RESEARCH ARTICLE

Evaluation of possible biological control of *Fusarium* sp. using plant extracts and antagonistic species of microbes *in vitro*  
[version 1; peer review: 2 approved with reservations]

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Abstract

**Background:** *Fusarium* species is one of the most devastating fungi responsible for fruit and vegetable crops rot worldwide. The present study was designed to find an ecofriendly control measure for pathogenic *Fusarium* species, using suitable bioagents.

**Methods:** Medicinal plant extracts were evaluated or their antifungal activities against *Fusarium* species using the poisoned food method. Antagonistic potency of some nonpathogenic microbes was also assessed on *Fusarium* species using the dual culture method.

**Results:** Highest inhibition of growth of *Fusarium* sp. was observed with 68.1% (0.389 mg per 90 mm Petri plate) of mycelia on *Coccinia grandis* plant leaf extract, in comparison to the control grown with 100.0% (1.22 mg/dish). The highest inhibition of radial growth was observed using *Trichoderma viride* on *Fusarium* sp. (46.01% inhibition).

**Conclusions:** The findings of present study would be benevolent for antifungal drug development to control *Fusarium* sp. causing fruit and vegetable rot.

**Keywords**

Fusarium sp., Plants extract, Non-pathogenic microbes, Antagonisms, Biocontrol

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Introduction

Fusarium species are a large genus of hyaline filamentous mold fungi, responsible for fruit and vegetable crop rot (Al-Najada & Gherbawy, 2015; Ziedan et al., 2018). Fusarium species are deeply invasive and can cause hematogenously disseminated infections with high mortality in neutropenic patients (Dignani & Anaissie, 2004). Numerous species of Fusarium contribute to yield loss and reduced quality to varying degrees by infection with some mycotoxins (O’Donnell et al., 2009). They also cause decay of various fruit in storage and postharvest conditions (Whiteside et al., 1988). The fruit rot caused by Fusarium incurs enormous yield losses and is often observed in fields and markets (Baria et al., 2015). The application of antagonistic agents and plant extracts in agriculture are becoming a major focus of plant protection research. Different preservatives or fungicide treatments are frequently applied to manage fruits diseases and decay, which is an alarming health concern (Munhuweyi et al., 2020). Since most chemical fungicides are highly toxic to humans and animals and they frequently cause water and soil pollution (Al-Najada & Gherbawy, 2015). Moreover, continuous and indiscriminate use is leading to the development of fungicide resistant strains of pathogens (Tafinta et al., 2013).

In Bangladesh, fruit rot is a destructive disease caused by Fusarium species on pre-harvest and postharvest fruits. To the best of our knowledge, there is no previous research on biological control of this pathogenic fungus. Therefore, the main objective of the study was to find an ecofriendly control system of Fusarium sp., to decrease fruit and vegetable rot in Bangladesh.

Methods

Collection of Fusarium sp.

A pure culture of Fusarium sp. was previously isolated and identified (Accession No. MT856371) from postharvest Citrus reticulata fruit rot (Hasan et al., 2020). The culture was preserved at the Department of Genetic Engineering and Biotechnology, University of Rajshahi, as the part of a collaboration.

In vitro assessment of antifungal potential of selected plants

For antifungal activities screening, six healthy, mature medicinal plants, Allium sativum, Zingiber officinale, Coccinia grandis, Brassica juncea, Ocimum tenuiflorum and Hibiscus rosa-sinensis were collected from Mirzapur, Binodpur and Kajla village, Motihar, Rajshahi, Bangladesh.

Collected plants were washed with water to remove dust from the plants’ surface and dried under room temperature. Plant extract preparation and fractionation was performed according to the method by Kader et al. (2018). Different parts of selected plants (bulb of Allium sativum; rhizome of Zingiber officinale; leaves of Coccinia grandis, Brassica juncea, Ocimum tenuiflorum; and flowers of Hibiscus rosa-sinensis plants) were cut into small species and ground by blender to form fine powder. The dried powder of the plants (100gm of each plant) were rinsed in methanol (500ml) using a conical flask, and were incubated in a shaking incubator with occasional shaking for fourteen days. The liquid contents were pressed through Markin cloth followed by filtration using Whatman no. 1 filter paper. Obtained filtered liquids were dehydrated in vacuo to leave a blackish and sticky mass. The extracts were collected in vials and preserved in a refrigerator at 4°C.

The inhibitory effect of different plant extracts was measured by following the poisoned food technique (Balamurugan, 2014). For this, 20µg of each plant extract was added to 20ml of potato dextrose agar (PDA) to fill a 90mm size Petri plate and mixed well. After solidification, seven day old 6 mm size fungal plug was placed in the center of the Petri plates. The Petri plates were incubated at 35°C for seven days in static condition.

In vitro antagonistic test

For evaluation of antagonistic effects, six non-pathogenic pure microbe cultures, Escherichia coli, Rhizobium phaseoli, Rhizobium leguminosarum, Neofusicoccum mangifera, Trichoderma viride and Pestalotiopsis sp. were used against Fusarium species. The pure microbe cultures were kindly provided by Dr. Md. Salah Uddin, Associate Professor and Director, Microbiology Lab., Department of Genetic Engineering and Biotechnology, University of Rajshahi, as the part of a collaboration.

To assess the antagonistic effects, the dual culture technique was used, as previously described (Vethavalli & Sudha, 2012). A mycelial disc of 6 mm diameter was cut from the periphery of both antagonist cultures and the test pathogen and placed on a Petri plate with PDA media. For the control, only the test pathogen was placed in the centre of a Petri plate. The Petri plates were incubated at 35°C in darkness.

Data analysis

The inhibition percentage of mycelial growth= [(Gc-Gt)/Gc] × 100; Where, Gc = Mycelial growth in terms of colony diameter in control set, Gt= Mycelial growth in terms of colony diameter in treatment set. The inhibition percentages of Fusarium species growth were calculated using the following formula: Inhibition percentage (%) =100× (dc– dt)/dc; Where, dc = radial growth of pathogen in control, dt = radial growth of pathogen in dual culture. Mean values were compared through least significant different test using SAS software, version 9.4M5 (SAS Inc., Cary, NC, USA). All the experiment and test were replicated thrice.

Results

In vitro screening of extracts presenting antifungal activity

All plant extracts showed a degree of growth inhibition of the tested fungus at the same concentrations. The highest inhibition of growth of the isolates was observed at 68.1% of mycelium of Coccinia grandis, which was followed by 64.1% on Allium sativum, in comparison to the control culture (100.0%). Hibiscus rosa-sinensis showed the lowest inhibition of mycelium with 29.6% against the fungal isolate in comparison to the control. The results are presented in Figure 1 and Figure 2.
Figure 1. Effect of different methanol plant extracts on percentage inhibition of mycelial growth of *Fusarium* species. Mycelia were collected after seven days of incubation on potato dextrose agar at 35°C in darkness. 90 mm Petri plates were used to culture the tested fungus.

Figure 2. Petri dish images showing the effect of plant extracts on inhibition of mycelial growth of *Fusarium* species. (A) *Allium sativum*, (B) *Zingiber officinale*, (C) *Coccinia grandis*, (D) *Brassica juncea*, (E) *Ocimum tenuiflorum*, and (F) *Hibiscus rosa-sinensis*. Mycelia were collected after seven days of incubation on potato dextrose agar at 35°C in darkness.

Figure 3. Effect of microbe antagonistic agents on inhibition of mycelial growth of *Fusarium* species. (A) *Escherichia coli*, (B) *Rhizobium phaseoli*, (C) *Rhizobium leguminosarum*, (D) *Neofusicoccum mangifera*, and (E) *Trichoderma viride* and (F) *Pestalotiopsis sp.* Mycelia were collected after seven days of incubation on potato dextrose agar at 35°C in darkness.

In vitro antagonistic assay

The highest percentage inhibition of radial growth was observed with *Trichoderma viride* (46.01%) against *Fusarium*, which was followed by 43.33% and 32.05% on *Escherichia coli* and *Rhizobium phaseoli*, respectively (Figure 3). The antagonistic agent *Rhizobium leguminosarum* did not show any inhibitory activity against the isolated fungus (Figure 3). The control group also did not show any inhibition of radial growth of *Fusarium* sp.

Discussion

Fruit rot caused by *Fusarium* species is very common in Bangladesh. The main objective of the present study was to study biological control measures for this fungus. Plant extracts are now a superior choice to control different plant pathogens, as reported by several previous studies (Hasan *et al.*, 2020; Kareem & Al-Araji, 2017; Parveen *et al.*, 2014). In our study, we found that the plant extracts *Allium sativum*, *Zingiber officinale*, and *Coccinia grandis* have significant inhibitory effects on mycelial growth of *Fusarium* species. Hosen & Shamsi (2019) also found significant antifungal activity using *Allium sativum* (53.85%), *Ocimum sanctum* (48.72%) and *Zingiber officinale* (49.35%) against *Fusarium solani* and *F. oxysporum*. Our current results were also supported by data from Khatun *et al.* (2020) and Kareem & Al-Araji (2017). Confirmation of the potential of
antagonists on the radial growth of the pathogen in dual culture have been previously reported by Akhtar et al. (2010). By contrast, Nasrin et al. (2018) reported 87% inhibition potency on mycelium growth of Fusarium oxysporum f. sp. lycopersici by Calotropis proceraan plant extract. In our study, Trichoderma viride, Escherichia coli, Rhizobium phaseoli and Alternaria sp. showed significant antagonistic activity against Fusarium species. Trichoderma viride showed 45.88% growth inhibition on Fusarium merismoides fungi in a study by Hosen & Shamsi (2019), which support our present findings. Nasrin et al. (2018) also reported 82% inhibition radial growth by Trichoderma sp. against Fusarium oxysporum f. sp. lycopersici. In contrast, Bashar & Chakma (2014) reported that volatile substances produced by T. viride, A. niger, A. flavus and A. fumigatus showed 29.75, 20.15, 15.78 and 12.25% growth inhibition, respectively, on F. oxysporum.

In the current investigation, there are some limitations. Although this study showed that some plant extracts and nonpathogenic microbes could control the fungal stain, the number of plant extracts and microbes was limited. In addition, we used only methanol solvent for extraction and did not use other extractions. Moreover, we performed only in vitro techniques for antifungal potency screening and did not use any in vivo techniques. Therefore, we need to perform further studies to detect ecofriendly control this devastating fungal stain in the future.

Conclusions

We evaluated different biological control measures for the devastating Fusarium fungi. Various medicinal plant extracts and non-pathogenic microbes showed promising inhibitory activities on Fusarium sp. in vitro. These identified control measures of Fusarium species show the importance of further research on Fusarium taxonomy to decline the risk of Fusarium-caused fruit rot in Bangladesh.

Data availability

Underlying data


Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

Acknowledgements

A previous version of this article is available on Figshare: https://doi.org/10.6084/m9.figshare.13012517 (Hasan, 2020c).

References

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Kader SMA, Hasan M, Ahmed S, et al.: Antioxidant, Antibacterial and...


Shaikh Jamal Uddin
Pharmacy Discipline, Life Science School, Khulna University, Khulna, Bangladesh

Authors presented the antifungal activity of some plant extract as a eco-friendly control measure for pathogenic Fusarium species using the poisoned food method. They found some plant extracts showed promising (>65%) inhibitory activity against Fusarium sp. and suggested to use as bioagents to control fungal affected fruit and vegetable rot.

However, the authors can improve the article if they consider and revise the below points:

1. Authors did not mention any MIC values. It will be good if they included MIC values of each extracted.

2. In introduction section author might include a table on the selected plant with their traditional uses and list of active constituents.

3. In the discussion section, there is a lacking of discussion between antifungal activity of selected plant extracts and their traditional uses and reported phytoconstituents.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Pharmacological evaluation of ethnomedicinal plants, natural products chemistry and drug discovery

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 13 April 2021

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Natarajan Amaresan
C. G. Bhakta Institute of Biotechnology, Uka Tarsadia University, Surat, Gujarat, India

The authors are reporting some interesting results which will be of significance to the readership however, the manuscript lacks indepth research.

The effect of the bacteria and botanical extracts should be tested in the pot studies for their effectiveness. In vitro studies alone will not warrant their suitability to be used as bioinoculants for management of pathogens.

Without the in vivo studies the work appears as shallow research. The authors may be encouraged to do pot studies and update the manuscript.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes
Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Microbial Diversity, Plant-Microbe interaction, Phytoremediation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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