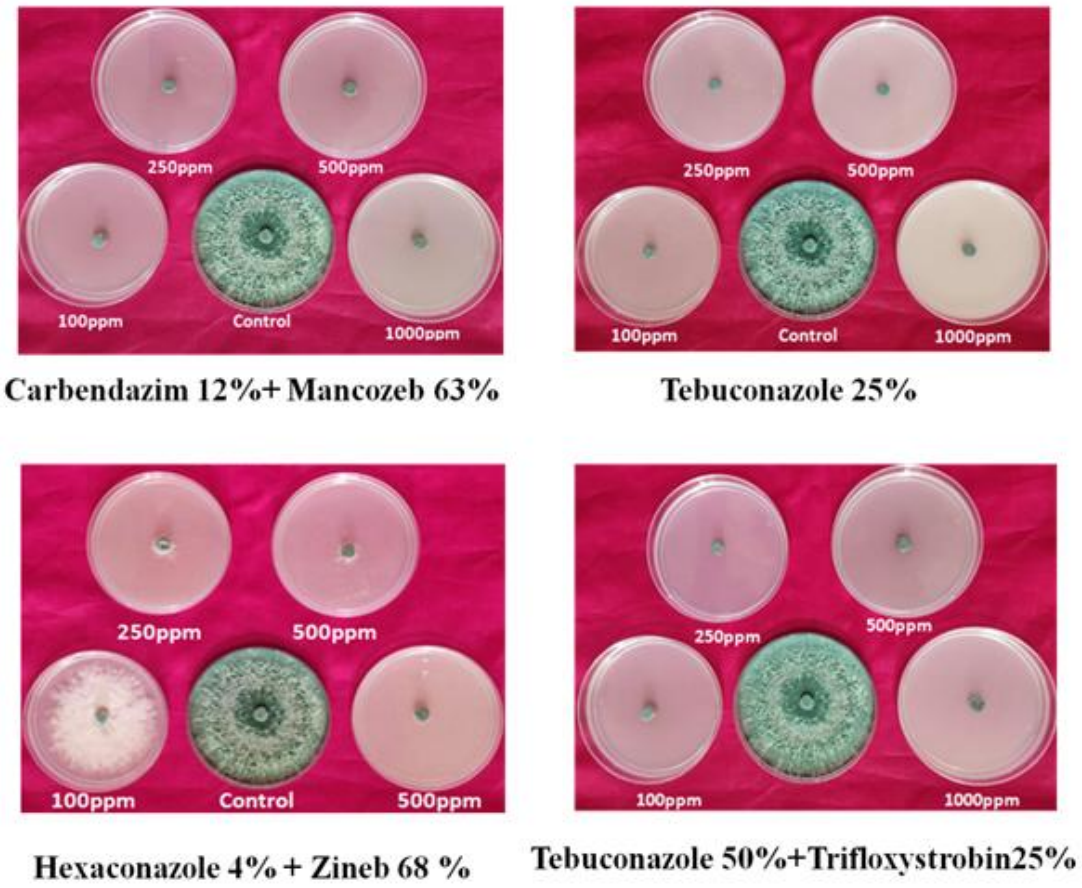

Plate 2 :Effect of fungicides on the mycelial growth of *Trichoderma asperellum*

4. CONCLUSION

Among the fungicides, Hexaconazole 4% + Zineb 68% WG exhibited complete inhibition of the pathogen at all concentrations. Carbendazim 12% + Mancozeb 63% WP and Tebuconazole 50% + Trifloxystrobin 25% WG showed complete inhibition at higher concentrations (1000 ppm), and Tebuconazole 25% WG also displayed complete inhibition at 250 ppm, 500 ppm, and 1000 ppm. The results indicate that all tested fungicides were effective in suppressing *R. bataticola* mycelial growth, with efficacy varying with concentration. The compatibility of various fungicides with the bioagent *T. asperellum* was tested at different concentrations to determine their inhibitory effects on mycelial growth. With Hexaconazole 4% + Zineb 68%, highest compatibility (88.89 %) was observed at a concentration of 100 ppm, resulting in 11.11% mycelial growth inhibition. At higher concentrations (250 ppm and 500 ppm), mycelial growth was significantly reduced with inhibition percentages of 70.37% and 90.74% respectively, indicating lower compatibility but stronger inhibitory effects. However, Carbendazim 12% + Mancozeb 63%, Tebuconazole 25%, and Tebuconazole 50% + Trifloxystrobin 25% showed complete inhibition (100%) of mycelial growth at all concentrations tested, indicating no compatibility between the bioagent

and the fungicides. These results suggest that Hexaconazole 4% + Zineb 68% WG showed varying degrees of compatibility and inhibitory effects at different concentrations, while the other fungicides exhibited no compatibility with *T. asperellum* and completely inhibited its mycelial growth. The compatibility of *T. asperellum* with Hexaconazole 4% + Zineb 68% WG offers the possibility of integrating biocontrol strategies with chemical fungicides for improved disease management and better outcomes in groundnut cultivation.

REFERENCES

Agale, R.C., Suryawanshi, A.P., Rathod, R.R and Apet, K.T. 2018. Bioefficacy of Various fungicides against *Rhizoctonia bataticola*, causing Dry Root Rot of Soybean. *International Journal of Current Microbiology and Applied Sciences*. 7 (10): 1856-1864.

Bharani Deepan, A., Manasa, R and Ramanathan, A. 2018. Combination of fungicides offers substantial potential for management of rice blast disease by *Magnaportheoryzae*. *International Journal of Chemical Studies*. 6(2): 391-396.

Bindu Madhavi, G., Bhattiprolu, S.L and Bali Reddy, V. 2011. Effect of various plant extracts on dry root rot of chillies caused by *Sclerotium rolfsii*. *Journal of Horticultural Sciences*. 6(2): 156-158.

Johnson, L.F. and Curl, E.A. 1972. Methods for research on the ecology of soil-borne plant pathogens. *Methods for research on the Ecology of Soil-Borne Plant Pathogens.*

Kumar, T.V., Veena, S.S., Karthikeyan, S. and Sreekumar, J. 2017. Compatibility of *Trichoderma asperellum* with Fungicides, Insecticides, Inorganic fertilizers and Bio-pesticides. *Journal of root crops*. 43(2) : 68-75.

Maheshwary, N., Gangadhara Naik, B., Amoghavarsha Chittaragi, M., Naik, S.K. and Nandish, M. 2020. Compatibility of *Trichoderma asperellum* with fungicides. *The Pharma Innovation Journa.* 9(8): 136-140

Nene YL, Thapliyal PN. Fungicides in plant disease control. Oxford and IBH Publishing Company Private Limited. Calcutta 1993,531-550.

Raj, T.S., Graff, K.H. and Suji, H. 2016. Bio efficacy of fungicides against rice sheath blight caused by *Rhizoctonia solani* under in vitro condition. *Int. J. Plant Prot*, 9 : 615-618.

Rangaswamy, G and Mahadevan, A. Diseases of Crop Plants in India. Prentice Hall of India Pvt. Ltd. New Delhi 1999;607 p

Sharma, M., Ghosh, R and Pande, S. 2016. Dry root rot (*Rhizoctonia bataticola* (Taub.) Butler): an emerging disease of chickpea – where do we stand? *Archives of Phytopathology and Plant Protection*. 48 (13): 1-16.

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Singh, M., Singh, R., Mishra, P., Sengar, R.S. and Shahi, U.P. 2021. *In-vitro* compatibility of *Trichoderma harzianum* with systemic fungicides. *International Journal of Chemical Studies*. 9(1) : 2884-2888.

Tekade, A., Koche, M.D., Kothikar, R.B. and Kirde, C.V. 2021. Evaluation of Fungicides and Antagonists Against *Rhizoctonia Bataticola* and *Fusarium Solani* Causing Root ROT in *Plantago Ovata*. *Journal Of Plant Disease Sciences.* 16(1) : 28-30.

Vineela, D.R.S., Beura, S.K., Dhal, A., Swain, S.K. and Sethi, D. 2017. Efficacy of chemicals, bio-agents and their compatibility in management of stem rot disease of groundnut. *International Journal of Chemical Studies,* 5(5) : 443-446.