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Bioprospection of some plant extracts for antifungal activity against wheat pathogens

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Abstract
The present study aims at exploring the antifungal potential of some plant extracts in fighting the menace of fungal pathogens attacking wheat, as a cost-effective and eco-friendly alternative to the chemical fungicides currently in use. Scientists have obtained remarkable results against phyto-pathogenic fungi using extracts from various aromatic and poisonous plants under *in vitro* and *in vivo* conditions. The efficacy of different plant extracts in controlling fungal diseases of wheat investigated so far indicate that almost all treatments inhibited spore germination to a significant extent comparable to that of synthetic fungicides. These results may be extended to the local flora unexplored so far in order to devise a novel, safe and sustainable disease management strategy for the staple crop of North and North Western India.

Keywords: Plant extracts, antifungal, wheat, fungal pathogens

1. Introduction
Wheat is the staple crop of a large part of India. A large number of fungal pathogens including rusts and smuts infest the crop and result in huge economic losses. Stripe rust is the most damaging disease of wheat which is appearing continuously since 2006-07 in sub-mountainous districts of Punjab and Haryana [1]. The farmers in the state resort to chemical fungicides to control these pathogens. But unfortunately, these pesticides are not only expensive but also detrimental to the environment and human health. According to one study, during 2010-11, the cost of single spray of fungicide to control stripe rust in sub-mountainous districts of Punjab was estimated to be Rs.36 crores [1]. Serious diseases are caused by fungal pathogens in wheat crop resulting in substantial quantitative and qualitative losses. Prominent diseases that contribute to these losses include the rusts, the blotches and head blight. In Asia, susceptible varieties of wheat, if grown, could affect production on approximately 60 and 43 million hectares, due to attack by leaf and stripe rust, respectively [2]. Huge economic losses are incurred annually due to the diseases caused by fungal pathogens in wheat. Resistant cultivars and fungicides are the chief recommended measures for controlling these pathogens [3]. Plant breeding programs aiming at developing wheat cultivars resistant to fungal diseases have already gained success in many countries. But growing resistant cultivars is a short-term solution since the pathogen tends to develop new pathogenic strains [4-5]. The other line of control i.e. the use of synthetic fungicides for controlling plant diseases has ultimate negative effects on human and animal health and environment[6]. In recent years, the increased awareness on the detrimental effects of pesticides and the development of resistant strains of pathogens, have necessitated to explore new alternatives to pathogen control [7-9]. Eco-friendly control measures including plant extracts, which act directly on the plant pathogens, have gained considerable attention as alternative means to synthetic fungicides [6].

2. Materials and Methods
The present review is based on selected studies on the efficacy of phytoextracts against various fungal pathogens covering almost two decades. The search was mainly confined to the web search engines such as Google scholar, PubMed, Research Gate and Directory of Open Access. The available articles were systematically examined to derive some comprehensive conclusion.

3.1. Plant extracts against fungi

Plant pathogenic fungi pose serious threat to agricultural crops and forest plantation which are of great economic value [10]. Efforts have been made to exploit the antifungal potential of plants against phytopathogens. The plant extracts of many aromatic plants have been screened for their antifungal activity and tested against phytopathogenic fungi. The essential oils from aromatic plants have also been reported to exhibit remarkable biological activity [11-13]. These are reported to be effective in controlling many fungal pathogens such as *Colletotrichum musae*, *Lasiodiplodia theobromae* and *Fusarium proliferatum* [14, 15]. The essential oils of onion and eucalyptus can completely inhibit the spore germination of *Fusarium solani* [16]. Essential oils of some aromatic plants i.e. cinnamon, thyme, clove, mint and orange have exhibited remarkable inhibition of mycelial growth of fungus that causes corm rot in gladiolus [17]. Essential oils of clove, eucalyptus, neem, lemon and mint have been reported to inhibit the growth of black mold, a post-harvest disease in pomegranate [18]. *In vitro* and *in vivo* screening of antifungal activity of essential oils against *Fusarium oxysporum* f. sp. *lycopersici* 1322 also resulted in inhibition of mycelial growth and spore germination in tomato plants [19]. Leaf extracts of yarrow, tansy and wormwood were also found to be effective against various species of *Fusarium* as the mycelial growth could effectively be inhibited *In vitro* by using these extracts [20]. In another study, turmeric and nutmeg were shown to effectively inhibit various *Colletotrichum* species [21]. Curcumin from turmeric has also been reported to be effective in controlling gray mold in kiwi [22]. Six compounds from turmeric have shown antifungal activity against *Fusarium solani sensu lato* [23]. Many medicinal plants i.e. garlic, Indian aloe, licorice and Peru balsam have been reported to be effective in controlling fusariosis in pineapple [24]. The *In vitro* efficacy of garlic extracts has also been confirmed against *Botrytis* and *Penicillium* species [25] and the fungus that causes anthracnose in common bean and cowpea [26]. Other medicinal plants i.e. Fragaria, epilobium and potentilla [27], amaltas [28], ashoka [29], neem [29, 30], pepper [30], garlic [26, 30, 31], datura [29, 31-33], musli [26], marigold [34], licorice, turmeric [34, 35] amla [32] have also shown promising results against several species of fungi that cause diseases in various economically important plants. Some poisonous plants have toxins in their extracts that inhibit the germination of the fungal spores [24]. The poisonous plants including castor, congress grass and stinging nettle have proven to be effective against phytopathogens to the levels comparable to fungicides [30, 36]. The extracts of some fruit plants such as sapota, pomegranate [32] and papaya [37] have also been tested to possess satisfactory levels of antifungal activity against various phytopathogenic fungi. Excellent antifungal activities have also been shown by Vasaka, tulsi and Indian elm against various fungal species of *Aspergillus, Alternaria* and *Trichoderma* [37]. *Smilax*, *Rhododendron*, *Trachystemon*, *Phytolacca* and *Prunus* spp. have been found to inhibit the mycelia of the fungi that cause great losses in tomato, strawberry, potato and cucumber [39].

3.2. Plant extracts against fungal pathogens of wheat

A limited literature data is available regarding the effectiveness of plant extracts against fungal wheat pathogens till date[3]. In one of the studies, out of eight plant extracts (garlic, clove, garden quinine, Brazilian pepper, anthimandhaari, black cumin, white cedar and neem) tested against rust of wheat, all the treatments inhibited the spore germination to the levels comparable to the fungicide Sumi-8 with neem extract being 100% efficacious [6]. The extracts of Henna, Acalypha, Pomegranate and Lantana when applied at pre-infection stage were found to inhibit the leaf rust infection, with Lantana extract being the most effective [40]. Similarly, 100% inhibition of spore germination was exhibited by the extracts from seven plants *viz*., Henna, Blue gum, Acalypha, Chinaberry, Pomegranate, Basil and Lantana in controlling leaf rust of wheat comparable to the levels of synthetic fungicide, Fungshou [41]. Leaf extracts of some poisonous phanerogamic plants i.e. oleander, milkweed, datura and neem were also reported to show results comparable to the fungicide Bay tan in the control of wheat rust [42]. The essential oils from eight plants i.e. castor, corn, cottonseed, linseed, olive, peanut, soybean and sunflower, tested (*in vitro* and *in vivo*) against leaf rust disease, were found to be significantly effective with Linseed oil being the most effective [3]. In another study, Titanium oxide nanoparticles prepared using leaf extracts of *Trianthema portulacastrum* and *Chenopodium quinoa* were shown to exhibit good antifungal activity against Ustilago tritici, the wheat rust pathogen [43]. The plant extracts of garlic, neem, eucalyptus, asuro and bojho were tested against *Bipolaris sorokiniana* which causes spot blotch of wheat and the extract of garlic cloves was found to be most effective against the fungus followed by that of bojho rhizome [44].

4. Results and Discussion

The literature available till date indicates that though the antifungal potential of various plant extracts has been successfully exploited against many phytopathogenic fungi, but the data on bioactive compounds against wheat pathogens still remains limited. More over the work on wheat has mainly been confined to *Puccinia striiformis*. This work can further be extended to smuts, blotches and head blight disease of wheat. Only a limited number of plants have been tested for their antifungal potential against wheat pathogens. There is a need to explore the local flora of Punjab for its antifungal potential against the pathogens of wheat in order to fight the menace of fungal diseases of wheat in a more economic and eco-friendly manner. In the background of these facts, the future studies must be designed to explore the antifungal potential of some local flora against major pathogens of wheat that cause huge economic losses, with the following objectives in view:

i. To devise an economic and eco-friendly solution to the menace of fungal pathogens of wheat in the region and pave the way for replacing the expensive and noxious synthetic fungicides with cheap and biodegradable bioactive compounds. ii. To evolve and standardize a novel and sustainable way of pathogen control of the important cereal so that nutritional security of the country is ensured without compromising the environment and health of the people.

5. Conclusion

The fungal diseases of wheat are of frequent occurrence. Many districts in the states of Punjab and Haryana are currently under the attack of *Puccinia striiformis*, causing yellow rust of wheat. This disease spreads rapidly causing severe losses, if not checked in time. Besides this, a number

of other fungal pathogens also infest the crop causing severe losses. Though a number of plants have been screened for their antifungal potential, there is a need to explore the local flora of Punjab in order to devise an economic and eco-friendly solution to this problem in the near future. The work needs to be extended to other diseases, like, smuts, blotches and blights along with rusts. The extracts of local flora need to be tested against these diseases as well and their antifungal activity assessed and compared with standard chemical fungicides. This is how the scourge of fungal pathogens may be overcome in a novel way that is less expensive, sustainable and free of the ill impacts on human health and environment.

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