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Review on - Chili and Its Endophytes and Secondary Metabolites

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Abstract

Chili (*Capsicum annuum* L.) is common vegetable crop in India, which is grown for both unripe (green) & ripe (red) fruit. Damping-off, wilt, anthracnose, dieback, root rot, bacterial wilt & other diseases all damage chili crop. Damping-off caused by Pythium aphanidermatum (Edson) Fitz. In nurseries, is major restriction in chili growing, causing 62 percent seedling mortality & 90 percent plant death either as pre-emergence damping off or post-emergence damping off in nursery fields, & is very common issue in fields & greenhouses, where organism kills newly emerging seeps. Chili (Capsicum annuum L.) is common vegetable crop in India, which is grown for both unripe (green) & ripe (red) fruit. Damping-off, wilt, anthracnose, dieback, root rot, bacterial wilt & other diseases all damage chili crop. Damping-off caused by Pythium aphanidermatum (Edson) Fitz. In nurseries, is major restriction in chili growing, causing 62 percent seedling mortality & 90 percent plant death either as pre-emergence damping off or post-emergence damping off in nursery fields, & is very common issue in fields & greenhouses, where organism kills newly emerging seeps. In mutualistic symbiosis arrangement, endophytes are plant-colonizing microorganisms. They are present in most habitats, where they promote immune responses, exclude plant pathogens by niche rivalry, & engage in antioxidant activities & phenylpropanoid metabolism, which generates plant defense, structural support, & survival molecules.

Key words- Chili, Endophytes, Bioactive compound, Secondary metabolites, Endophytic enzyme, Disease managements.

INTRODUCTION

One of the most common spices that have been used from ancient era till today is Chili which is known for its taste, pungent nature. Beside its flavor adding ability it is also known to have therapeutic values. In spite of its value, this crop is affected by many factors such as physical, biological and also there is continuous loss due to plant pathogens attack. In order to cope up with the scarcity of the bioactive compounds' scientists have started to explore endophytes that are associated with the plant and has the ability to produce more or less similar compound or analogues compounds to that of the host plant. In this review an attempt has been made to provide the information of bioactive compounds, their structure along with therapeutic importance and has also included the reports of endophytes associated with chilli plant and has ability to possess therapeutic properties.

Chillies are enriched with minerals (potassium, manganese, iron and magnesium) that help control heart rate and blood pressure (Bhowmik *et al*. 2012). Besides their commercial and domestic value, Chili has a predominant role in medicine since ancient times. They are reported to prevent diabetes, spread of cancer, stomach ulcers, assists weight loss, anti – inflammatory, clear digestion, boosts immunity, anti – bacterial, and pain reliever (Roy *et al*. 2013).

Chili (*Capsicum* L.) is one of most common ingredients in tropical & subtropical cuisines, as well as world's fourth most grown flower. About 400 different types of chilies are grown all over world. Most common variety is "Carolina Reaper," produced by West Indian grower Ed Currie, with maximum pungency of about 2.2. Scoville Heat Units. Million SHU. One of world's hottest chili varieties is "Naga Jolokia," product of Tezpur in Assam, India. Many varieties of chili are cultivated for tomatoes, herbs, condiments, sauces, & pickles & they play important role in Indian cuisine. Apart from its apparent significance in diet, chili is also used in other ways such as medications & drinks, as well as ornamental plant in gardens. In terms of diet, these are high in vitamin & C; high in iron potassium &

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magnesium material with potential to strengthen immune system. India has been leading producer & buyer, according to Mohd Anuar *et al*. 2004 & exporter of chilies, especially in dried form. Cropare is found in India, & its quality varies by state of country. In terms of total area under chili production, India is also leader. Chili fruit is used in sauces & as powder for hot spices raw, fried, pickled, & dried. Chili has many medicinal properties, according to Nadkarni (1927). Its paste is applied to tonsils as rubefacient & local stimulant in case of tonsillitis. Internally, it irritates stomach & causes gastroenteritis. It's mixed with number of other products to produce local remedies (Bull and Stach 2007). Chili crops are vulnerable to number of biotic & abiotic pathogens, resulting in severe losses for farmers. Damping off disease is one of them & it costs farmers lot of money. It is responsible for 90% of plant mortality in nurseries & fields, either as pre-emergence damping off or post-emergence damping off. These diseases of vegetables & field crops are widely regarded as major stumbling block to good crop plant production around world. Extra-nutritional constituents contained in small amounts in lipid-rich foods & plant products are known as "bioactive" or "biologically active" compounds. Plants & bacteria contain majority of these molecules, which have anti-cancer, cardiovascular, anti-lipidemic, antihypertensive, anti-glycemic, anti-tithrombotic, anti-atherogenic, & anti-diabetic properties. Bioactive agents are also often used as preferred synthetic drugs for variety of diseases since they have few side effects. Bioactive Compounds from Chilies such as homocapsaicin, nordihydrocapsaicin, and homodihydrocapsaicin have been found to be present in chilies (Shaha*et al*.2013 & Karnka*et al*. 2002). Among all these capsaicin compounds in chilies, almost 80-90% is composed of capsaicin (8-methyl-N-vanillyl-6-nonenamide). This compound has lots of biological potency and has been found to be of profound pharmaceutical importance (Shaha*et al*.2013). Certain compounds such as 2-isobutyl3-methoxypyrazine, 2, 3-butanedione, trans-2-hexenal, linalool, 3-carene, and hexanal are some of the principal compounds recognized to be components of fresh commercial chili (Capsicum annuum var annuum) at different stages of ripening. All those six compounds are volatile aromatic compounds. Presence of those compounds in chili was made and confirmed using analytical techniques such as high-performance liquid chromatography, gas chromatography retention time and mass spectrophotometry (Mazida*et al*. 2005). In development of bioactive substances, endophytic fungi, bacteria, & actinomycetes play important role. Endophytic microbes spend rest of their lives within plant tissues, causing little visible harm to host plant. Endophytes secrete variety of specialized metabolites & biologically active compounds (Cammack *et al*. 2006). Endophytic bacteria have ability to generate plant growth hormones, phosphate solubilization, nutrient acquisition, & N2 fixation, among other things. Gram-positive bacteria are important in activities such as bioremediation, biocontrol, plant development, symbiotic-mutualistic, commensality, trophobiotic interactions, control of soil-borne pathogens, & support of host plant defense against environmental stress. Plant-microbe & microbe-microbe interactions, as well as environmental factors, can all influence structure of endophytic population. Cultivation-based & culture-independent approaches are used to analyze bacterial endophytes diversity. In cultivation research, significant number of bacteria, mainly Proteobacteria has been classified as endophytes with Actinobacteria, Bacteroidetes & Firmicutes phyla being most common. Bacillus & Streptomyces species are most common metabolite-producing Gram-positive bacteria endophytes present in variety of ecosystems. Endophytes can be present in plants from all kinds of habitats are essential in agriculture because they aid in improvement of crops yields by promoting plant development & immune system function as result of niche competition. Plant diseases are pushed out as well as playing role in phenylpropanoid metabolism as well as antioxidant properties among plants most plants have microbiota or endophytic microbes. Roots, branches, stems, & number of other plant parts may all be used to classify species. Small number of flowers, vegetables & seeds, they have ability to manufacture wide range of secondary products metabolites for agricultural & medicinal applications & biotechnology for industry (Carvalho *et al*. 2016).

Use & Importance

Chili is used in variety of ways, beginning with fresh green fruits also along with dried powdered form. Salads, stuffing's & salsas are all popular uses for pungent fruits. Non-pungent varieties are used as flavoring agent in cooked meals. Cooked as vegetables or processed with additional food items quite pungent varieties are eaten. In small amounts, it's commonly thought of as condiment or spice. Hot peppers are also used for seasoning & stimulating appetite. Apart from its widespread application,

pickled in salt & vinegar is used in ketchup as flavoring agent. Chili varieties are also used in preparation of cooked food's coloring agents in pharmaceuticals, meat products, cosmetics, and uniformity in clothes. Capsicum has wide variety of medical & dietary properties. It's important to remember that fresh green chill fruits have higher vitamin C content than dried chill fruits, whereas dried chill fruits have higher vitamin content than carrots. Capsaicin, spice's active ingredient, is complex of capsaicinoid alkaloids present in varying concentrations in various chili varieties. It's abundant in placental tissues & cross walls of fruits. In rather pungent fruits, however, it is scattered across all of fruit's fleshy parts. Sum of capsaicin in chili variety is used to assess its pungency & is normally expressed in Scoville Heat Units. Capsaicin has antioxidant, antimutagenic, anti-carcinogenic, & immunosuppressive properties, preventing bacterial growth & platelet aggregation. It's also used as anti-inflammatory & anti-arthritic agent. Chili fruit intake is beneficial for haemorrhoids, varicose veins, anorexia, & liver congestion. Chilliextracts are used externally as rubefacient & analgesic in case of back pain, rheumatism, articular & muscle pains & swelling feet, as well as antidote in case of poisoning. Two non-food & non-pharmacological applications of capsaicin are in preparation of "pepper sprays" as self-defense weapons & in preparation of "pure & herbal pesticide" (Castillo *et al*. 2002).

Synthesis of Bioactive Compound by Endophytic Microbes

Endophytes produce bioactive compounds that aid host plant in developing systemic resistance to pathogens. These bioactive compounds are used in pharmaceutical industry as antibiotics, anti-cancer, anti-viral, anti-diabetic, & other bioactive compounds (Castillo *et al*. 2003).

Endophytic Fungi

Endophytic fungi are one of most important possible sources of useful bioactive compounds. Pestalotiopsis neglecta BAB-5510, endophytic fungus of Cupressus torulosa, is promising source of phenols, flavonoids, terpenoids, alkaloids, tannins, carbohydrates, & saponin, while Gilmaniella sp. AL12, another endophytic fungus, can induce Atractylodes lancea to develop volatile oils such as b-caryophyllene, Endophytic fungi are one of most important possible sources of useful bioactive compounds. Pestalotiopsis neglecta BAB-5510, endophytic fungus of Cupressus torulosa, is promising source of phenols, flavonoids, terpenoids, alkaloids, tannins, carbohydrates, & saponin, while Gilmaniella sp. AL12, another endophytic fungus, can induce Atractylodes lancea to develop volatile oils such as b-caryophyllene. Endophytic species have developed number of enzymes with possible medicinal applications. Europium sp., endophytic fungus isolated from Curcuma longa rhizomes, developed asparaginase, key anti-cancer enzyme. Anti-acetylcholinesterase activity was also observed in endophytic fungus Huperzia serrata strains L10Q37 & LQ2F02. Talaromyces pinophilus, endophytic fungus isolated from strawberry tree (Arbutus unedo), developed siderophores ferrirubin &herquline B, as well as antibiotic 3-O-methylfunicone. This strain was also shown to be poisonous to pea aphid Acyrthosiphon Pisum. Fusarium oxysporum 162, endophytic fungus, developed nematode antagonistic compounds such as 4-hydroxybenzoic acid, indole-3-acetic acid, &gibe pyrone D (Posada *et al*. 2018).

Endophytic Actinomycetes

Endophytic actinomycetes tend to be potential source of bioactive agents that can be used for crop defense& therapeutic drug growth. More than 140 actinomycetes genera have been identified to date, but only few of them are known to produce majority of important antibiotics. Actinomycetes contain variety of secondary metabolites, all of which have biological functions & may be used as therapeutic agents in future. Actinomycetes from sea are underutilized source of novel secondary metabolites. Streptomyces Roche CH1, endophytic actinomycete found in Cinnamomum sp., demonstrated antibacterial activity against aeromonas caviae, Vibrio parahaemolyticus, & Pseudomonas aeruginosa.

Streptomyces cyaneofuscatus (KY287599) had antimicrobial activity against Escherichia coli MTCC 739, Pseudomonas aeruginosa MTCC 2453, Micrococcus luteus NCIM 2170, Staphylococcus aureus MTCC, & Candida albicans MTCC 3017. Streptomyces KX852460 also had antifungal action against Rhizoctonia solani AG-3 KX852461, pathogen that causes tobacco leaf goal spot disease (Pratiwi *et al*. 2018).

Endophytic Bacteria

In response to biotic & abiotic stresses, majority of endophytic bacteria displayed beneficial effects such as increased biological N2-fixation, development of phytohormones, phosphate solubilization, & inhibition of ethylene (C2H2) biosynthesis, as well as bio-control operation. More than 300 endo-

phytic actinobacteria & bacteria were isolated from various tissues of Dracaena cochinchinensis Lour, including Streptomyces, Nocardiosis, Brevibacterium, Micro bacterium, Tsukamurella, Arthrobacter, Brachy bacterium, Nocardia, Rhodococcus, Kocuria, Nocardioides, &Pseudo nocardia. (Dragon's blood is traditional Chinese medicine). Antimicrobial & anthracycline-producing strains were shown to have antifungal & cytotoxic properties against two human cancer cell lines, MCF-7 & Hep G2 (Qin *et al*. 2011).

Bioactive Compound Synthesized by Endophytic Bacteria

Bacterial endophytes have number of possible uses in medicinal & drug development. Endophytes used in ethnomedicinal plants have been identified as possible source of natural products for use in oxidative stress & as new bioactive agents. Multidrug resistance (MDR) in pathogenic bacteria is combated by antimicrobial agents. Many agriculturally important microorganisms have developed resistance to widely used antimicrobial compounds, & interest in natural pathogen control from fresh, environmentally friendly agents is growing by day. Amines & amides are typical endophyte metabolites that are poisonous to insects but not mammals. To build resistance against plant invasions, endophytes generate extracellular hydrolyses such as cellulases, proteinases, lipases, &esterase's. Arthrobacter, Achromobacter, Bacillus, Enterobacter, Erwinia, Pseudomonas, Pantoea, Serratia, & Stenotrophomonas are among endophytic bacteria present in Hypericum perforatum & Ziziphora capitata. In contrast to Z. capitata, H. perforatum with antibacterial activity assisted colonization of more bacteria with antagonistic activity. These isolates were able to prevent F. oxysporum from causing tomato root rot (Raaijmakers *et al*. 2010).

Secondary Metabolites

While secondary metabolites are not required for organism's development, they play adaptive role by acting as defensive compound or signaling molecule during ecological interactions & environmental stresses. Antimicrobial agents, phytohormones or their precursors, vitamins like B12 & B1, & bioprotectants are among low-molecular-weight secondary metabolites produced by endophytic microorganisms. Alkaloids, hormones, terpenoids, peptides, polyketones, flavonoids, quinols, & phenols are examples of secondary metabolites. Anti-cancer, antioxidant, antimicrobial, anti-inflammatory, & immunosuppressive agents are just few of therapeutic uses for these substances (Rado *et al*. 2015).

Secondary Metabolits Synthesis

The development of secondary metabolites is regulated by certain endophytic bacteria. Only few primary metabolism precursors are used to make microbial secondary metabolites, & there are only few of them. Endophytes produce secondary metabolites in number of forms, including polyketide, isoprenoid, & amino acid synthesis, biosynthetic pathways; on other hand, are responsible for both primary & secondary metabolite production. Endophytes' high species diversity & tolerance to diverse habitats may be considered rich & virtually untapped source of potential secondary metabolites for pharmaceutical &agricultural applications. Nature has produced wide range of secondary metabolites with different structural characteristics. Ses metabolites function as biofilm, toxins, virulence factors, & hormone signalling disruptors in plants. Endophytic bacteria–plant interactions generate & modulate auxins & C2H2, which are essential for plant growth & drought stress management (Ramamoorthy *et al*. 2018).

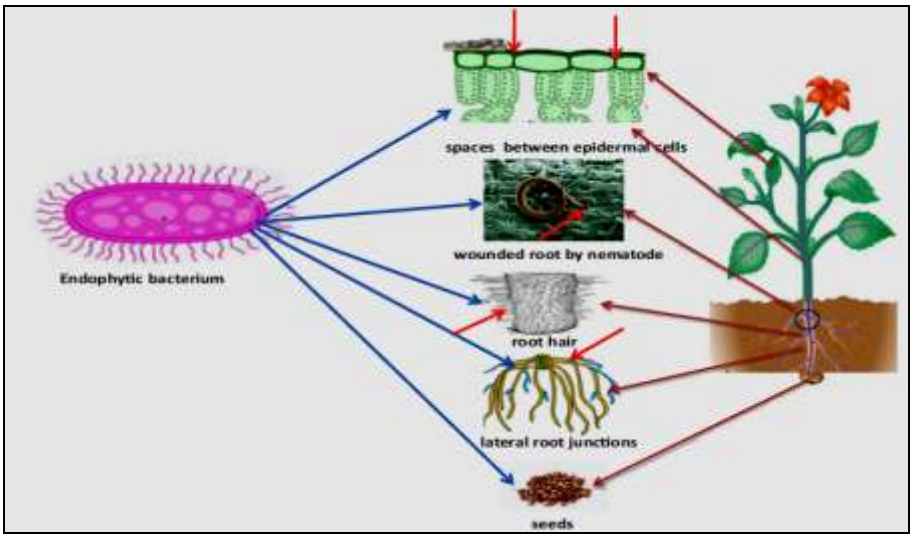

Fig. 1 Routes of entry of endophytic bacteria

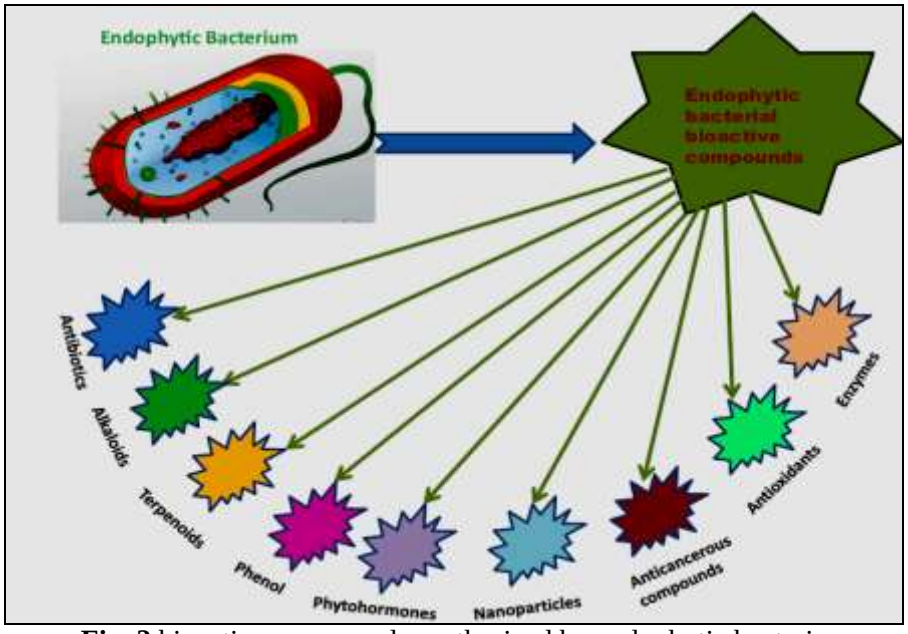

Fig. 2 bioactive compounds synthesized by endophytic bacteria

Gram-Positive Endophytes against Human/Animal Pathogens

Actinomycetes are Gram-positive filamentous bacteria with considerable ability as biocontrol agents, producing nearly two-thirds of natural antibiotics, with Streptomyces species accounting for 75%. Actinomycetes, which include genera Actinomyces, Actinoplanes, Amycolatopsis, Micromonospora, Saccharopolyspora, & Streptomyces, are noted for developing bioactive secondary metabolites that have antimicrobial, insecticidal, & antitumor properties. Lipopeptides, which are formed by cyclic or short linear peptides linked to lipid tails or lipophilic molecules, are one of most essential groups of secondary metabolites produced by endophytic bacteria. Lipopeptides have antimicrobial, cytotoxic, & surfactant properties; they are made up of hydrophobic fatty acid acyl chain of 13 to 17 carbons bound to hydrophilic peptide of 7–25 amino acids& are synthesized by non-ribosomal peptide synthetases (NRPS) or polyketide synthase (PKS). Lipopeptides are essential for inducing plant defense mechanisms as well as serving as antibiotics. Single bacterial strain can produce multiple polypeptides is forms. Lipopeptides from Bacillus & Paenibacillus have been studied most, although

some Bacillus amyloliquefaciens strains have been identified as higher lipopeptide producers. B. subtilis produces NRPS lantibiotics (lanthionine-containing antibiotics) in addition to lipopeptides; lipopeptides are responsible for biofilm & swarming growth, while lantibiotics serve as quorum-sensing pheromones. B. subtilis also produces polyketides, amino sugar, & phospholipids; polyketides include bacillomycin, fengycin, iturin, lichenysin, mycosubtilin, plipastatin, pumilacidin, &surfactin; & polymyxins are produced by Paenibacilluspolymyxa. Antimicrobial enzymes are generated by bacterial endophytes in addition to biologically active secondary metabolites, primarily by Bacilli class representatives. Gram-positive bacteria had higher hydrolytic activity than Gram-negative bacteria in sample searching for highly developing enzymes endophytes. B. infantis & B. grenadines displayed amylase, cellulase, & lipase activity in Rhizophoraceae hosts, while B. safensis showed amylase, cellulase, lipase, lipolytic, & proteinase activity in Rhizophoraceae hosts. Paenibacillus sp. & S. warneri all had cellulase, lipase, & proteinase activities in Acanthaceae family endophytes. Endophytes isolated from Brazilian mangrove plants displayed high enzymatic activity; Bacillus sp. (MCR2.56) was reported to have especially high amylase &esterasic activities; six Bacillus isolates had high endocellulolytic activity, while Microbacterium sp. (MCA2.54) &Curtobacterium sp. had high endoglucanase & protease activity, respectively. Streptomyces's with bioactive endophytic properties can be isolated from plants all over world. Medicinal plants have been used as alternative medicine for disease control for decades. Endophytic actinomycetes from Chinese medicinal plants have been shown to have antibacterial action against E. coli & S. aureus. Endophytic actinomycetes have been shown to have antibacterial action against Acinetobacter baumannii, Enterococcus faecalis, E. coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, & Staphylococcus aureus, some of which are immune to vancomycin, methicillin, & carbapenem antibiotics. Several metabolites from endophytic Streptomyces species, including kakadumycins, munumbicins, p-aminoacetophenonic acids, &xiamycins, have been identified & related to antibiotic activity, as well as antimalarial (coronamycin, munumbicin D) & antifungal activity. Endophytic B. subtilis from Malaysian plants had antibacterial activity against S. aureus, methicillin-resistant S. aureus, & P. aeruginosa. Antibacterial activity was found in African Combretum molle-endophytic Bacillus &Lysinibacillus species against B. cereus, E. coli, P. aeruginosa, & S. aureus. Munumbicins A, B, C, & D are developed by Kennedianigriscans-endophytic Streptomyces sp. strain NRRL 30562, & are successful against growth of B. anthracis, E. faecalis, vancomycin-resistant E. faecalis, MDR M. TB, S. pneumoniae, S. aureus, & methicillin-resistant. Streptomyces sp. strain SUK06, isolated from Malasian medicinal plant Thottea grandiflora, widely used as alternative way to cure wounds & treat skin infections & fever, develops secondary antimicrobial metabolites against B. cereus, B. subtilis, Plesiomonasshigelloides, & Plesiomonasaeruginii. Similarly, endophytic Bacillus sp., Micrococcus sp., &Plectranthustenuiflorus-endophytic Bacillus sp., Micrococcus sp., &Plectranthuspolymyxa metabolites & cell wall-degrading enzymes from Panax ginseng &Plectranthustenuiflorus-endophytic Bacillus sp., Micrococcus sp. soil actinomycete Saccharopolyspora spinosa produces secondary metabolites spinosyn & D, which are highly effective against lepidopteran & dipteran pests, among others, & whose commercial product, spinosad, has been commercialised for 250 countries & implemented in advanced pest control systems worldwide. Endophytic Saccharopolyspora species have also been recorded, but their potential as bioinsecticides has yet to be determined. Compounds formed by Azadirachta indica (also known as neem) have wide range of medical & agricultural applications. In fact, 80 percent of A. vera bacterial endophytes developed 1,1-diphenyl-2-picrylhydrazyl, demonstrating scavenging properties of over 75 percent. endophytic bacteria B. subtilis, Sphingobacteriumsiyangensis, & P. polymyxa found in leaves & roots of Raphanus sativus (young radish) have been shown to inhibit development of B. cereus, E. coli, P. aeruginosa, & S. aureus, as well as Salmonella, Shigella, & Listeria species. Endophytic Streptomyces sp. from Zingiber officinale roots are shown to have antimicrobial activity against B. cereus, B. subtilis, & S. aureus (Reinhold-Hurek & Hurek 2011).

Anthracnose Disease of Chili

Anthracnose disease has been reported to be major restriction in microbial development in tropical & subtropical countries, resulting in massive losses. India used to be world's largest producer & exporter of chili, but demand has fallen dramatically in recent years, & India now ranks third in terms of chili production. Approximate annual loss of around 29.5

percent, totaling US$491.67 million, has been recorded from India alone. Due to anthracnose disease, calculated loss of 10–54 percent in crop yield has been recorded in India. Large losses have been recorded from other parts of world as well, such as significant loss of 20–80 percent. The loss is large due to pathogen's post- & pre-harvest presence, which results in loss of 10–80 percent of marketable yield of chili fruits. Disease is said to affect nearly every aerial portion of farm. It mainly causes fruit in both green & red stages, primarily targeting ripe fruits, & is thus known as ripe fruit of chili. Disease is transmitted through soil, water, & air, & therefore can inflict harm during seedling stage or on aerial parts of plants. In various countries, several varieties of Colletotrichum have been linked to pepper-anthracnose, gives brief overview of various Colletotrichum species that have been linked to anthracnose of chilies in various parts of world. However, in India, disease has been related to three important species: C.capsici, C. acutatum, & C.gleosporoides, with C.capsiciSyd. Butler&Bisby causing significant damage at mature fruit stage of plant (Guetsky *et al*. 2002).

Disease Management

Today, no successful control mechanisms have been suggested for management of chili anthracnose, which has been raging problem for agriculturists & farmers. The decrease in chili demand & decline in fruit quality has heightened need for long-term strategy to monitor disease's spread. There is no one treatment strategy that has been discovered to effectively monitor disease. For controlling disease, it is commonly advised to use variety of various techniques such as chemical control, biological control, physical control, & intrinsic tolerance management methods for preventing transmission of Colletotrichum spp. & establishment of disease can be divided into four broad categories: Cultural practices, chemical control, immune varieties, & eventually biological control are all included.

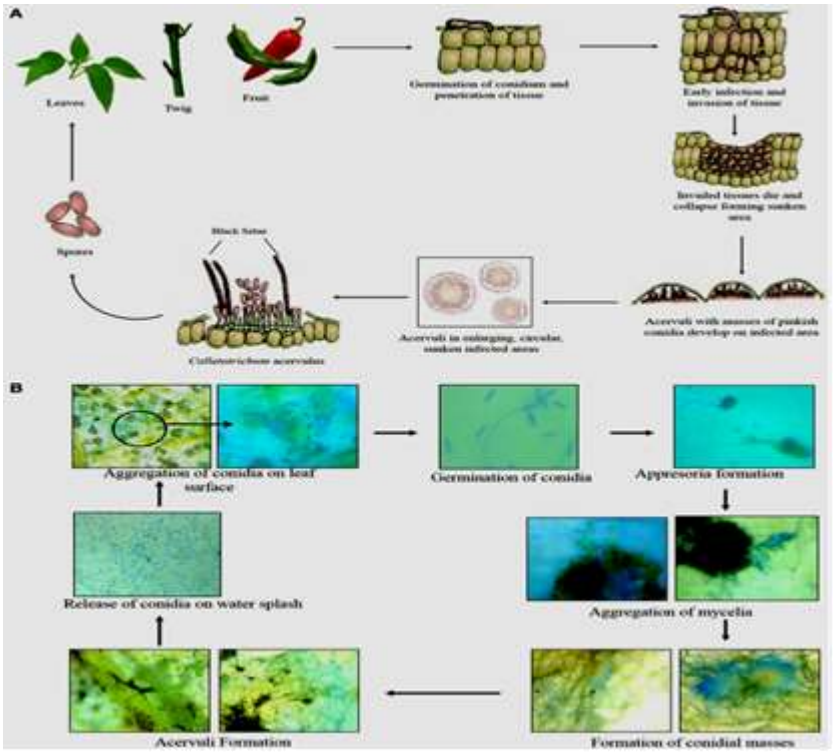

Fig. 3 Disease cycle of anthracnose disease of chili

Use of Culture Practices

Since pathogen is seedborne, windborne, & waterborne in addition to being soilborne, only way to monitor its spread is to focus on three primary areas of disease-free crop cultivation is proper irrigation, crop rotation & clearance of any weeds in field. In addition, relative humidity helps effective colonization. Pathogen path as consequence, field should be properly drained & irrigated to save epidemic from spreading. Often, correct distance between plants

should be preserved in order to preserve thick canopy that allows moisture to be produced. Another significant technique is use of transplants grown from disease-free chili seeds. Keep transplants weed-free & safe from other solanaceous crops. Ideally, crop can be rotated every 2–3 years with crops that aren't Colletotrichum hosts (Hanson 2003).

Use of Chemical Fungicides

Chemical management has been pursued as most efficient measure to control transmission of disease in absence of any accurate means of managing disease. Longer time it takes to grow resistant cultivar & short time it takes for fungicides to work further popularize this method of disease control, especially for anthracnose disease. However, residual toxic residues from chemicals in fruits obstruct planned export of chili goods to other countries, affecting country's economy. Furthermore, focusing on single chemical ingredient leads to production of resistance in pathogenic isolates, making disease control much more difficult. Traditional fungicides for prevention of disease include carbamate & carbendazim, though both have been proven ineffective in serious disease outbreaks. Copper compounds, dithiocarbamate, benzimidazole, & triazole compounds are among chemical fungicides often recommended for managing anthracnose disease. Newer compounds, such as strobilurin-based fungicides (e.g., azoxystrobin, pyraclostrobin), have also been used to control it. However, only few studies on this class of fungicides regulating chilli anthracnose in wide field trials are available. Chemical fungicides can be effectively controlled by applying them at right time during crucial phase where disease is most likely to develop. Fungicides can be used on young, spreading tissues such as fruits, leaves, & flowers to prevent pathogens from entering plant system. Numerous studies on negative effects of fungicide use on farmers' health, economic status, & harmful pollution of atmosphere, especially in developing countries, cannot be overlooked. Different types of fungicides have different modes of action & durations of effect on disease control. As result, farmers in certain region should make informed decisions about fungicides based on current environmental conditions (Harman 2006).

Future Aspects

When our knowledge of endophytic bacteria expands, so does our ability to manipulate their special bioactive compound synthesis characteristics alone or in conjunction with plants. Plant advantages augmented by use of beneficial microorganisms in form of bio-fertilizer have emerged as viable option for organic farming. In order to use endophytic bacteria as plant growth booster, we need to be able to recognise& use bacterial endophytes in agriculture as part of advanced biofertilizer technology programme. Endophytes modulate plant physiology & metabolism, & how they use primary & secondary metabolism intermediate substances as nutrition & precursors to create novel compounds or improve existing essential secondary metabolites, are still largely unknown.

CONCLUSION

After first findings of endophytic Gram-positive bacteria producing secondary metabolites with industrial potential, further evidence has emerged that endophytic Gram-positive bacteria are one of most valuable sources of novel compounds with known potential for agriculture, medicinal, and/or pharmaceutical applications, thanks to their PGP, antimicrobial, & anticancer activities. Endophytic Gram-positive bacteria do also assist plants in surviving under biotic & abiotic stress conditions. Many endophytic Gram-positive bacteria have been isolated from medicinal plants all over world, & this is not by chance. Many records of endophytic Gram-positive bacteria with such behaviours have been isolated from mangrove & under intense environmental conditions developing plants, such as crops from saline soils & crops & trees from cold regions, where phylogenic study of native strains shows they possess genes to produce various metabolites that, when combined, support host plant, not just host plant. Bacillus class endophytes have been shown to contain aromatic compounds, lipopeptides, plant hormones, polysaccharides, & several enzymes, indicating that they have greater capacity for PGP & crop management strategies in agriculture. Endophytes of Actinobacteria class have also been discovered to develop antimicrobial & antitumor-like action metabolites, suggesting that they have lot of promise in agriculture, medicine, & veterinary medicine.

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