Research Article

Assessment of Enzymatic Potential of Soil Fungi to Improve Soil Quality and Fertility

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ABSTRACT

Soil is the very good habitat of fungi. The fungi have capacity to adopt in response unfavorable conditions of soil ecosystem. The fungal communities play a predominant role in the litter decomposition due to their lingo-cellulolytic potential. These enzymes helps in humus formation, hence increase soil health or fertility. In the present study, a total of 11 forms of fungi were isolated from soil of Mullana-Ambala, Haryana, India. Out of these, 9 fungi were identified, among these two belongs to Zygomycotina (*Syncephalastrum* sp., *Mucor plumbeus*) and 7 belong to Deutromycotina (*Aspergillus fumigatus*, *A. niger*, *A. quadrilineatus, A. terreus, A. candidus, A. flavus, A. sydowi*). The ability of these fungi to produce extracellular enzymes *viz*. cellulolytic, pectolytic and lignolytic were tested *in vitro*. The wheat crop residues burning has observed a big problem in Haryana, hence *in vitro* decomposition of these post harvested residues was tested by using these fungi. It was observed that, *A. terreus* produce higher lignolytic activity, but did not cause much decomposition as compare to other fungus. *A. niger* and *Syncephalastrum* sp. showed more pectolytic activity as compared to other species. The *A. flavus, A. terreus, A. niger, A. fumigates, Syncephalastrum* sp. showed all three activity (CMCase, pectolytic and lignolytic). The *A. candidus* did not showed lignolytic activity but having good rate of decomposition of wheat straw. Since *A. niger* and *A. candidus* were found potential decomposers of wheat crop residues *in vitro*.

Key words: Soil fungi, Ecosystem, Lingo-cellulolytic potential, Soil health, Wheat crop residues.

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INTRODUCTION

Fungi are abundant in soil next to bacteria. Fungi are important in soil because and used as food sources for other larger organisms, pathogens. Fungi well grow in dry, arid soil and higher the moisture content in the soil, less oxygen is present for them. There are 3 categories of soil fungi: Pathogen, saprophytes and mycorrhizal fungi. The *Aspergillus flavus* contain aflatoxin which is toxin and carcinogenic and contaminate food such as nuts. The *A. fumigates* cause allergic diseases.[1] The spore of *A. fumigatus* is everywhere in atmosphere. It causes lethal invasive infection in immune compromised individuals.[2] The common saprophytic fungi are *Mucor, Penicillium,* etc. The *Penicillium* (saprophytic fungus) growing on dead organic matter like bread, vegetables, fruits. The mycorrhizal fungi improve plant growth by increasing the uptake of nutrients and protect them against pathogens.[3,4] The micro-organisms help in improvement and maintenance of soil quality. Organisms present in soil control the decomposition of plant and animal material, biogeochemical cycling rate, help in formation of soil structure and destiny of organic chemical in soil.[5,6] Microbial biomass is the living component of soil organic matter.[7] Mineralizable nitrogen is a useful soil quality indicator when used in connection with total nitrogen, total carbon and microbial biomass.[8] Moreover, fungi participate in nitrogen fixation, hormone production, biological control against root pathogens and protection against drought.[9-11] These were also played an important role in stabilization of soil organic matter and decomposition of residues.[12,13]

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Micro-organisms produced extra–cellular enzyme cellulase and empoyed released sugar for own growth.[14] Various physical and chemical parameters such as temperature, pH, Carbon and Nitrogen (Media component) which played an important role in enzyme degradation, that catalyzed the process of hydrolysis.[15] Fungi such as *Aspergillus* sp., *Fusarium* sp., *Penicillium* sp., were used as cellulase producers.[16] The *Rhizopus* sp. mainly degraded the homogalacturonan part of pectin while the enzyme produced by *Aspergillus* hydrolyzed all pectic structural elements.[17] The *A. niger* and *A. oryzea* are the industrial fungi used for enzyme production. The lignin bio-degradation is difficult because of its complex structure and macro-molecular feature.[18] Some micro-organisms reduced lignin partly because they decrease just the polysaccharide component.[19] The process of decomposition was governed by the succession of fungi at various stage of decomposition.[20-25] The diversity and activity of fungi was regulated by various biotic (plants and other organisms) and abiotic (soil pH, moisture, salinity, structure and temperature) factors.[26-28] Fungi can be found in almost every environment and can live in wide range of pH and temperature.[29] Crop residues are important to soil because these contain organic carbon and nutrient. The organic carbon improves soil fertility, soil structure, water infiltration, water holding capacity and sustained microbial activity.[30] The crop residues act as a physical barrier between soil and erosion forces of wind and rain and also used as a nutrient source.

MATERIALS AND METHODS

The study was conducted at Maharishi Markendeshwer (Deemed to be University), Mullana-Ambala, Haryana, India during January–June, 2019. The soil samples were collected from surface of soil and at a depth of about 2-3cm and taken with sterilized hand trowel. Ten samples of soil were collected from ten different sites and about 100g of soil from each site. The collected sample was stored at 4°C for further processing. The serial dilution technique was used for the isolation of fungi from soil.[31,32] The fungi were identified by following morphological literature.[33-37] The length, width of colony, colony color and presence of wrinkles, furrows and pigment production characteristics was observed after.[38] The record of mycobiota was maintained and calculated for different parameters by

$$\text{Percentage occurrence or Percentage isolates} = \frac{\text{No.of colony of individual species in all petri-plates}}{\text{Total no.of colonies of all species}} \times 100$$

$$\text{Moisture content} = \frac{W_1 - W_2}{W_1} \times 100$$

The fungal population per gram liter was calculated as:

$$\text{Number of fungi/gram} = \frac{\text{Average number of colonies} \times \text{dilution} \times \text{moisture percentage}}{100}$$

The loss in dry weight was calculated during *in vitro* initial rate of decomposition subsequently absolute decomposition rate (ADR) was also enumerated. The relative decomposition rate (RDR) was calculated in relation to weight lost and amount of litter at the start of respective interval. There were screenings for production of fungal species with pectinase, lignolyase and CMCase activity by after the method proposed by Hankin and Anagnostakis.[39] The broad taxonomic arrangement was based on taxonomic hierarchy proposed in the '*Dictionary of fungi*' and '*The fungi: An advanced Treatise*'.[40-42]

RESULTS

The total of nine forms of fungi has been isolated and screened out from the soil throughout the period of study (Figure 1; Table 1). The genera and species within a family were arranged as:

Zygomycotina
- Zygomycetes
  - Mucorales
    - Mucoraceae
      1. *Mucor plumbeus* Bonorden
      - Syncephalastraceae
      2. *Syncephalastrum* (Cohn) Schroeter

Deuromycotina
- Hyphomycetes
  - Hyphomycetales
    - Moniliaceae
      1. *Aspergillus candidus* Link
      2. *Aspergillus flavus* Link
      3. *Aspergillus fumigates* Fresenius
      4. *Aspergillus niger* van Tieghem
      5. *Aspergillus quadrilineatus* Thom and Raper
      6. *Aspergillus sydowi* (Bainier and Sartory) Thom and Church
      7. *Aspergillus terreus* Thom

During *in vitro* cellulolytic activity analysis, *A. niger* and *Syncephalastrum* sp. showed comparatively better activity followed by *A. flavus, A. terreus, A. candidus, A. fumigatus* and *A. quadrilineatus* with lesser activity respectively (Figure 2). However, during *in vitro* pectolytic enzymatic activity *A. terreus, A. niger, A. candidus* and *Syncephalastrum* sp. showed more activity followed by *A. flavus, A. fumigates*. On contrary the fungus *A.quadrilineatus* did not showed pectolytic activity (Figure 3).

The highest lignolytic activity was recorded for *A. terreus* followed by *A. fumigatus, A. flavus, A. quadrilineatus* and *Syncephalastrum* sp., however, *A. candidus* did not showed any sign of lignolytic activity during *in vitro* study

(Figure 4). The *A. flavus, A. terreus, A. niger, A. fumigatus, Syncephalastrum sp.* showed all three activities (CMCase, pectolytic and lignolytic). While the *A. candidus* reflected both CMCase and pectolytic activities. On the other hand *A. quadrilineatus* showed both CMCase and lignolytic activity but did not showed pectolytic activities.

The *in vitro* decomposition of post harvested wheat crop residues was calculated as percentage loss in the dry weight along with the time interval; absolute decomposition rate per day (ADR); relative decomposition rate per day (RDR) and have been summarized in Table 2. The *A. niger* showed highest rate of decomposition followed by *A. candidus, A. quadrilineatus, A. fumigatus, Syncephalastrum* sp. and *A. terreus* respectively (Figure 5). The comprehensive analysis reflected that *A. candidus* had efficient rate of decomposition, however, *A. quadrilineatus, A. fumigates, Syncephalastrum* sp. and *A. terreus* showed moderate rate of decomposition (Figure 6). The ADR and RDR value was higher for *A. niger* was than *A. candidus* and *A. quadrilineatus.*

DISCUSSION

In the present study, a total of 11 forms of fungi were isolated from soil and out of these, 9 fungi were identified. Among these fungi, two belongs to Zygomycotina and seven to Deutromycotina. The Deutromycotina was dominant during investigation and corroborated to earlier reports.[43-46] The *A. terreus* showed higher cellulolytic activity by producing cellulase enzyme in both submerged and solid state fermentation,[47,48] on contrary in present study, *A. terreus* produced higher lignolytic activity, moderate pectin and lesser cellulolytic activities. The *Syncephalastrum* sp. and *A. niger* gave fairly high cellulolytic and pectolytic activities and fewer lignolytic activity.[49-51]

The species of *Aspergillus* were known to produce all 3 enzymatic activities (CMC, pectin and lignin). The *A. niger*, *A. terreus*, *A. candidus* and *A. flavus* were known to be effective in the biodegradation of lignocellulosic biomass corroborated to the present findings.[52-54] Haung *et al.* observed highest lignolytic activity and good cellulolytic activity during lignocellulosic waste

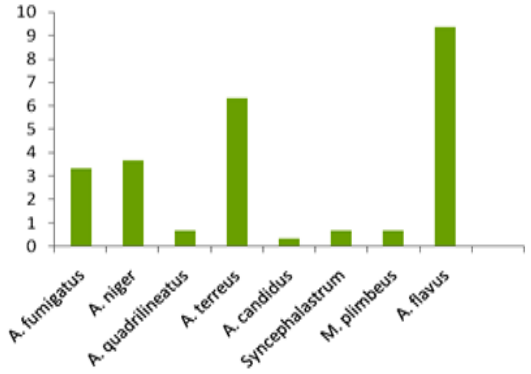

Figure 1: The fungal population in per gram of soil (x10³).

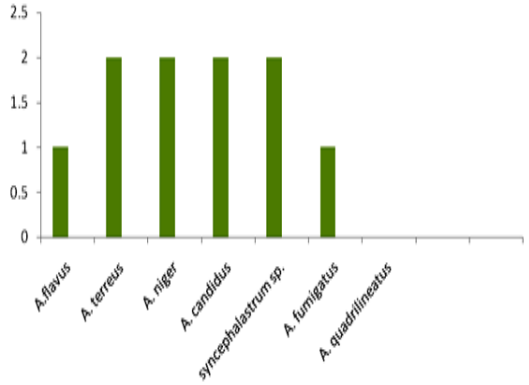

Figure 3: Pectolytic (PG) activity of recovered soil fungi.

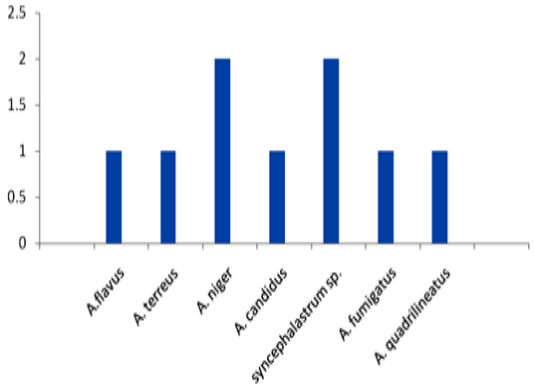

Figure 2: The cellulytic CMCase activity of recovered soil fungi.

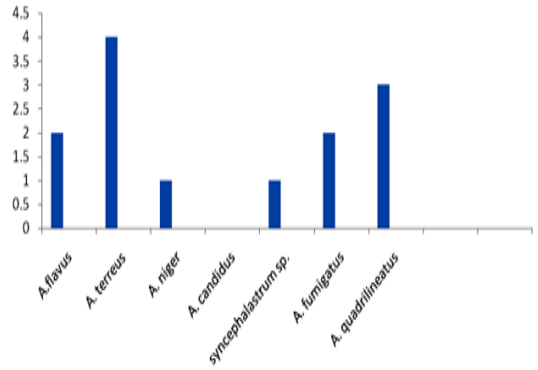

Figure 4: Lignolytic activity of recovered soil fungi.

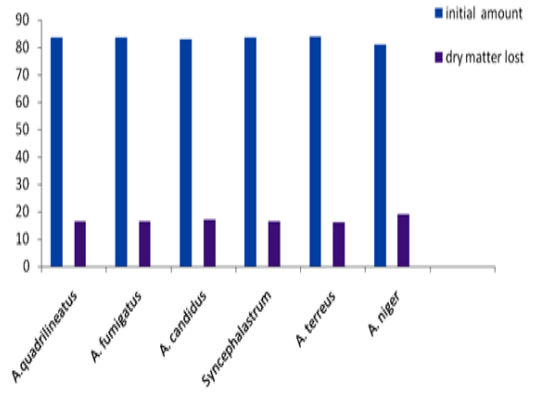

Figure 5: Dry matter lost in wheat crop residues after 30 days of decomposition.

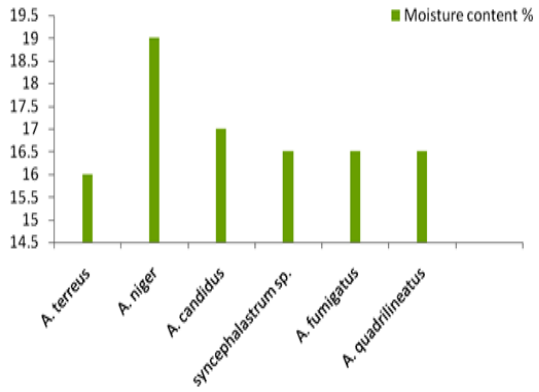

Figure 6: Moisture content of decomposed material.

Table 1: Population biology of the recovered soil fungi during investigation.

Fungal species	Frequency class	Frequency %	Total isolates	Percentage isolates
A. fumigatus	III	44	23	22.85
A. flavus	II	22	30	28.57
A. niger	III	44	17	16.19
A. terreus	II	33	22	20.95
A. quadrilineatus	II	22	3	2.85
A. candidus	II	22	3	2.85
A. sydowi	I	11	3	1.90
Mucor plumbeus	II	22	3	2.85
Syncephalastrum	I	11	2	1.90

Table 2: The *in vitro* decomposition rate of post harvested wheat crop residues, straw after exposure of soil fungi.

Fungal species	Initial weight (g)	Dry weight (g)	ADR (%)	RDR (%)
Aspergillus quadrilineatus	2	1.67	0.55	0.0055
A. fumigatus	2	1.67	0.55	0.0055
A. candidus	2	1.66	0.56	0.0056
A. terreus	2	1.68	0.53	0.0053
A. niger	2	1.62	0.63	0.0063
Syncephalastrum sp.	2	1.67	0.55	0.0055

composting, when inoculated with *A. terreus*.[55,56] In the present study, results for *A. terreus* were very well matched with the earliest report. The maximum decomposition of wheat straw reported by *A. niger* (19%), followed by *A. candidus* (17%), *A. fumigates* (16.5%), *A. quadrilineatus* (16.5%), *Syncephalastrum* sp. (16.5%) and *A. terreus* (16%), within 30 days. The decomposition of given substrate by a given fungal species depended upon a number of factors including C:N levels, stimulatory or inhibitory effects of chemicals present in the substrate of the fungi.[57-59]

CONCLUSION

All the agricultural wastes are consisting lignin, cellulose, hemicellulose and pectin and as the structural components. The soil inhabiting mycobiota has the ability to decompose these wastes into their components by breaking the complex compounds in its simple forms; and the nutrients pass down the soil profile.

This biological or mycobio-mediated decomposition of crop residues played a key role in formation of humus of soil, hence escalating fertility and quality of soil. The fertility of soil having the direct impact on healthy food production, sustainable agriculture which improve the economy of country along with health of human beings, animals and environment. Thus the present study was able to attain major objective of investigation by identifying the soil fungi, their enzymatic potential and role in decomposition of post harvested crop residues and wheat straw for further utilization as biofertilizer or organic manure. The more research is going on to find the best way to improve the soil health.

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CONFLICT OF INTEREST

The author claims no conflicts of interest because none financial support was received from any government, non-government agency or organization to conduct this research work.

ABBREVIATIONS

ADR: Absolute Decomposition Rate; **RDR:** Relative Decomposition Rate; **CMC:** Carboxy Methyl Cellulose; **CMCase:** Carboxy Methyl Cellulase.

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