Plant Archives Vol. 25, No. 1, 2025 pp. 540-544 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.082

ECONOMICS FOR MANAGING FUSARIUM WILT CAUSED BY *FUSARIUM OXYSPORUM* SCHLECHT IN ISABGOL (*PLANTAGO OVATA*)

Shaik Munnysha*, R.N. Bunker and Smriti Akodiya

Department of Plant Pathology, Maharana Pratap University of Agriculture and Technology, Udaipur -313 001 (Rajasthan), India.
*Corresponding author E-mail: munnysha118@gmail.com
(Date of Receiving-08-12-2024; Date of Acceptance-19-02-2025)

ABSTRACT

The experimental trail conducted during *Rabi* 2021-22 and 2022-23 at Research farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur on economics for managing fusarium wilt caused by *Fusarium oxysporum* Schlecht in isabgol by utilizing integrated modules under field condition. The results showcased application of shelled maize cob powder-based formulation of *Trichoderma viride* (T.v.-5) 2% @ 500g/m^2 + seed treatment with Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.1% + soil drenching of Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.1% was recorded with highest benefit cost ratio (3.61) pooled data of year 2021-22 and 2022-23. Whereas in control, it was found to be significantly lessened in benefit cost ratio. Consequently, the integration of bioagents with organic amendments harnessed low-cost and free from residual effects.

Key words : *Fusarium oxysporum* Schlecht, Isabgol, *Trichoderma viride*, Organic amendments.

Introduction

Isabgol (*Plantago ovata*) belonging to the family *plantaginaceae*. It is a medicinal annual herb plant with short stems that grows up to a height of 30 to 40 cm. Isabgol to be known by Ashwagolan, aspaghol, aspagol, bazarqutuna and blond Psyllium. It is native of Mediterranean and West Asian regions extending upto Sujlaj and Sindh in Pakistan. Isabgol is commercially cultivated for the mucilage production across the globe. The cultivation of crop is confined to particular agro-climate of arid to semi-arid regions with low rainfall. The seeds are sown between the end of October and middle of December, when the day temperature ranges between 18^o and 26^{o}C. The seeds germinate within 4-5 days. Flowering starts two months after sowing and the crop is ready for harvesting in the month of March or April (Theuissen, 2008 and Meena, 2019).

In the world market, India has a monopoly on the production and export of isabgol seed and husk. India produces 9 million tonnes of isabgol, accounting for 98% of global output (Rajendaran, 2009). The total export value of medicinal and aromatic plants in India was 200894.08 lakhs in the year 2019-20 (Ministry of Commerce and Industry, New Delhi). In India, area under Isabgol cultivation was estimated of 31,205 hectares with production of 12,951 metric tonnes (Anonymous, 2022-23). *Plantago ovata* is commercially cultivated in the western states of Gujarat, Madhya Pradesh and Rajasthan during winter season. At present, isabgol has acquired the name “Dollar earner” in north Gujarat and south western Rajasthan. In Rajasthan Isabgol is cultivated in about 333954 ha with a production of 170646 tonnes and productivity about 511 kg/ha (Anonymous, 2019-20). The major Isabgol growing districts in Rajasthan include Chittorgarh, Barmer, Jalore, Jodhpur, Pali, Sirohi and Udaipur. Copious number of fungal pathogens *viz*., *Alternaria alternata* (Fr.) Keissler (leaf spot), *Fusarium oxysporum* Russel (Fusarium wilt), *Pythium ultimum* (damping off), *Peronospora plantaginis* Underwood (downy mildew) and *Erysiphe cichoracearum* D.C. (powdery mildew) evading and suppressing the Isabgol crop, consequently it poses 18-40% significant yield losses and depletion of seed quality (Abhinav *et al*., 2022; Meena and Satyajit, 2020; Mandal, 2010). *Fusarium oxysporum* Schlecht has deems crucial from phytopathological point of view as it is most serious soil-borne disease (Russel, 1975; Mehta *et al.*, 1985). Meena and Roy (2020) reported fusarium wilt as one of the crucial and highly devastating diseases of Isabgol which inflicted to economic damage in various number of growing countries. Since a decade ago, synthetic chemicals have been utilized to amend crop productivity. The over-exploitation and heavy discharge of chemicals poses a negative impact on living ecosystem. To mitigate the misuse of chemical, the alternative source of biopesticides have been addressed for managing the diseases. In contrast, *Trichoderma* is a versatile, beneficial and filamentous fungus, showcasing significant services such as enhancing soil fertility, bolstering nitrogen fixation, lessening hazardous gas emissions, and retarding escalated impact of diseases in plants (Xu *et al.*, 2019; Tamizi *et al.*, 2022). In light of these compensations, exploitation of bioformulation enriched with *Trichoderma* indeed a prospective aspect to curb Isabgol wilt in field. Therefore, keeping in view the above facts, different management tactics for enhancing natural ecosystem, fend off the pathogen by harnessing bioformulation implication, proclaiming the role of pathogen causing significant yield losses and notably the study have been tackled to fill up some of the gaps existing in literature.

Materials and Methods

Field trial on disease management of the Isabgol wilt was conducted during *Rabi* season 2021-22 and 2022-23 at Research farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. Field experiment with ten different treatments including control, was laid down in Randomized block design. Plot size was 3×2 m^2 with spacing of 30×5cm, with 3 replication. The treatments comprised of different innovative integrated management practices. Observation on different yield parameters were taken and economic analysis was done by calculating cost of cultivation, gross return, net return and B:C ratio.

Treatment combination

S. no.	Treatment details
1	SA of FYM based formulation of *T. viride* (T.v.-5) 2%@ 500g/m^2 + ST with Tebuconazole 50% + Trifloxystrobin 25% WG
2	SA of Shelled maize cob powder-based formulation of *T. viride* (T.v.-5) 2%@ 500g/m^2 + ST with Tebuconazole 50% + Trifloxystrobin 25% WG
3	SA of Neem cake-based formulation of *T. viride* (T.v.-5) 2%@ 100g/m^2 + ST with Tebuconazole 50% + Trifloxystrobin 25% WG
4	SA of Neem cake-based formulation of *T. viride* (T.v.-5) 2%@ 100g/m^2 + Shelled maize cob powder-based formulation of *T. viride* (T.v.-5) 2%@ 500g/m^2 + ST with Tebuconazole 50% + Trifloxystrobin 25% WG
5	SA of Neem cake-based formulation of *T. viride* (T.v.-5) 2%@ 100g/m^2 + FYM based formulation of *T. viride* (T.v.-5) 2%@ 500g/m^2 + Shelled maize cob powder-based formulation of *T. viride* (T.v.-5) 2%@ 500g/m^2
6	ST with Tebuconazole 50% + Trifloxystrobin 25% WG + SD of Tebuconazole 50% + Trifloxystrobin 25% WG
7	SA of FYM based formulation of *T. viride* (T.v.-5) 2%@ 500g/m^2 + SD of Tebuconazole 50% + Trifloxystrobin 25% WG
8	SA of Shelled maize cob powder-based formulation of *T. viride* (T.v.-5) 2%@ 500g/m^2 + ST with Tebuconazole 50% + Trifloxystrobin 25% WG + SD of Tebuconazole 50% + Trifloxystrobin 25% WG
9	SA of Neem cake-based formulation of *T. viride* (T.v.-5) 2%@100g/m^2 + ST with Tebuconazole 50% + Trifloxystrobin 25% WG + SD of Tebuconazole 50% + Trifloxystrobin 25% WG
10	Control

SA-Soil application; **ST-** Seed treatment; **SD-**Soil drenching; **FYM-** Farm yard manure

The items covered in costs are:

1. Value of hired human labour
2. Value of seed
3. Value of organic amendments and bioagents
4. Value of plant protection
5. Value of fertilizers
6. Irrigation charges
7. Miscellaneous expenses

Gross and net returns

Gross returns : Gross return of the farmers under the present study was estimated from returns obtained from sale of main produce.

Net returns : Net returns were computed at different costs by deducting respective costs from the gross returns.

Benefit-cost ratio

The healthy marketable yield obtained from different treatments was collected separately and weighed. The cost of fungicides, bioagents and organic amendments used in this experiment was recorded during *Rabi* season 2021-22 and 2022-23. The total cost of plant protection consisted of cost of treatments and labour charges for the spray. There were two sprays throughout the research period and the overall plant protection expenses were calculated by benefit-cost ratio.

B:C ratio is a ratio between the value of gross output and the cost of cultivation at different cost concepts. The probability of crop production cannot be justified completely unless benefit cost ratio were worked out. This is the ratio which represents returns obtained per rupee of investment. It was worked out by dividing gross return by the total cost.

The B:C ratio can be calculated by formula

BCR = Gross returns / Total costs incurred

Where, BCR = Benefit Cost Ratio

Gross returns = Marketable yield × Market price

Net return = Gross return – Cost of cultivation (Zorempuii and Kumar, 2019).

Results and Discussion

The fungicides, bio-agents and organic amendments found effective under *in vitro* study, were further assessed as seed treatment individually as well as in different combinations to prevent fusarium wilt in the field. The pooled data analysis of years 2021-22 and in 2022-23 pointed out that maximum benefit cost ratio of 3.61 owing to lower cost of cultivation and higher return, observed in module consisting of Soil application of Maize shelled cob powder based formulation of *T. viride* (T.v.-05) 2% @ 500g/m^2 + Seed treatment with 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG + Soil drenching of 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG, which was followed by module comprising of Soil application of Neem cake based formulation of *T. viride* (T.v.-05) 2% @100g/m^2 + Seed treatment with 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG + Soil drenching of 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG with benefit cost ratio of 3.18. Whereas other treatment module consisting of treatment with Soil application of FYM based formulation of *T. viride* (T.v.-05) 2% @ 500g/m^2 + Soil drenching with 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG found effective with 2.78 benefit cost ratio. The individual module comprising of Seed treatment with 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG + Soil drenching of 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG with benefit cost ratio of 2.83. The remaining modules such as Soil application of Neem cake based formulation of *T. viride* 2% @ 100g/m^2 + Maize shelled cob powder based formulation of *T. viride* (T.v.-05) 2% @ 500g/m^2 + Seed treatment with 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG, Soil application Neem cake based formulation of *T. viride* (T.v.-05) 2% @ 100g/m^2 + FYM based formulation of *T. viride* (T.v.-05) 2% @ 500g/m^2 + Maize shelled cob powder based formulation of *T. viride* (T.v.-05) 2% @ 500g/m^2, Soil application of Maize shelled cob powder based formulation of *T. viride* (T.v.-05) 2% @ 500g/m^2 + Seed treatment with 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG, Soil application of Neem cake based formulation of *T. viride* (T.v.-05) 2% @ 100g/m^2 + Seed treatment with 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG and Soil application of FYM based formulation of *T. viride* (T.v.-05) 2% @ 500g/m^2 + Seed treatment with 0.1% Tebuconazole 50% + Trifloxystrobin 25% WG resulted in benefit cost ratio of 2.49, 2.18, 2.31, 1.76 and 1.54, respectively (Table 1b and Fig. 1). A study by Meena

Table 1a: Net inputs and returns due to management of Isabgol wilt using promising organic based bio-formulation with integration of fungicides under field condition.

Treatments	Cost of treatments (Rs/ha)			Input cost + cost of treatments (Rs/ha)			Net yield increased over control		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1	3158.82	3608.82	3383.82	29,976.82	30,428.82	30,202.82	26.86	25.89	26.36
T_2	908.82	908.82	908.82	27,728.82	27,728.82	27,728.82	77.44	70.03	73.63
T_3	1448.82	1448.82	1448.82	28,268.82	28,268.82	28,718.82	42.85	40.51	41.64
T_4	2348.82	2348.82	2348.82	29168.82	29168.82	29168.82	110.94	103.16	106.93
T_5	5840	5940	5890	32,660	32,760	32710	98.82	88.41	93.46
T_6	890.82	890.82	890.82	27,710.82	27,710.82	27,710.82	115.88	108.31	111.98
T_7	4382	4482	4432	31,202	31,302	31252	139.46	131.72	135.47
T_8	1790.82	1790.82	1790.82	26,610.82	28,610.82	26610.82	174.92	164.63	169.77
T_9	2330.82	2330.82	2330.82	29,150.82	29,150.82	29,150.82	157.55	145.16	151.35
T_{10}	-	-	-	-	-	-	-	-	-

*Selling price of Isabgol Rs 100/kg, Cost of labour: Rs 270/day.

Table 1b : Net inputs and returns due to management of Isabgol wilt using promising organic based bio-formulation with integration of fungicides under field condition.

Treatments	Net output (Rs/ha)			Net increase (%) over control			B:C ratio		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1	43401	50295.3	46848.15	26.86	25.89	26.34	1.44	1.65	1.54
T_2	60707	67931.6	64319.3	77.44	70.03	73.45	2.18	2.44	2.31
T_3	48872	51032	49,952	42.85	27.73	34.71	1.72	1.80	1.76
T_4	72166	73788	72,977	110.94	84.69	96.80	2.47	2.52	2.49
T_5	68021	75274.1	71,647.5	98.82	88.41	93.21	2.08	2.29	2.18
T_6	73857	83222.7	78,539.85	115.88	108.31	111.80	2.66	3.00	2.83
T_7	81925	92574.9	87,249.95	139.46	131.72	135.29	2.62	2.95	2.78
T_8	94056	105,723.2	99889.6	174.92	164.63	169.77	3.53	3.69	3.61
T_9	88111	97945.1	93028.05	157.55	145.16	151.35	3.02	3.35	3.18
T_{10}	34211	39,950.9	37080.95	-	-	-	-	-	-

*Selling price of Isabgol Rs 100/kg, Cost of labour: Rs 270/day.

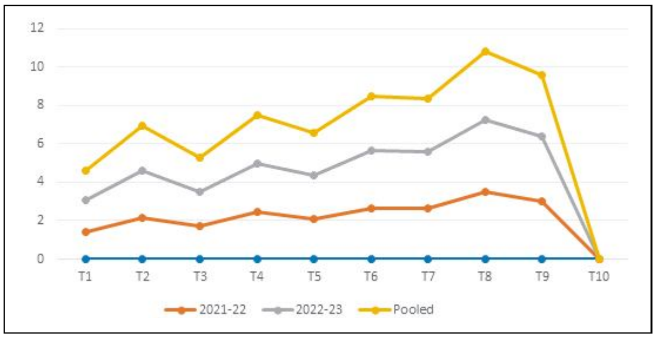

Fig. 1 : Evaluation of promising bio-formulation with integration of organic amendments and fungicides on B:C Ratio.

and Roy (2020) reported that wilt disease of isabgol can be controlled by the integration of seed treatment using fungicides, organic amendments and bio-control agents, *T. viride* enriched organic products. In addition, Mengal *et al*. (2015) and Kewal and Singh (2021) studied efficacy of different nine fungicides against *Fusarium oxysporum in vitro* and found that fungicides Tebuconazole 50% + Trifloxystrobin 25% WG showed best effective against pathogen. Furthermore, the chemicals also have residual effects on associated beneficial microbiota in soil and contributing to the source of environmental pollution. Aside from that, eco-friendly management strategies (microorganisms and organic amendments with integration of chemicals) have shown to be effective in plant growth promotion and protection due to their role in nutrient cycling and disease control (Bhattacharyya and Jha, 2012). Therefore, it was intended for its effective management of pathogen through biocontrol agent *Trichoderma viride*, which has been shown to suppress *Fusarium oxysporum* (Adhikary *et al*., 2017; Chen *et al*., 2021; Zhang *et al*., 2022).

Conclusion

Fusarium oxysporum is a highly devastating soil borne filamentous fungi, which has siezed much attention due to its potential to cause significant yield losses in copious number of field crops. In addition, isabgol is the important medicinal crop, significantly affected by *F. oxysporum*, which posing a major production constraint. Keeping the above objectives in mind, the study was conducted to estimate the cost and returns of isabgol production during *Rabi* season 2021-22 and 2022-23. The benefit-cost ratio which is an indicator of economic efficiency in crop production for the crop. As a consequence, it could be concluded from the investigation that fungal antagonists coupled with organic amendments influenced immensely on soil microbial community and enhances the yield, economics of crop and fertility status of soil.

Acknowledgement

The authors express thanks to R.N. Bunker, Department of Plant Pathology, Rajasthan College of Agriculture, Udaipur for providing bioagents and valuable suggestions for present research work.

Declaration of Competing Interest/Conflict of interest : The authors have said that there were no conflicting agendas.

Consent to publish : All authors agree to publish paper in your esteemed journal.

References

Abhinav, Gahlot N., Bunker R.N., Rajoriya S.K., Kumar S. and Charpta K. (2022). Survey, distribution and incidence of Isabgol wilt incited by *Fusarium oxysporum* Schlecht in different agro climatic zones of Rajasthan. *The Pharma*

Innov. J., **11(5)**, 75-80.

Adhikary, M.C., Begum H.A. and Meah M.B. (2017). Possibility of recovering Fusarium wilt affected egg plants by Trichoderma. *Int. J. Agricult. Res., Innov. Technol.*, **7(1)**, 38-42.

Anonymous (2019-2020). Directorate general of foreign trade, Ministry of Commerce & Industry, New Delhi.

Anonymous (2019-2020). Rajasthan agricultural statistics at a glance, 144.

Anonymous (2022-2023). *Department of Agriculture Research and Education*. Directorate of Medicinal and Aromatic Plant Research, Anand, Gujarat.

Bhattacharyya, P.N. and Jha D.K. (2012). Plant growth-promoting rhizobacteria (PGPR): Emergence in agriculture. *World J. Microbiol. Biotechnol.*, **28**, 1327-1350.

Chen, J., Zhou L., Din I.U., Arafat Y., Li Q. and Wang J. (2021). Antagonistic activity of *Trichoderma* spp. against *Fusarium oxysporum* in rhizosphere of radix pseudostellariae triggers the expression of host defense genes and improves its growth under long-term monoculture system. *Front. Microbiol.*, **12**, 579920. doi: 10.3389/ fmicb.2021.781826

Kewal, C. and Singh S.K. (2021). Evaluation of different novel chemicals against panama wilt of Banana Incited by *Fusarium oxysporum* f. sp. *cubense*. *Int. J. Curr. Microbiol. Appl. Sci.*, **10(2)**, 951-957.

Mandal, K. (2010). *Disease of some important medicinal crops and their management*. Microbial Diversity and Plant Disease management. VDM Verlag Dr. Muller, Germany. p. 509.

Meena, R.P. and Satyajit R. (2020). Morphological and molecular characterization of *Fusarium* spp. causing wilt of isabgol. *J. Appl. Res. Medicinal and Aromatic Plants,* **2(44)**, 520-524.

Meena, R.P. and Roy S. (2020). Morphological and molecular variability characterization of Fusarium sp. causing wilt disease of isabgol (*Plantago ovata* Forsk.) and its management strategies. *J. Applied Research on Medicinal and Aromatic Plants*, **16**, 100244.

Meena, R.P. (2019). Wilt diseases of medicinal and aromatic crops and their management. In: *Wilt Diseases of Crops*. Today and Tomorrow Printers and Publisher, New Delhi. India, pp. 123-139.

Mehta, N., Madan R.L. and Thakur D.P. (1985). Record of isabgol wilt from Haryana. Haryana Agricultural University. *J. Agricult. Res.*, **15**, 473-474.

Mengal, A.S., Hussain S., Ali M., Abro, Maari A.K.S.A., Jatoi G.H., Nisa T., Rafiq M. and Iqbal S. (2015). Evaluation of different botanical extracts on the linear colony growth of the fungus causing fusarium wilt of mango. *Europ. J. Biotechnol. Biosci.*, **3(11)**, 7-14.

Rajendran, M. (2009). India has failed to manage indigenous products like Isabgol. *Business World* 31 March-6 April.

Rathore, B.S. and Pathak V.N. (2002). Studies on the tissue culture and host range of *Peronospora alta* causing downy mildew of blond psyllium. *J. Mycol. Plant Pathol.*, **32(2)**, 201-203.

Russel, T.E. (1975). Plantago wilt. *Indian Phytopathol.,* **65**, 359-360.

Tamizi, A.A., Mat-Amin N., Weaver J.A., Olumakaiye R.T., Akbar M.A. and Jin S. (2022). Genome sequencing and analysis of *Trichoderma* (Hypocreaceae) isolates exhibiting antagonistic activity against the papaya dieback pathogen, *Erwinia mallotivora*. *J. Fungi*, **8**, 246. doi: 10.3390/jof8030246

Theuissen, E.A.M. (2008). Water soluble dietary fibers and cardiovascular disease. *Physiology and Behavior*, **94**, 285-292.

Xu, W., Wang H., Lv Z., Shi Y. and Wang Z. (2019). Antifungal activity and functional components of cell-free supernatant from *Bacillus amyloliquefaciens* - LZN01 inhibit *Fusarium oxysporum* f. sp. *niveum* growth. *Biotechnol. Biotechnol. Equip*., **33**, 1042–1052.

Zhang, C., Wang W., Hu Y., Peng Z., Ren S. and Xue M. (2022). A novel salttolerant strain *Trichoderma atroviride* HN082102.1 isolated from marine habitat alleviates salt stress and diminishes cucumber root rot caused by *Fusarium oxysporum*. *BMC Microbiol.*, **22**, 67. doi: 10.1186/s12866-022-02479-0

Zorempuii, R. and Kumar A. (2019). Efficacy of certain chemicals and botanicals against aphid, *Lipaphis erysimi* (Kaltenbach) on cabbage (*Brassica oleracea* L.). *J. Entomol. Zool. Stud.*, **7(5)**, 89-93.