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Bio-agents for the Management of Blast Disease of Finger Millet (*Eleusine coracana*): A Brief Review

H.M. Navya[1], Karibasappa[1], Jahanara Kudsi[2], Tathagath Waghmare[3], Prabhurajeshwar[1]

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ABSTRACT

Finger millet (*Eleusine coracana*) is one of the major staple food in India. the crop yield and its quality is affected by numerous factors including pre and post-harvest pathogens, poor storage conditions, improper irrigation practices and others. Among different phytopathogens which attack the *Pyricularia grisea* affects major yield loss in finger millet and many researchers developed potential management strategies to combat against target pathogen. This review deals with the overall information available for the utilization of bio-agents, against blast pathogen. Various researchers reported utilization of bio-agents is an effective management strategy against blast pathogen also economical and environmentally safe. In this review we made an attempt to present detailed overview potential utilization of bio-agents in supressing *Pyricularia grisea*.

Key words: Disease resistance, Eco-friendly approach, Non-pathogenic microorganisms, *Pyricularia grisea*.

Millets are the most important cereals food grain crops, especially grown in arid and semi-arid regions of the Asia and Africa. Finger millet (*Eleusine coracana*) is popularly known as ragi. Karnataka, Tamil Nadu andhra Pradesh, Orissa, Maharashtra, Uttar Pradesh, Bihar and Gujarat are major finger millet growing states in India and together contribute for more than 95 per cent of the total area under finger millet and more than 98.13 per cent of the total production in the country (Prajapati, 2020). The outer layer of the grain or the seed coat contains dietary fiber, minerals, phenolics and vitamins hence the use of millets as whole grain provides essential nutrients and also offer health benefits.

Finger millet is a good source of carbohydrates and hence it supplies high amounts of energy. Because of its rich sulphur containing amino acids, proteins due to its low glycemic index with high fibre. Hence, it is recommended for diabetic patients as it is very effective in controlling blood glucose levels of diabetics. Finger millet also contains high calcium, high soluble fibre and low fat. High diastatic power of malted grains makes finger millet unique. Consumption of finger millet prevents cholesterol and constipation (Panwar, 2016).

About 5-8% of protein is present in finger millet, 65-75% carbohydrates, 15-20% dietary fibre and 2.5-3.5% minerals (Chethan and Malleshi, 2007). Powder of naked caryopsis is generally used for the preparation of roti, mudde and thin porridge called ambali. Regular consumption of whole grain cereals and their products have shown in epidemiological studies that they can protect against risk of diabetes mellitus, gastrointestinal diseases and cardiovascular risks. Finger millet contains lower levels of protein (6-8%) and fat (1.5-2%), their proteins are unique because of the sulphur rich amino acid contents. Finger millet is the richest source of calcium (300-350 mg/100 g), also rich in phytates 0.48 g/100 g, polyphenols, tannins 0.61%. Finger millet contains 8.71 mg/g dry weight fatty acid and 8.47 g/dry weight protein.

[1]Department of Studies in Biotechnology, Davangere University, Shivagangothri, Davangere-577 007, Karnataka, India.
[2]Department of studies in Biotechnology, Khaja Bande Nawaz University, Kalaburagi-585 104, Karnataka, India.
[3]Department of Agricultural Biotechnology, Lokmangal College of Agricultural Biotechnology, Wadala Mahatma Phule Agricultural University, Rahuri-413 722, Maharashtra, India.

Corresponding Author: Prabhurajeshwar, Department of Studies in Biotechnology, Davangere University, Shivagangothri, Davangere-577 007, Karnataka, India. Email: p.v.chidre@gmail.com

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Health benefits of finger millet

Finger millet is also a good source of essential amino acids like arginine, lysine, methionine, lecithin etc. and performs a number of essential health promoting functions including precursor for the synthesis of nitric oxide and it helps in stimulation and release of growth hormone (Pragya, 2012). It reduces the healing time of bone injuries and helps in increased blood circulation and muscle mass. It also alleviates male infertility, improving sperm production and motility. Finger millet may prevent cardiovascular disease by reducing plasma triglycerides in hyperlipidemic rats (Lee *et al*., 2010). Finger millet based diets have shown lower glycemic response due to high fibre content and also alpha amylase inhibition properties which are known to reduce starch digestibility and absorption (Kumari and Sumathi, 2002).

Diseases of finger millet

Although finger millet is considered a hardy crop, it is affected by more than 20 diseases caused by different pathogens *i.e.* Bacteria, fungi and virus. The pathogens infect different parts and stages of the plants from seedling to grain formation result in reduction in total yield and ultimately results in economic loss to farmers. Following are the major diseases of finger millet (Table 1).

Blast disease

The causal agent of blast in finger millet is a heterothallic filamentous fungus pathogenic to almost 50 plant species in 30 genera of Poaceae including *Eleusine* (Rossman *et al*., 1990). The fungus appears to overwinter as mycelia in the infected living leaves or dead plant debris in the soil (Uddin, 2003). Among various diseases serious losses in finger millet caused by blast pathogen *Pyricularia grisea* (Cooke) Sacc. [Teleomorph: *Magnaporthe grisea* (Hebert) Barr.]. The average loss due to blast has been reported to be around 28 to 36 per cent (Pordel, 2018) and in certain areas, yield losses could be as high as 80 to 90 per cent. The disease affects finger millet at all growth stages but neck and finger blast are the most destructive forms capable of causing up to 100% reduction of biomass and average yield per year (Takan *et al*., 2012; Lenne *et al*., 2007).

The blast disease in finger millet often resulting in more than 50% yield losses (Shaikh, 2017 and Esele, 2002) and it is as high as about 80-90% in endemic areas. In India, Ramappa *et al*. (2002) recorded upto70 % finger blast and 50 % neck blast during Shaikh, 2017 in Mandya and Mysore districts of Karnataka. Also affected significant yield loss in other states of India including Andhra Pradesh, Madhya Pradesh, Haryana and Maharashtra. Pordel *et al*. (2018) reported that the ultimate loss in yield is due to enhanced spikelet sterility and reduction in grain weight and number.

Fig 1: Symptoms of leaf blast.

Fig 2: Healthy finger millet panicle.

Symptoms of blast disease

Initial inoculum comes from weeds or collateral hosts; spread by air-borne conidia Blast symptoms can be observed on the seedling, leaf, leaf sheath, rachis, nodes, glumes, peduncle and finger, depending on the stage of the crop (Fig 1 and 2). Elliptical or diamond shaped lesions on leaves with grey centers, water-soaking and chlorotic halo surrounding the lesions are characteristic symptoms. It is characterized by typical spindle shaped spots on leaf lamina. Under highly congenial conditions such spots enlarge, coalesce and leaf blades especially from the tip towards base give a blasted appearance. Finger blast symptom starts at the tip and proceeds toward the base of the finger, which becomes brown. Neck infection is the most serious phase of the disease that causes major loss in grain number, grain weight and increase in spikelet sterility. The pathogen also attacks fingers. Pathogen Minimum temperature of 15-25°C and relative humidity of more than 85 % with intermittent rainfall are congenial climatic conditions for disease

Table 1: Major diseases of *Eluesine coracana.*

Disease	Pathogen
Blast (Leaf blast neckblast finger blast)	*Pyricularia grisea*
Cercospora leaf spot	*Cercospora eleusinis*
Seedling and leaf blight	*Helminthosporium nodulosum*
Rust	*Puccinia substriata*
Green Ear Disease/Downy Mildew/Crazy Top	*Sclerophthora macrospora*
Brown Spot (Seedling blight or leaf blight)	*Drechslera nodulosum*
Smut	*Melanopsichium eleusinis*
Foot rot	Sclerotium rolfsii
Bacterial leaf spot	*Xanthomonas eleusinae*
Bacterial leaf stripe	*Pseudomonas eleusinae*
Bacterial leaf streak	*Xanthomonas axonopodis*

development. Environmental factors including high temperature, high relative humidity and leaf wetness influence disease development (Ruiz, 2003, Sekar 2014 and 18).

Management strategies

Eco-friendly management strategies are important in achieving agriculture sustainability with high quality, disease free crops. Blast pathogen is the most damaging disease of finger millet, affecting the finger millet production and causing massive yield loss of up to 80% of finger millet yield per annum globally (Mgonja *et al*., 2013). In this review an attempt has been made to report the utilization of various bio-agents in controlling the blast pathogen and its adverse effects in finger millet.

Finger millet blast infection primarily comes from the seeds because the disease is externally seed borne. The most efficient, feasible, ecofriendly and cheapest way to control the plant diseases is the host plant resistance. Efforts are being made to develop finger millet resistance lines to understand inheritance of resistance to *Pyricularia grisea* (Patro *et al*., 2013; Patro and Madhuri, 2014).

Chemical methods

Since, the primary infection comes from seed-borne inoculum, treating seeds with various kinds of fungicides has been carried out by many research groups. Ramaswamy (2007) used Tricyclazole (8 g/kg seed) followed by sprays of two plant extracts of notchi and *Prosopohis* sp. have been found effective. During later stages of the crop two sprays of Ediphenphos or Kitazin or propiconazole (0.1%) or Carbendazim or tricyclazole (0.05%) (Palanna, 2021), first at the time of ear emergence and second after 10 days or an initial spray of 0.05% Carbendazim or tricyclazole followed by a spray of Mancozeb (0.2%) 10 days later are effective (Palanna, 2021). Two sprays of Saaf (0.2%) first at 50 per cent flowering and again 10 days later were also found effective in reducing the blast and increasing the yield (Ramappa *et al*., 2002).

Management through bio-agents

It involves the use of naturally occurring non-pathogenic microorganisms that are able to reduce the activity of plant pathogens and thereby suppress diseases. Hence, controlling this pathogen using bio-agents will help in enhancing the yield of the crop. Among different biological approaches, use of the microbial antagonists like yeasts, fungi and bacteria is promising and gaining popularity. In addition biological control using PGPR represent a potentially attractive, alternative disease management approach, which are known for growth promotion and disease protection against several plant pathogens.

Prajapati *et al.* (2020) studied the management of finger millet blast disease with fungicides and bioagents as seed treatment as well as foliar spray. Among all the tested fungicides and bioagents, seed treatment with carbendazim, 2 g/kg seed + 2 sprays of tricyclazole, seed treatment with carbendazim, 2 g/kg seed + 2 sprays of tebuconazole and seed treatment with *Pseudomonas fluorescens,* 10 g/kg seed + 2 sprays of *P. fluorescens* significantly control the blast disease of finger mill*et al*so promoted grain and fodder yield. These findings are in support of Madhukeshwara *et al*. (2005) who found that seed treatment with carbendazim @ 2 g/kg seed and tricyclazole @ 2 g/kg seed gave lowest leaf blast, neck blast and finger blast incidence and enhanced the yield of finger millet.

A study carried out by Patil and Kumudini (2019) evidenced the induction of resistance in finger millet plants by seed priming against blast pathogen *M. grisea*, which has become the most effective approaches in induction of resistance. The greenhouse studies revealed that seed priming with plant growth promoting bacteria (PGPR) fluorescent *Pseudomonas* isolates JUPC113 and JUPW121 from cotton and wheat rhizosphere enhanced the rate of disease protection by fungal inhibition compared to that of control plants.

Netam *et al*. (2016) conducted a field experiment to evaluate the efficacy of bioagents spray combination to control blast disease in finger millet caused by *Pyricularia grisea*. In addition to significant increase in grain yield, lowest neck blast incidence, leaf blast severity and finger blast incidence was effectively controlled by three sprays of *Pseudomonas fluorescens*, followed by two sprays of *P. fluorescens*.

Negi *et al*. (2017) identified competent rhizobacteria having promising biocontrol activity against *M. grisea* infecting ragi. Among 70 rhizospheric pseudomonads isolated from various annual plants, of which 10 isolates showed maximum inhibition of two test isolates of *M. grisea. Pseudomonas fluorescens* isolate Pf-30 exhibited maximum inhibition (81.25 and 88.43%) against the test pathogen, followed by Pf-53. Of all, 19 isolates were prominent in chitinase production with Pf-30 showing maximum efficiency (218.18%) for enzyme production. Implant evaluation in polyhouse revealed that different pseudomonads could suppress the disease significantly when given as seed treatment and foliar spray. Maximum disease suppression was exhibited by Pf-47 and Pf-53 (82.77 and 82.06%, respectively).

In vitro evaluation of the effectiveness of biological agents and fungicides against the mycelial growth of *P.grisea* isolates was studied by Gashaw *et al*. (2014). They collected a total of 42 isolates of *P.grisea* were collected and isolated from infected finger millet plants and wild relatives from five agro-ecological zones of Ethiopia. The highest percent of mycelial growth inhibition of *P. grisea* isolates was observed by *T. harzianum*, *T. viride* and *P. fluorescens* respectively. Sancozeb was the most effective fungicide than ridomil, bayleton and curate in significant inhibition of *P. Grisea* mycelial growth.

Sekar *et al*. (2014) demonstrated the potential of the indigenous rhizospheric *Pseudomonas* sp. strain MSSRFD41 to control blast disease and promote the growth of finger millet. In dual plate culture assays, strain MSSRFD41 significantly suppressed mycelial growth of *P. grisea* consistent with antifungal action through the production of secondary metabolites, antibiotics, volatiles and hydrolytic enzymes. Further research Sekar *et al*. (2018) suggested MSSRFD41 exhibited multiple beneficial traits to the host plants and results of compatibility and survival assessment revealed that MSSRFD41 could be a substitute and sustainable resource to reduce the usage of chemical fungicides for control of blast disease on finger millet.

Kumar and Kumar (2011) reported that seed treatment with Pseudomonas fluorescens @ 0.6% along with two sprays @ 0.6% were significantly most effective in reducing blast disease of finger millet. They carried out seed treatment with *Pseudomonas fluorescens* Pf 2 (@ 0.6%)+ its two foliar sprays (@ 0.6%) followed by two sprays of hinosan @ 0.1% were significantly most effective in reducing blast disease. Similar finding was reported by Patro, *et al*. (2008). Several other workers *i.e*. Krishnamurthy and Gnanamanickam (1998); Vidhyasekaran *et al*. (1997) and Ramappa *et al*. (2002) were also reported the effectives of *P. fluorescens* applied as foliar spray.

Seed treatment with *P. fluorescens* @ 0.6% followed by two sprays of same, first at 50% flowering followed by second spray 10 days later was found to be the best for the management of blast disease (Patro *et al*., 2008 and13). Under *in vitro* conditions a synthetic product of garlic oil and neem oil called allitin (0.1%), were also found effective against blast pathogen, *P. grisea*. Similar results were reported by Mannuramath (2015) on which *Pseudomonas fluorescens* was shown to effectively inhibit *Rhizoctonia solani* and *Pyricularia oryzae* by agar plate method. These might be due to producing secondary metabolites, which inhibited the mycelial growth of *P. grisea* isolates.

Two sprays of *P. fluorescens* against *Pyricularia grisea;* first spray at 50% flowering followed by second spray 10 days later are recommended for the control of neck and finger blasts (Ramappa *et al*., 2002). Palanna, 2021 reported the effectiveness of six strains of *Pseudomonas fluorescens* for their ability to inhibit the blast fungus. The application of bioagents in reducing the blast disease of finger was also reported by (Senthil *et al*., 2012).

CONCLUSION

Even though promising results have been reported with the utilization of chemicals over broad spectrum of phytopathogens, however their adverse effect with ecological disturbances, environmental and groundwater pollution and trace amount reach to human beings back through contaminated agricultural produce also many health issues in humans and other animals lead to the development of eco-friendly management.

Bio-agents, an alternative to synthetic chemical pesticides, offer multiple beneficial traits; they can ensure the production of quality grains, protect plants against biotic and abiotic stresses; enhance soil fertility and are sustainable and environmental safe. The development and application of indigenous bio-inoculants products has gained momentum among researchers, because they can play a vital role in plant growth promotion and crop protection in sustainable farming systems and also for their economic value. In many agricultural crops including wheat, rice, millet and barley the application of bio-agents reported to enhance the productivity in addition to blast diseases management (Kumar and Kumar, 2011; Prajapati *et al*., 2013; Cruz and Valent, 2017). Many bio-agents have shown promising biocontrol and plant growth promotion under in vitro conditions, but exhibit variable performance in greenhouse and field trials. Hence, identifying suitable crop specific bio-agents is critical for growth promotion and disease suppression under variable ecological conditions.

Induction of disease resistance in finger millet plants via seed priming or foliar spray with bio-agents is the present day focus due to its beneficial, sustainable and eco-friendly approach. Other solutions include the elimination of the pathogen's inoculum and development by good cultural practice; intercropping and rotation; the development of resistant varieties, understanding and combating virulence mechanisms of the pathogen, post-harvest protection and improving plant performance through biotechnological approaches.

Conflict of interest: None.

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