Biology of rice bacterial brown stripe pathogen and integrated strategies for its management

ABSTRACT

Rice (*Oryza sativa* L.) is most commonly cultivated food grain crop in India as well as over the world. Rice is susceptible to many destructive diseases, among them bacterial diseases reported to major constrain in their production which causes significant yield loss. Major bacterial diseases affecting their *viz.*, Bacterial leaf blight (BLB) (*Xanthomonsoryzae*pv. *oryzae*), bacterial leaf streak (BLS) (*Xanthomonasoryaze*pv. *oryzacol*a) and bacterial panicle blight (BPB) (*Burkholderiaglumae*) and Bacterial Brown stripe (BBS) (*Pseudomonas avenae*) are of regular occurrence. On the basis ofdiseases severity and economic losses BPB, BLB and BLS are most destructive respectively reported by many researchers.Management of such disease is a challenge without harming environment and human health. Chemicals having adverse effect on natural ecosystem and not economically feasible. In this review management of suchdiseases by eco-friendly approach is discussed. Adopting such practices is helpful in maintaining cost benefit ratio byresulting in profit. These practices can reduce the harmful residual effect of the chemical. It also suggests at aboutadopting effective cultural and physical method.

Keywords:*Oryza Sativa*,*XanthomonasOryzae*, *Burkholderiaglumae,* and Eco-friendly Practices

1.1 INTRODUCTION:

According to archaeological evidences and by the numerous references made to rice in ancient Hindu scriptures and literature rice is supposed to be cultivated since ancient times in India. Carbonised paddy grains were found in the excavation at Hasthinapur (Uttar Pradesh) at a site dated between 1000-750 B.C. This is the oldest rice specimen yet known in the world. As per the De candolle (1886) and Watt (1892) rice was originated in South India. Later, Vavilov in 1926 suggested that India and Burmaorigin place of cultivated rice.

Rice is one of the major important cereal crops and of great significance in India and world. It is cultivated over an area of about 155 million hectares with a production of about 596 million tonnes (paddy). Worldwide in terms of area and production it ranks second to wheat but in India it stand first in position in terms of both area and production. It provides about 22 per cent of the world's supply of calories and 17% of the proteins. Maximum area under rice cultivation is in Asia. Among all the rice growing countries, India stands first in terms of area (44.8 million hectares) followed by China and Indonesia. In respect of production, India ranks second with 117.47 million metric tonnes of paddy next to China (148.5 million metric tonnes of paddy). Egypt ranks first in terms of productivity. Average yield per hectare of Egypt is followed by USA. Average rice yield of India is only 2929 kg per hectare.It is primary staple food for huge population in Asia, Africa and Latin America. Consumption of rice accounts for over 90% of the world's population in Asia, with China, India and Indonesia producing 30.85%, 20.12% and 8.21%, respectively of total global rice production (USDA, 2012; Kadu, *et al.,* 2015). In India rice covers about 23.3% of gross cropped area of the country and plays a vital role in the national food grain supply. It puts up 43% out of total food grain production and for total cereal production 46% of nation. The success of the Green Revolution was attributed due to the use of high-yielding varieties, adequate irrigation facilities, fertilizers availability, and other complementary inputs.

Over the last three decades, rice production in Asia has increased at very pace rate 2.5% peryear than any other crop and has kept pace with population growth since the 1960s. The most important outcome of this is that it secures an adequate supply of the food grain, which decreases the prevent index. However, in recent years, population growth has outpaced rice production due to exponential rise in population and several constraint *i.e* pest and disease problem in rice cultivation (Hossain, 1999). Disease have always proved a significant impact on rice supply. Historically, severe epidemics led to serious food shortages in different region of our country such as Bihar and West Bengal. The Bengal famine in 1942was, in part, attributed to brown spot disease caused by *Helminthosporiumoryzae*(Padmanabhan, 1973).

Rice blast epidemics was responsible for major food crisis in Korea in the 1970s (Ou, 1985). Estimates indicated yield losses ranging from 10 to 50%. Considering the large rice production area in the world, even a conservative estimate of 1 to 5% annual loss would translate into thousands of tons of rice and billions of dollars lost. Thus, minimizing the occurrence of disease epidemics are central way to sustain rice productivity and reducing year-to-year losses. To achieve this goal, it is important for us to know the extent of damage caused by diseases. Two technological changes associated with the Green Revolution have important impact on diseases. Firstly, the development of shorter duration and agronomically well-adapted varieties allowed intensification of rice crop in time and space. Although these are necessary component to achieve greater rice productivity, intensification also increases the vulnerability of the rice crop to pests and diseases by continuously exposing them. Secondly, the use of genetically uniform varieties reduces buffering capacity in the cropping system and leads easy adaptation of pathogen towards the crop. For decades, disease and pest management have completely relied on use of new resistant varieties and on application of synthetic chemical pesticides. This often results into familiar “boom and bust” cycles where a few disease-resistant varieties were available for cultivation.

Ou (1985) reported 56 different disease caused by fungi, among them 41 were of seed borne (Richardson, 1979, 1981). The global losses due to seed-borne diseases are estimated to be 12% - 15% of potential production (Agarwal and Sinclair, 1987). When seeds are sown in the field without treating with biological antagonist or fungicide then seed-borne pathogen reduce the crop yield up to 15-90% (Zafar, *et al.*, 2014). It is prone to many diseases, among them bacterial diseases are most destructive which cause significant yield loss. Prominent bacterial diseases such as Bacterial blight of rice (*Xanthomonsoryzae*pv. *oryzae*), bacterial leaf streak (*Xanthomonasoryaze*pv. *oryzacola*) and bacterial panicle blight (*Burkholderia glume*) Bacterial Brown stripe (BBS) (*Pseudomonas avenae*)all produces seedborne inoculum due to which they became important seedling diseases. Seed treatment by chemicals are already practiced in most of East Asian country. Bacterial Brown Stripe also in known as bacterial stripe reported to cause problem in upland, wetland and nursery in boxes as well. Although it is widely distributed in the rice growing countries (Shakya*et al,* 1985).

1.2 LIST OF BACTERIAL DISEASE HAMPERING THE RICE PRODUCTION

Sr. No.	Common Name	Causal organism
1.	Bacterial leaf blight	*Xanthomonsoryzae*
2.	Bacterial leaf streak	*Xanthomonasoryaze*pv. *oryzacola*
3.	Sheath brown rot	*Pseudomonas fuscovaginae*.
4.	Grain rot / Panicle Blight	*Burkholderiaglumae*
5.	Bacterial Brown stripe	*Pseudomonas avenae*

One of the main hindrance in the production of rice is the frequent attack by bacteria. There are three main important disease of bacteria which causes considerable economic loss in rice production are bacterial leaf blight (BLB), bacterial leaf streak (BLS) and bacterial brown stripe (BBS), which are caused by *Xanthomonasoryzae*pv. *oryzae* (Xoo), *Xanthomonasoryaze*pv. *oryzacola* and *Acidovoraxoryzae* (Ao), respectively. The current control of rice bacterial leaf blight and bacterial brown stripe is mainly dependent on the use of bactericide. Present day our environment is continuously depleting due to indiscriminate use of chemical fungicide, insecticide, bactericide and herbicide. So, we should paid more and more attention towards environment's health to sustain our live. For this, there is a need of sustainable approach to manage the disease instead of indiscriminate use of chemical pesticide.

1.3HISTORY OF PATHOGEN:

Bacterial Brown Stripe of Rice (BBSR), known to be caused by *cidovoraxavenae*subsp.*avenae*, was first time reported on rice in Japan (Goto and Ohata 1961). Later, It has been subsequently reported from many countries including continent such as Asia, Africa, the Americas and Europe (Xie et al. 1998). In China, the causal agent of this disease was often reported as *Pseudomonas syringae*pv. *panici* or *Pseudomonas panici*. Disease inciting pathogen belong to domain Bacteria, phylum proteobacteria, class betaproteobacteria, order Burkholderiales and family comamonadaceae. However, neither epithet has been validly published (Duan et al. 1986). Initially, the disease was of minor importance and occasionally occurredat small scale in rice production area particularly near Yangtze River basin andsouthern China in the past three decades. Recently it's presence also seen in northerncolder region of rice growing area.

1.4GEOGRAPHICAL DISTRIBUTION AND ECONOMIC LOSS HISTORY:

Bacterial Brown stripe occurs in areas with high temperature and high humidity. Infected leaves, water that harbour bacteria our left over plant part or debris of*Acidovoraxavenae*subsp.*avenae*serve source of disease in healthy crop in the water, orin the debris left after harvest. It occurs mainly in Asia, Africa, South America, and Australia, Bangladesh, Cambodia, China, Comoro Islands, Egypt, Ethiopia, Ivory Coast, Kenya, Madagascar, Malawi and Mauritiuswhere tropical and subtropical conditions are prevalent.

The progress of disease development was 20% to 25% in common paddy fields. But the possibility of mortality rateof seedling could reach above 60%. Recently in a decade (2010-

2020), two times serious outbreak occurred in china, fist in 2010 and later in 2018. The outbreak of disease are reported in area including Sichuan, Hunan, Hubei,Anhui and Chongqing provinces (municipality) in upper reaches ofYangtze River, Liaoning and Jilin provinces in northeast. More than 1million hectare area of rice field were seriously infected/damaged by BBSR. Outbreak of this disease was observed on the varieties such as YLiangyou 957 (hybrid rice) and Yanjing 47 (japonica) in China.

1.5 HOST PLANT

Plant on which pathogen/ microorganism live, survive, get nutrition and multiply to increase their population in nature is known as host plant. This bacteria mainly survive and multiply on member of poaceae family. eg- Rice (*Oryzasativa*), Maize (*Zea mays*), Sugarcane (*Saccharumofficinarum*), Teosinte (*Euchlaena Mexicana*) and other member of poaceae family.

1.6SIGNS AND SYMPTOMS:

Bacterial brown stripe of rice, caused by *Pseudomonas avenae*Manns is a disease that affects mainly at seedlings stage of rice. The symptoms at seedling stage of rice can be divided into four different stages namely- **i)** inhibition of germination **ii)**curving of a leaf sheath **iii)**abnormal elongation of a mesocotyland **iv)**brown stripes on a leaf either along mid ribs of leaves or along leaf margins.Bacterial brown stripe of rice, caused by *Pseudomonas avenae*Manns is a disease that affects mainly at seedlings stage of rice. The symptoms at seedling stage of rice can be divided into four different stages namely- **i)** inhibition of germination **ii)** curving of a leaf sheath **iii)** abnormal elongation of a mesocotyl and **iv)** brown stripes on a leaf either along mid ribs of leaves or along leaf margins. At seedling stage first inhibition of germinationcould be seen when the seed starts to germinate. When the coleoptile length is approximately 1 cm long it turned to pale yellow-brownish colour accompanied by a water-soaked lesion and stopped growing further. Subsequently, these seeds died without germination. Later, on Curving of a leaf sheath can be observed in case of infected seedlings, though not dead at the germination stage due to unfavourable climatic condition for pathogen either provided by host or slight disturbance in micro and macro environment grew less in size than healthy ones. One side of the leaf sheath may grew better than the other, resulting in curving of leaf sheath. The degree of curving of leaf sheath varied among the seedlings of different varieties. Remarkable reduction in growth of seminal root could be observed in case of curved seedling.Abnormal elongation of mesocotyl can be observed along with crown root grew at the node of coleoptile. The majority of the seedlings showing these symptoms died before the 3rd or 4th leaf stage. Brown stripe occurred on the coleoptile at first in the form of water-soaked dark-brown regions with a less than I mm width each. The regions extended to sheaths and blades of the 1st and 2nd leaves. The symptom might be emerged on the curved and seedlings of elongated mesocotyl at the same time. Most of the seedlings with this symptom died until the 2nd or 3rd leaf stage. When symptom appeared at/ after the 4th leaf stage, it appeared only on the lower leaves and had little impact on the growth of the seedlings.In the mid stage of crop growthThe symptoms started as brown stripes from the bottom of stems 5 days after emergence and frequently extended into the sheaths, then spreading along the leaf midrib and throughout the entire seedling at the one-leaf stage.When the infected seedlings is used for transplanting to the paddy fields, the symptoms are generally masked. Consequently, natural occurrence of the disease could be unnoticeable by farmer at this stage. However, it can be confirmed by needle prick inoculation on the leaf sheath. When leaf sheath are inoculated with needle prick the brown stripe appeared around the inoculated spots at tillering stage. (Kadota and Ohuchi, 1983).In light of the perception of the covered manifestations at the tillering stage as referenced above, it can be assumed that the manifestations of the illness may happen just at the seedling phase of rice plants. Symptom may develops at the panicle initiation stage when the paddy fields are flooded. Heavy rainfall at panicle formation stage leads to Twisting of the panicles. It included: 1) anomalous stretching of the first and second internodes; 2) bending of rachis; 3) decrease of rachis-branch and turning earthy coloured tone; 4) strange elongation of palea and lemma to the long pivot.At Heading stage a dark green water-soaked lesion appeared slightly on the palea and lemma only. When these seeds were planted in nursery boxes, brown stripes came out on the seedlings, and the rate of the infected seedlings is upto 80%.

1.7PATHOGEN BIOLOGY

Bacterial brown stripe is caused by both *Pseudomonas avenae*and *P. syringae*pv. *panici*.*P. avenae*is a Gram-negative, non-spore forming, non-encapsulated rod. 0.92-2.4x0.5-0.7 um, with one or two flagella. *P. syrinage*pv. *panici*, is also a Gram-negative, spore forming, non-encapsulated rod (Shakya*et al*.1985).

1.8DISEASE CYCLE AND EPIDEMOLOGY

*P.avenae*is seedborne, and *P. syrinage*pv. *panici*is likely seed borne. Natural infection of*Panicummiliaceum*, *Hordeumvulgare*and *Setariaitalica*by *P. syringae*pv. *panici*has been reported.

The disease cycle begins when seedborne inoculum are sown in the nursery and it transplanted in main field.Bacterialcells in infested crop debris starts to colonize the cotyledons upon germination. The bacterium infects the hosts through natural openings and wounds, multiplying in and on leaves. It is believed that windblown soil containing infested crop debris is an effective means of spreading the bacterium inoculum. The pathogen can be disseminated from one field to another field by irrigation water, splashing rain, workers, contaminated equipment, and by wind as aerosols. *P.avenae*is seedborne, and *P. syrinage*is likely to surviveon the other member of poaceae family viz., pearl millet, sugarcane, proso millet, maize etc.

1.9 INTEGRATED APPROACH OF DISEASE MANAGEMENT

IDM programme implies all the available disease management approaches including cultural, biological and chemical control with the main objective to keep the disease incidence below economic threshold level and environment safe. These may include i) **cultural practices,**It is an important practices that helps in prevention and management of plant disease. Cultural practices favour the plant growth over the harmful pathogen.Field sanitation by burning of infected crop residue. It is used to eradicate, eliminate the pathogen and make the transplant free from pathogen.Avoid soil movement from one field to another field by decontaminating the implement used on farm.Crop rotation should be adopted for 2-4 year so that life cycle of pathogen may be interrupted. Collection and destruction of infected plant debris.Destruction of alternate as well as collateral host. Avoid intercultural operation in early stage of the crop as pathogen can directly enter the host through wound. Proper use of organic amendments such as FYM and Vermicompost.Soil solarisation and mulching with polyethylene may be effective in the management of this disease.Use of wider spacing (30x15 cm).Avoid clipping of tip of seedling at the time of transplanting.Proper irrigation and drainage.Use of Healthy and resistance variety for sowing as it is the safest and most economical for production eg- IR-20, IRBB21, IR-36, Sasyasree, Govind, Pant Dhan-4,Pant Dhan-6, Saket-4,RajendraDhan 200, Pusa-2-21, Ratna CR-10, IR64, IR72, Minghui 63 BG 90-2. **ii) Mechanical control**involvesDeep and summer ploughing of the field so that bacteria surviving at depth of soil can be overturned and exposed to intense sun light by which pathogen may kill due to desiccation.Then, physical control also reported to be involvedry heat treatment at 65OC for 6 days can eliminate the pathogen from seeds (Zeigler and Alvarez, 1988).Primary inoculum, in seed eradicate by hot water treatment at 57ºC for 10 minutes (Tagami and Mizukami, 1962). Solar heat treatment should also be performed by soaking the seed for overnight and then dry the seed at pukka floor at high light intensity *i.e* at 12:00 noon.In recent trends due to rise in temperature day by day and environment hazard biological controlare in great demand and it is nothing but ecological management of community of organisms. It involves harnessing disease suppressive microorganism to improve plant health. Disease suppression by use of biological agent is the sustained manifestation of interaction among the plant (host), the pathogen, the biocontrol agent (antagonist), the microbial community on and around the plant and the physical environment.**Bio-rationals :-**Bio-rationals word is made of two words-i) biological ii) rational. Bio-rationals can be defined as compound originated from the plants, animals and other microbes that have limited or no adverse effects on the environment or beneficial orgsanism. Commerciallyavailable biocontrol agents are **Fungi:** *Trichodermaharzianum* and *Gliocladiumvirens*, **Actinomycetes:***Streptomyces griseoviridis*, **Bacteria:** *Bacillus subtilis*. **Bacteriophages (phages)**against bacterial spot on tomato. Phages are viruses that exclusively infect bacteria. Spray fresh cow dung extract 20% twice (starting from initial appearance of the disease and another at fortnightly interval). Spray application of Neem oil 60 EC @3% or NSKE @5% for disease control.Application of *P. fluorescens* includes wet seed treatment (ST) @ 10g per kg of seed; Soil application (SA) @ 2.5 kg/ha basal along with 50 kg of well decomposed FYM and Foliar spray @ 0.2 per cent on 60 and 75 DAS (Jeyalakshmi 2010). For quick action we all and farmer have to be mainly rely on chemical control.In plant major disease are known to be caused by fungi>bacteria> virus. So, fungicide and bactericide are the important component in plant disease management.Chemical pesticide show quick action in plant disease management *i.e*, it show immediate action.Fungicide show four different physical mode of action: i) protective, ii) after infection, iii) pre-symptom, and iv) antisporulant (post-symptom)The word “fungicide” is derived from two latin words, *viz*., “fungus” and “caedo”. Fungus- means fungi and caedo- means to kill. Thus, the fungicide is any agency/chemical which has the ability to kill the fungus.**Antisporulant**Chemicals may inhibit the spore production without affecting the growth of vegetative hyphae and are called as “Antisporulant”.**Fumigants**A fumigant can be defined as a chemical substances that act as a lethal gas at ambient temperatures and pressures. In gaseous form it diffuses through air and penetrate the soil and most products of the farm and forest. This penetration interferes with the metabolic activity of organisms, producing a lethal effect on most living organisms,in plant disease management fumigants are generally used to manage soilborne pathogens. In nursery boxes, spraying of Kasugamycin can control the pathogen.Seed soaking overnight in 100ppm streptocycline solution (Devadath and Padmanabhan, 1970). Seed soaking in 0.025% streptocycline and hot water treatment at 52 °C for 30 minutes are effective in eradicating theseed infection.Using of Streptocycline @ 100 µga.i./*l*,or Agrimycin-100 @ 100 µga.i./*l* (Banerjee *et.al.,* 1984), Oxolinic acid @ 300 µga.i./*l* or streptomycin sulfate @ 100 µga.i./*l*, glycocide B @ 700 µga.i./*l*, kasugamycin @ 80 µga.i./*l* (Shtienberg*et al.*, 2001) recommended 3 spray at intervals of 10 days starting from the earliest appearance of the disease (Banerjee *et al*., 1984). Application of *Streptomyces toxytricini, Bacillus subtilis*var. *amyloliquefaciens, Pseudomonas floroscence*and *Lysobacterantibioticus*includes wet seed treatment (ST) @ 10g per kg of seed (Velusamy*et al.,* 2006, Ji*et al.,* 2008, Nagendran*et al.,* 2013, Hop *et al.,* 2014, Sharma *et al.,* 2015).Viral disease can be only manage by controlling its insect vector. So, application of insecticide is the only way to manage viral disease among chemical control.

1.10CONCLUSION

The major challenge in production /cultivation of crop is biotic and abiotic constraints. Abiotic constraints are the constraints arises due to non-living component of the environment. However, biotic constraints are due to living component of the nature. Among biotic constraints pest and disease produces major challenge. In plant major losses are due to disease caused by Bacteria and fungi. Rice occupied maximum area under any crop and it also contribute maximum food grain production. In spite of leading in production, rice crop faces a lot of disease and pest problem which retard their productivity. Among all the disease now a days bacterial brown stripe (BBS) are emerging as a major disease of rice which are previously of minor importance. Bacterial brown stripe of rice first time reported from Japan in 1961. *Acidovoraxavenae*subsp.*avenae* is reported as a causal organism. But later, *Pseudomonas syringae*pv. *panici* or *Pseudomonas panici* reported as a causal organism from China. Later *Acidovoraxavenae* or *Pseudomonas avenae* was believed to be causal agent of this disease. To overcome these challenge against pathogen farmers and growers started indiscriminate use of chemical pesticide as well as fertilizers due to which our environment gets deteriorated and health of human and animal came in danger. Due to indiscriminate use of pesticide and fertilizer, Resistance against such chemical pesticide has been reported. To conserve our natural ecosystem use of bio-agent become necessary. But, bio-agent show slow and steady action and farmer need immediate action, complete dependence on biological control is also not practically possible. So by integrating all available possible combination disease management strategies should be applied. Integrated approach of disease management are ecofriendly in nature and low cost input. As an ecological point of integrated approach of disease management bring harmony between natural and artificial ecosystem. If it is adopted for long term then chance of development of Biotype depletion of diversity becomes very less. Integrated approach of disease management should be adopted right from plaughing to marketing.

Bacterial diseases of rice continue to intrigue the plant pathologists in its management as chemical control is really hard to devise. Specific bactericides are gradually coming to the fore but it has to be coupled with cultural, breeding and biotechnological techniques so as to usher in a polyphasic approach of the disease management.

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