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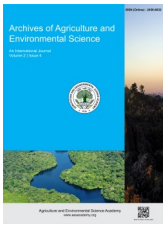

REVIEW ARTICLE

# A review on comparative effect of chemicals and botanicals in management of brown spot diseases of rice (*Oryza sativa* L.)

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**ABSTRACT**

Brown spot of rice is a fungal disease caused by either *Bipolaris oryzae*, *Helminthosporium oryzae* or *Drechslera oryzae* species, which is found to be a major problem eventually causing sustainable losses both in quality and quantity. The pathogen after infection shows the symptoms on the leaves, panicles, glumes, and grain causing first as small, circular, and dark brown to purple-brown spots and fully developed lesions are circular to oval with a light brown to gray center, surrounded by a reddish-brown margin and ultimately killing the leaf. We have collected our information from secondary sources. In this review article, we have discussed the effects of bio-agents and chemicals and their comparative efficacy. Fungicides like: propiconazole, Carbendazim, Mancozeb, Hexaconazole, Cabendazim, Bion, Amistar, Tilt etc. are discussed which showed diverse performance on the diseases brown spot of rice. Extracts from the plant parts like roots, stem, leaves etc. are comparatively analyzed and studied that effected on mycelial growth and spore germination of *Bipolaris* pathogen. The plant components with phenolic structures like carvacrol, eugenol, and thymol are found to be highly active against the pathogen. The extracts of plants like *Azadirachta indica*, *Nerium oleander*, *Curcuma longa*, *S. indicum*, *Cymbopogon citratus* etc. are found suitable against brown spot in rice. Chemical fungicides were found to have more inhibition rate against the pathogen, even up to 100%. Although being eco-friendly, plant extracts were recorded to be less effective in comparison to chemical fungicides for suppressing plant pathogen. This article promotes the use of plant extracts for human health and environmental benefits over the use of chemicals for the control of plant diseases.



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## INTRODUCTION

Paddy or rice crop (*Oryza sativa* L.) belongs to the Poaceae family ("true grass") and is the domesticated species of genus oryzae. Its native place ranges from tropical and subtropical southern Asia, while the African rice *Oryzae glaberrima* is native to West Africa (Gutaker *et al.*, 2020). It is the most important cereal crop next to the wheat in area and production which is the primary source of food for nearly 90% of the world's human population, especially in Asia. Rice is an important grain, which is enriched with a high amount of carbohydrates, protein, and fats. It provides more than 1/5$^{th}$ of calories consumed by humans worldwide (Fukagawa and Ziska, 2019). There is a continuous increase in the global demand for rice grain due to the continuous increase in the world population. The global demand is expected to be 852 million tons by the year 2035 with the current production of approximately 770 million tons (Gadal *et al.*, 2019). To fulfill the demand, there is a need to intensify production technology. But with the introduction of improved technologies and high-yielding varieties, the crop becomes susceptible to many biotic and abiotic stresses, especially biotic stresses like diseases. Among several diseases of rice, the brown spot of rice

caused by *Bipolaris oryzae*, *Helminthosporium oryzae*, and *Drechslera oryzae* is found to be a major problem eventually causing sustainable losses both in quality and quantity. Brown spot is a fungal disease that can infect both seedlings and mature plants (Manandhar *et al.*, 2016). The disease causes blight on seedlings, which are grown from heavily infected seeds, and can cause 10-58% seedling mortality. The first documented case of *H. oryzae* was reported in Bengal, India. In 1942-43, 50-90% of the rice crops were destroyed which caused a major famine in which two million people died of starvation (Bowbrick, 2020). The pathogen after infection shows the symptoms on the leaves, panicles, glumes, and grain causing first as small, circular, and dark brown to purple-brown spots and fully developed lesions are circular to oval with a light brown to gray center, surrounded by a reddish-brown margin and ultimately killing the leaf (Manandhar *et al.*, 2016). The management of the brown spot can be done mainly through resistant varieties, chemicals, biological, cultural, etc. Disease control by foliar spray with bio-agents is not enough for the management of the disease. The application of fungicides for the control of brown spots is the most effective management option effective and widely recommended methods of disease control (Nancy Doubrava, 2019). Fungicides, such as iprodione, propiconazole, azoxystrobin, and carbendazim are effective in the management of brown spot disease (Poudel *et al.*, 2019). Although rice is cultivated in most parts of the world after wheat, there is significant yield loss due to brown spot diseases. Rice is the first major cereal crop in Nepal in terms of area of production but due to disease infestation especially by the fungus, the productivity of rice is not obtained in the expected ratio. Due to limited research on brown spot diseases of rice, farmers are not known or little known to the management methods for this disease. Therefore, this study is carried out to collect the information about proper management of brown spot diseases and analyze the comparative efficacy of botanicals and chemical fungicides.

## METHODOLOGY

This review article is prepared based on secondary sources of information. This paper is based on relevant information, research papers from different journals, and reports from a different organization. Pieces of literature were collected from different journal articles, government institutes, and other relevant reports were studied and finally, major findings were evaluated and summarized.

### Efficacy of chemicals on the brown spot of rice

The use of chemicals in the control of brown spot of rice is widely practiced throughout the world. Efficacy evaluation of different chemical fungicides in the market shows diverse performance against brown leaf spots of rice. Poudel *et al.* (2019) selected Khumal 9, a long-duration variety of rice for the experiment in the Baglung district, and used seven fungicides. They reported that the application of propiconazole for the management of brown spots in the field was most effective in reducing the severity of the disease and increasing economic yield. Maximum test weight (12.68g) and grain yield (4.277 t/ha) was obtained from propiconazole followed by Azoxystrobin + Tebuconazole (12.62g) and (4.120 t/ha), respectively. So, Propiconazole and Tebuconazole +Azoxystrobin appeared as the efficient ones against brown leaf spot among all chemical fungicides in the field. The application of Carbendazim +Mancozeb, Hexaconazole, Cabendazim, and Mancozeb resulted in an average grain yield of 3.847 t/ha, 3.377 t/ha, 3.470 t/ha, and 3.333 t/ha, respectively. Sunder *et al.* (2010) also reported propiconazole at 0.1% and hexaconazole at 0.2% to be most effective and significantly superior to other recommended fungitoxicant, mancozeb at 0.25% on a mean basis. They conducted field trials in randomized block design with three replications at CCS HAU Rice Research Station, Kaul during Kharif 2005, 2006, and then leaf area affected (%), stalk rot (%), and grain yield (%) were calculated on the mean basis. Ferric chloride, sodium selenate, and nickel nitrate provided more than 26.6% reduction in leaf spot severity and 14.7-24.2% reduction in stalk rot incidence amongst the non-conventional chemicals. However, sodium selenate and nickel nitrate showed some phytotoxic effects on leaves. The application of Bion, Amistar, and Tilt at tillering stage increased yield by 25.87%, 32.17%, and 26.74%, respectively over untreated control (Hossain *et al.*, 2012). It was found Bion, Amistar and Tilt significantly increased the number of grains/ear and the number of healthy grains/ears by reducing the number of diseased grains/ears. When *in-vitro* studies were carried out to evaluate the efficacy of fungicides in inhibiting the mycelial growth of *H. oryzae* pathogen causal organism of leaf brown spot of rice, Carbendazim (Bavistin) @ 1500 ppm was found significantly effective in inhibiting the radial growth of mycelium after 144 hrs. of incubation (Sandeep, 2015). On the contrary, propiconazole (Tilt) at 500 ppm maximum inhibited (96.58 %) the growth of *D. oryzae* under in vitro conditions (Kumar et al., 2017). Under field conditions, seed treatment (ST) with Bavistin @ 0.2 g a.i./kg and foliar spray (FS) with Tilt @ 1ml/liter led to a significant reduction in disease severity (37.26%), in addition to a significant increase in the grain yield (55.49 %) and its components. Monisha *et al.* (2019) reported that under in vitro and in vivo evaluation, Hexaconazole 5% EC and Tebuconazole 25% + Trifloxystrobin 50% WP, Zineb 68% + Hexaconazole 25% WG were effective at 50 ppm concentration with 100 percent inhibition against *B. oryzae* pathogen.

### Effects of plant extracts on *B. oryzae*

**Effect of leaf extracts and oilcake against *B. oryzae*:** The use of alternative methods of disease control is currently becoming popular to minimize the negative effects of agrochemicals and to facilitate sustainable food production. These methods rely on the use of natural plant extracts and oils that are sources of various compounds with antimicrobial action that can be utilized in integrated disease management (Dorneles *et al.*, 2018). Plant extracts are excellent sources of new agrochemicals with large antimicrobial spectrum properties for the control of plant

diseases (Shuping and Eloff, 2017). Plants contain thousands of constituents and are valuable sources of new and biologically active molecules possessing antimicrobial properties (Khameneh *et al.*, 2019). According to the report by Kisiriko (2021), different plants can synthesize aromatic secondary metabolites, like phenols, phenolic acids, quinones, flavones, flavonoids, tannins coumarins, etc. The components with phenolic structures like carvacrol, eugenol, and thymol, were highly active against the pathogen (Khameneh *et al.*, 2019). The ethnobotanical study of the plant is important for modern-day medicine due to the various importance of plant extracts in disease control and management. Plant extracts are nature friendly, reduces chemical hazards, and are economical and feasible thus easily accessible to the growers. After reviewing many articles, it can be clarified that a wide range of plant extracts can be used for disease management. Some of the plants used for the extracts are *Azadirachta indica*, *Nerium oleander*, *P. dulce*, *Curcuma longa*, *S. indicum*, *Calotropis gigantean*, *Mimordica charantia*, *Vitis quadrangularis*, *Vinca rosea*, *Astercantha longifolia*, *Solanum nigrum*, *Cymbopogon citratus*, *Thymus vulgaris*, *Ocimum gratissimum*, *C. odorata*, *Callistemon citrinus*, *Embilica officinalis*, and *P. glabra*.

**Effect on mycelium growth:** The inhibition of *B. oryzae* by *N. oleander* is attributed to the fungal toxic substances present in the plant extracts. The extracts of *N. oleander* and *P. dulce* showed a reduction in the mycelial growth of the *B. oryzae* pathogen by 77% and 75%, respectively (Harish *et al.*, 2008). According to the research experiment done by Nguefack *et al.* (2013), *C. citratus* was found to be active against *B. oryzae* by reducing 77 % the radial mycelial growth at 10 000 µg/ml. It was recorded that at 3% concentration of neem oil the growth of pathogen was inhibited to the maximum of 54.75% followed by neem oil 2%, the inhibition was seen up to 51.73%. The neem oil 1% showed 49.89% inhibition. Similarly, the extent by neem leaf extract 7% (53.88%), and neem leaf extract 5% (51.66%) and neem leaf extract 3% expressed minimum growth inhibition that is 49.74% (Kumar *et al.*, 2015). Harish *et al.* (2008) found that spraying rice plants twice with neem cake extract and *Nerium oleander* leaf extract in the field reduced the severity of brown spot by 70% and 53 %, respectively, and increased the yield by 23 % and 18 %, respectively. Neem plant extract and neem oil were reported to have antifungal activity by Devi and Chhetry (2013). According to the research performed by Pandey (2015) on the efficacy of plant extracts to control *Bipolaris oryzae*, *A. indica* (neem) leaf extract @ 0.5% was found highly effective in reducing the radial growth of the 34.90 and 37.20 mm in *B. oryzae* after 120 and 196 hours of incubation, respectively. The *P. glabra* leaf extract was the second effective treatment minimizing radial growth of mycelium to 30.10 mm after 96 hours which gradually increase to 35.20 and 37.80 mm after 120 and 196 hours of incubation, respectively. Similarly, the leaf extract of *E. officinalis* shows effective suppression in radial growth in the range 31.22, 37.80, and 38.90 mm after 96, 120, and 192 hours of incubation, respectively.

Faruq (2015) observed that seed treatment with Neem and Alamanda leaf extract showed an effective reduction in brown spot incidence but was less significant than standard fungicides and hot water treatment at flowering, milking, and maturity stage of seed growth in vivo. From the critical analysis of findings from the research on the topic by Kumar and Simon (2016) it was concluded that among all the treatment, botanical extracts were most effective in all plant observation. Neem products are highly efficient for the management of brown spot disease in the laboratory as well as in the field. The leaves extract from *S. indicum*, *Calotropis gigantean*, *Mimordica charantia*, *Vitis quadrangularis*, and *Vinca rosea* showed between 60 and 70% mycelium inhibition (Harish *et al.*, 2008). The mycelial growth inhibition was at least 21% in *Astercantha longifolia* leaf extract. Nguefack *et al.* (2008) showed that the essential oils of *Cymbopogon citratus*, *Thymus vulgaris*, and *Ocimum gratissimum* can be used as seed treatments to control seed-borne fungi in rice. Under semi-controlled conditions, aqueous extracts of *C. odorata* reduced the severity of important rice diseases, brown spot (*Bipolaris oryzae*) up to 57 %. Treating the seeds with the essential oil of *C. citrinus* significantly reduced the incidence of *B. oryzae* by 77–100 % in the rice seeds (Nguefack *et al.*, 2013). Hajano *et al.* (2012) also studied the efficacy of garlic and neem and observed that only a higher dose of garlic completely inhibited the mycelial growth of *B. oryzae*.

**Effect on spore germination:** Leaf extract effect on spore germination showed that the leaf extract (10%) of *L. inermis* and *P. dulce* were on par with each other and recorded 76.4% reduction on spore germination over control (Akila *et al.*, 2020). Naik *et al.* (2016) indicated in their findings that the leaf extract (10%) of *L. inermis* and *P. dulce* recorded reduction in mycelial growth of 65% and 60.56%, respectively. In a study conducted by Dorneles *et al.* (2018) to evaluate the use of *C. longa* extract against *Bipolaris oryzae* significant result was seen in inhibition of sporulation. Evaluation using the three concentrations of *C. longa* that is (20, 40, and 80) mg/mL with a control treatment of 0 mg/mL was done and an average inhibition of 84% of sporulation was observed for the tested strains compared with the control treatment.

**Effects of *Curcuma longa* against *B. oryzae*:** Turmeric (*Curcuma longa*) is popular drug which is used for its anti-inflammatory, antimutagenic, antimicrobial, antibacterial and antioxidant pharmacological functions (Ahmad *et al.*, 2020). Stangarlin *et al.* (2011) indicated that the rhizomes of *C. longa* were highly effective in inhibiting mycelial growth and spore germination in the pathogen. A study was conducted by Dorneles *et al.* (2018) to evaluate the use of *C. longa* extract in the in vitro control of *B. oryzae* (Breda de Haan) and to characterize the effect of this extract on rice seed germination. Evaluation using the three concentrations of *C. longa* that is (20, 40, and 80) mg/mL with a control treatment of 0mg/mL was done. An average inhibition of 84% of sporulation was observed for the tested strains compared with the control treatment. The treatment of rice seeds

with *C. longa* extract does not affect seed germination but has an impact on mycelial growth and sporulation, affecting the in vitro sporulation of the different isolates of *B. oryzae* (Dorneles *et al.*, 2018).

## Drawbacks of plant extracts for management of plant disease

Although plant extracts are highly eco-friendly and easy to use there are some limitations of using plant extracts in the management of plant disease which is as follows:

- Rapid degradation
- Some chemical compounds are toxic to plants and humans.
- Plant extracts are less effective in comparison to chemicals.
- It is difficult to extract botanicals as extraction methods are
- not standardized.
- Most of the studies are in vitro efficacy.
- Fewer availability formulations.
- The development of formulations is required.

## Conclusion

From the findings of the earlier work, it is assumed in the present study the application of propiconazole for the management of *B. oryzae* in the field was most effective in reducing the severity of the disease and increasing economic yield than other tested fungicides. Plant extracts from *A. indica*, *N. oleander*, *P. dulce*, *C. longa*, *S. indicum*, *C. gigantean*, *M. charantia*, *V. quadrangularis*, *V. rosea*, *A. longifolia*, *S. nigrum*, *C. citratus*, *T. vulgaris*, *O. gratissimum*, *C. odorata*, *C. citrinus*, *E. officinalis*, and *P. glabra* were found not to affect seed germination. However, it has shown an impact on mycelial growth and sporulation, affecting the in vitro sporulation of the different isolates of *B. oryzae*. Moreover, reports from other findings show that antifungal activity of *A. indica* reduced the growth of *B. oryzae*. The components with phenolic structures like carvacrol, eugenol, and thymol were highly active against the pathogen. Leaf extract of *N. oleander*, *P. dulce*, *S. indicum*, and *C. gigantea* had the highest inhibition of the spore germination of *B. oryzae* (80, 80, 78, and 77%, respectively) as compared to that of the leaf extract of *A. longifolia* (22%). Chemical fungicides were found to have more inhibition rate against *B. oryzae* pathogen, even up to 100%. Whereas, botanicals although being eco-friendly was reported to be less suppressive for pathogen as compared to chemicals.



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