A Review on Endophytic Bacteria and their Uses
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Abstract:
Currently major method to control any plant disease is use of chemical which potentially can have side effect such as toxicity in human and animals or reduce overall fertility of soil. As alternative several biocontrol agents are used in agriculture to control diseases in the plants. Endophytic bacteria can be considered as a new source of biocontrol agents in the plant disease management. Endophytic bacteria have antagonistic property against many fungal diseases in plants. They produce bio chemicals that counter attack the pathogens. The review paper focus to determine how molecular characters, biochemical production and activities of the fungi can be used in the growth and protection of plant.

Key words: Endophytic bacteria, bio-chemical production, molecular characterization.

I. INTRODUCTION

Endophytic bacteria can be defined as those bacteria that can be extracted from surface sterilized plant tissue and do not harm the plant. After they gain entry into the plant, they may be either localised at the point of entry or spread through the plant (Hallman et al., 1997). Endophytes enter into plant tissue primarily through the root zone. Aerial portions of the plant may also aid in entry of endophytes (Kobayashi and Palumbo, 2000). Endophytes synthesize bioactive compounds like alkaloids, steroids, terpenoids, peptides, polyketones, flavonoids, quinols and phenols that stimulate plant growth and increase resistance to plant pathogens (Rosenblueth and Romero, 2006). Endophytic bacteria can be considered as a new source of biocontrol agents in the plant disease management (Backman and Sikora, 2008), as they share the same ecological niche as that of plant pathogens, which makes them suitable for biocontrol (Ryan et al., 2008). Endophytic bacteria form associations such as symbiotic, mutualistic, and trophotrophic relations (Momota et al., 2012). Roots and other underground tissues yielded the highest number of bacterial colony forming units compared to above ground portions (McInroy and Kloeper, 1995).

Isolation of endophytic bacteria

Amaresan et al. (2012) isolated endophytic bacterial isolates from surface sterilized seeds of tomato and chilli and identified using a microbial identification system. Isolates were found to belong to the genus Bacillus and the remaining two isolates belong to the genus Serratia. All the isolates showed antagonistic activity against Sclerotium rolfsii. Fusarium oxysporum, Colletotrichum capsicum and Pythium sp. under in vitro conditions. The isolates were also shown to produce IAA and siderophore.

Munif et al. (2012) isolated 564 strains of endophytic bacteria from tomato plants grow in West Java and Indonesia. Of these 564 strains, fifty species and thirty two genera were found to be in association with root. Most of these strains were Bacillus spp. and Pseudomonas spp. Among these strains, 181 strains were tested for antagonism towards Rhizoctonia solani, Fusarium oxysporum f.sp. radicis-lycopersici and F oxysporum f.sp. lycopersici under in vitro conditions. Fourteen strains showed antagonistic activity against R. solani, nine strains against F oxysporum f.sp. radicis-lycopersici and seven strains against F oxysporum f.sp. lycopersici.

Patel et al. (2012) isolated eighteen isolates of endophytic bacteria from root and stem regions of tomato plants in Gujarat, each of which is showing characters like IAA production, siderophore production and antifungal activity. Among the eighteen isolates, four isolates showed positive results of which the best isolate was selected and sequenced and was later identified as Pseudomonas aeruginosa.

Gupta et al. (2015) isolated three endophytic bacteria from Prosopis cineraria plant at Pune, India. Out of three strains, two strains were obtained from root tissue and one strain from the leaf tissue. The two strains from root tissue were identified as Bacillus subtilis and Stenotrophomonas maltophilia and the strain from leaf tissue was identified as Stenotrophomonas maltophilia.

Xia et al. (2015) isolated endophytic bacteria from surface sterilized root, shoot and seed tissues of corn, tomato, melon and pepper. A total of 336 endophytic bacteria were isolated amongst which 55 per cent of the isolates belong to the Phylum Firmicutes.

Yi et al. (2015) isolated BT4, an endophytic bacterium from healthy tomato plants that exhibits antifungal activity against Alternaria solani and was identified as Bacillus amyloliquefaciens.

Inuwa et al. (2017) isolated sixteen endophytic bacteria from lemon grass (Cymbopogan citratus) and were identified based on morphological, biochemical and microscopic characteristics. They were identified as Bacillus spp., Escherichia coli,
Klebsiella pneumoniae, Micrococcus spp., Pseudomonas spp., Rhizobium and Staphylococcus aureus. They reported that Gram negative rod shaped bacteria were dominant in roots and Gram positive cocci were dominant in leaves.

Yanti et al. (2018) isolated fifteen endophytic Bacillus strains from tomato roots of which six strains showed good ability in promoting growth. They were sequenced and identified as Bacillus pseudomycoides strain NBRC 101232, Bacillus cereus strain CCM 2010, Bacillus toyonensis strain BCT-7112, Bacillus anthracis strain ATCC 14578, Bacillus cereus strain JCM 2152 and Bacillus cereus ATCC 14579.

Biochemical characterization of endophytic bacteria

Indole acetic acid production

Ahmad et al. (2005) isolated twenty one bacterial isolates (ten Azotobacter sp., and eleven fluorescent Pseudomonas sp.) from different rhizospheric soils. These isolates were tested for the production of IAA in a medium with 0, 1, 2.5 mg/ml of tryptophan. Low amount of IAA production (2.68-10.8 mg/ml) was recorded by Azotobacter without tryptophan addition. Seven isolates of Azotobacter showed high level (7.3 to 32.8 mg/ml) of IAA production at 5 mg/ml of tryptophan. At one and two mg/ml of tryptophan, the production was in the range of 1.47 to 11.88 and 5.99 to 24.8 mg/ml, respectively. Fluorescent Pseudomonas isolates showed an increase in IAA production with the increase in tryptophan concentration.

Ashraf et al. (2011) isolated twelve bacterial strains from root and rhizosphere samples collected from different sugarcane growing areas. Of these twelve strains, ten were identified as Pseudomonas and two strains were identified as Azotobacter based on colony morphology. All the isolates showed a positive reaction for IAA production in media with tryptophan. Maximum IAA production was recorded by the strain A17 at 4.49mg/ml whereas significant IAA production was shown by the strains A4 and A11.

Allu et al. (2014) isolated nineteen endophytic bacteria from chilli fruits and tested them for plant growth promoting abilities. All the isolates have shown IAA production. In addition, they have also recorded positive response for other plant growth promoting characters like ammoni a production and phosphorous solubilization. These strains have also shown positive response for siderophore and HCN production. The strains were tested for antagonism to Colletotrichum gloeosporioides, the causal agent of chilli anthracose. Ten strains were found to be promising in biocontrol of the pathogen. The strains were identified based on 16S rDNA sequencing as Pseudomonas aeruginosa.

Abbaldiah et al. (2018) isolated thirty eight endophytic bacterial isolates from healthy tomato plants and eight isolates among them were found to be effective in promoting plant growth. The eight isolates were sequenced and identified as Stenotrophomonas maltophilia (3 strains), Pseudomonas geniculata (1 strain), Bacillus amyloxydans (1 strain), Bacillus licheniformis (1 strain) and Bacillus subtilis (1 strain). All the isolates showed a positive reaction for IAA production.

Fuentes et al. (1993) isolated eighteen strains of Acetobacter diazotrophicus from cane cultivars and reported that all strains produced IAA in defined culture medium.

HPLC analyses revealed that A. diazotrophicus strains produced 0.14 to 2.42 μg of IAA/ml in culture medium. The biosynthesis of IAA suggests that the bacteria could promote rooting and improve sugarcane growth by direct effects on metabolic processes, in addition to their role in N2 fixation.

Herlina et al. (2017) isolated endophytic bacteria from Arachis hypogea and these isolates were tested for the production of IAA. A total of sixteen isolates were selected based on IAA producing ability. The highest amount of IAA production was 69.68 mg/l and the lowest was 8.50 mg/l.

Phetcharat and Duangpaeng (2012) isolated endophytic bacteria from rice tissues focusing mainly on their ability to produce IAA. They obtained seventy one isolates from which only four isolates produced IAA efficiently @ 10 μg/ml. The isolate 01R-4 (2) produced the highest amount of IAA (14.58 μg/ml) and identified as Bacillus sp.

Padder et al. (2017) isolated eighteen endophytic bacteria from roots of brown sarson (Brassica rapa L.). These isolates were screened for IAA production and it was observed that 41 isolates produced IAA with an average production of 8.15 μg/ml.

Verma et al. (2011) isolated endophytic actinomycetes strains from root tissues of Azadirachta indica and reported that the seed treated with spore suspension of three selected strains resulted in plant growth promotion. The strains were also found positive for IAA production and siderophile production. Streptomyces strain AzR-051 produced highest amount of IAA and it also produced higher siderophores compared to other strains.

Zaghoul et al. (2016) isolated bacterial endophytes from leguminous and non-leguminous plants at flowering stage. A total of 167 isolates were screened for plant growth promoting traits of which twelve isolates produced IAA more than 25μ/ml in presence of tryptophan.

Ammonia production

Gayathri et al. (2010) isolated 104 endophytic bacteria from leaves of mangrove plants. Among these 104 isolates, 36 fast growing isolates were screened for biological activity and plant growth promotion ability. Ammonia production was reported by the isolates 22 and 25 to an extent of 61.1 and 69.4 % respectively. Kumar et al. (2012) evaluated thirty bacteria from six different rhizospheric soil samples for their plant growth promoting ability. All the thirty bacterial isolates were tested for phosphate solubilization, IAA production, ammonia production, ACC deaminase activity, HCN production and catalase. Three isolates were positive for ammonia production and HCN production. Twelve isolates were positive for phosphate solubilization and ACC deaminase activity was shown by nine isolates. All isolates showed a positive reaction for IAA production and catalase test.

Naphade and Hussain (2014) screened the rhizospheric bacteria Pseudomonas putida for plant growth promoting activities. The bacteria was tested for its ability to produce ammonia, siderophore, IAA and HCN. The strain has shown a positive result for all the plant growth promoting traits except for HCN production.
Moustaine et al. (2017) isolated three different bacterial colonies (2025-1, 2066-7 and 2027-2) from tomato and tested for their plant growth promoting activities such as phosphorous solubilization, ammonia production, IAA production and antimicrobial enzyme activity. All the three strains have shown ammonia production, IAA production and antimicrobial enzyme activity. Only one strain (2066-7) has shown phosphorous solubilization.

Tangapo et al. (2018) isolated cultivable rhizospheric bacteria and endophytic bacteria from cilembu sweet potato. The isolates were identified based on 16S rRNA gene sequencing as Methylobacterium, Sphingomonas, Paracoccus, Klebsiella, Enterobacter, Pseudomonas, serrata and Streptomyces. They were tested for plant growth promotion alone and in combination. Out of 40 rhizospheric bacteria, only 12.5 per cent were positive for ammonia production, phosphate solubilization, IAA production siderophore production, nitrogen fixation and cellulolytic activity whereas 22.7 per cent of the endophytic bacterial isolates were positive for all the plant growth promoting traits tested.

**HCN production**

Castric (1975) tested 110 strains of *Pseudomonas aeruginosa* for HCN production out of which 74 strains produced HCN when grown in 2 per cent peptone or nutrient agar. Of the 25 species tested, other than *P. aeruginosa*, *P. fluorescens* and *P. polychloro* showed positive results for HCN production.

Bano and Musarrat (2003) validated the soil isolate NJ-15 as *Pseudomonas aeruginosa* based on sequence homology of 16s rDNA amplicon. The strain exhibited significant production of HCN and siderophore. The strain exhibited biocontrol activity against some phytopathogenic fungi.

Nandhini et al. (2012) isolated four genera of bacterial endophytes from healthy tomato plants and they were identified as *Bacillus*, *Pseudomonas*, *Klebsiella* and *Citrobacter* using standard biochemical methods. Among these isolates, the maximum quantity of HCN (45%) was produced by *Bacillus*.

Reetha et al. (2014) evaluated two strains of *Bacillus subtilis* (Bs10, CBs5) from rhizosphere soil and two strains of endophytic bacteria, *Pseudomonas fluorescens* (Pf1, CPs5) for HCN production and their antagonistic activity against *Macrophomina phaseolina* (Tassi.) Goid. The *Bacillus* strains did not show production of HCN. Both the *Pseudomonas* strains have shown HCN production with the maximum production by Pf1 strain.

Ozaktan et al. (2015) isolated 112 endophytic bacterial strains from healthy cucumber plants and screened for their plant growth promoting traits (IAA production, HCN production, siderophore production, Phosphate solubilization). Only three *Pseudomonas* (CA17/3, CA27/2, and CC27) isolates have shown HCN production. The IAA, siderophore and phosphate solubilization was reported to an extent of 30, 46 and 29 per cent respectively. All the endophytic bacteria were also screened for their inhibitory effect against *Fusarium oxysporum* f.sp. *cucumerinum* under in vitro conditions. Most of the strains have inhibited the pathogen in vitro but the strains CC29/3 and CC25/2 were more effective than other strains against *Fusarium oxysporum* f.sp. *cucumerinum*.

Apastambh et al. (2016) isolated eight strains of fluorescent *Pseudomonas* and four strains of *Bacillus* from the banana rhizosphere. These strains were biochemically characterized for IAA, HCN, siderophore and GA production. It was reported that all the four isolates of *Bacillus* were weak producers of HCN. Seven *Pseudomonas* strains exhibited HCN production from weak (Yps1, Yps3, Yps6, and Yps8) to moderate range (Yps2, Yps5, Yps7). Only the *Pseudomonas* strain Yps4 exhibited weak production of HCN.

Rekha et al. (2018) isolated forty one endophytic bacteria from mung bean nodule. HCN production was shown by forty one isolates to an extent of 71 per cent. In addition to these, the isolates have also shown siderophore (29%), ammonia (0-3.47 µg/ml) and IAA production (1.12-44.88 µg/ml).

**Siderophore production**

Lacava et al. (2008) reported the production of siderophores by an endophytic bacteria *Methylobacterium* spp., in citrus plants. The siderophore production of these bacterial strains is tested as per chrome azurol agar assay test, hydroxamate test and catechol test. The ability of *Xylella fastidiosa* subsp. *pauca* (*Xfp*) to use siderophores produced by endophytic bacteria was tested in vitro. All the thirty seven strains of *Methylobacterium* spp., were CAS-positive for siderophore production. *Methylobacterium* spp., produced hydroxamate-type of siderophores. The growth of *Xfp* was stimulated under *in vitro* due to the presence of supernatant siderophores produced by *Methylobacterium mesophilicum*.

Chaiharn et al. (2009) isolated 216 bacterial isolates from rice and tested them for siderophore production and also for their efficacy in inhibiting fungal pathogens of rice. They examined that 23 per cent of the bacterial isolates have shown siderophore production. The bacteria recorded varied levels of per cent reduction against *Alternaria* (35.4), *Fusarium oxysporum* (37.5), *Pyricularia oryzae* (31.2) and *Sclerotium* sp. (10.4).

Logeshwaran et al. (2009) isolated nine isolates (L1, L2, L3, L4, L5, L6, L7, L8, L9) of endophytic bacteria, *Gluconacetobacter diazotrophicus* from sugarcane roots and evaluated them for siderophore production. Methods such as FeCl3, CAS assay, hydroxamate test and catecholate test were used. In CAS assay, the siderophore production was recorded to a maximum rate in L5 followed by L3 and L7. In hydroxamate assay, the isolates L5 and L3 recorded the highest value. Positive reaction was not observed in any of the isolates to carboxylate test.

Yu et al. (2011) studied the siderophore producing bacteria from rhizosphere soil of pepper using Chome Azurol Sulphonate (CAS) agar plate assay. *Bacillus subtilis* strain, CAS 15 which produced a large orange halo. The strain produced catechol type of siderophore. It has also shown antagonistic activity against fifteen fungal pathogens in the dual-culture test. CAS 15 reduced the incidence of *Fusarium* wilt in pepper by 12.5-56.9 per cent.
Rungin et al. (2012) isolated an endophytic streptomyecete from a Thai jasmine rice plant (Oryza sativa L. cv. KDML 105) and evaluated the Streptomyces sp. (GMKU 3100) for siderophore production. The strain recorded highest siderophore production on CAS agar. This strain showed enhanced plant growth compared with control and siderophoredeficit mutant treatments. Jasmin et al. (2014) extracted four different endophytic bacterial strains from the rhizome of ginger. The isolates were tested for IAA, ACC deaminase and siderophore production. Out of the four isolates, ZoB1, ZoB2 and ZoB3 were found to produce siderophore. These isolates were reported as Bacillus sp., Pseudomonas sp., and Stenotrophomonas sp. respectively based on 16S rDNA sequence.

Abdallah et al. (2016) isolated seven bacterial isolates from Solanum elaegnifolium stem tissues. The isolates have shown the production of siderophores. Bacillus tequilensis strain SV104 has also shown production of IAA and pectinase and chitinase. Bacillus strains SV101 and SV104 have shown antagonistic activity against Fusarium oxysporum f.sp. lycopersici by 64 per cent.

Panigrahi et al. (2018) extracted thirty eight endophytic bacteria from six medicinal plants and screened them for plant growth promoting traits. Among thirty eight endophytic bacterial isolates, twelve (AP01, OS01, OL01, OS03, NSB001, CL02, CL03, CS10, CSLS16, RSTS01, RSTS02, RSTS03) isolates gave a positive result for siderophore production. Maximum siderophore production was recorded by the isolate OS03.

**Introduction of endophytic bacteria into plant**

Bressan and Borges (2004) evaluated the effectiveness of five delivery methods to introduce ten bacterial endophytes into root and stem tissues of maize. The delivery methods were seed inoculation, soil drench, foliar spray, pruned-root dip and seed inoculation + soil drench. Among these five methods, the pruned root-dip method was found to be effective as all the endophytic bacteria introduced into the plant were recovered. It was also reported that no isolates were recovered from the stem tissue by using seed treatment and from the root tissue following foliar spray method.

Algam et al. (2005) tested the efficacy of three methods to introduce endophytic bacteria into tomato plants namely, seed treatment+soil drench, soil drench and foliar spray. It was found that the most effective method to deliver endophytic bacteria into the plants was seed treatment+soil drench. They have also reported that all the isolates enhanced growth of tomato plants in all the methods employed.

**Antagonistic activity of endophytic bacteria**

Sessitsch et al. (2003) isolated endophytic bacterial communities from potato plants and were characterized by 16S rRNA sequencing. The isolates were found to be closely related to α, β, and γ Proteobacteria. A total of thirty five bacteria were screened for in vitro antagonism against the fungal pathogens namely, Verticillium dahliae, Rhizoctonia solani, Sclerotinia sclerotiorum and Phytophthora cactorum. Only two isolates of endophytic bacteria (Paenibacillus sp. pfB19 and Methylbacterium sp. pfB20) exhibited antagonistic activity against V. dahliae and the isolate Clavibacter michiganense pfB26 in addition to the above two isolates exhibited antagonism against R. solani. Four isolates recorded antagonistic activity against S. sclerotiorum whereas none of the isolates exhibited antagonism towards P. cactorum.

Cao et al. (2005) isolated 131 endophytic actinomycete strains from banana roots and they were found to be Streptomyces, Streptoeverticillium and Streptosporangium. The Streptomyces strain S96 was similar to S. griseorubiginosus. The antibiotic assay revealed that a total of twenty four strains were antagonistic to F. oxysporum f.sp. cubense.

Tiwari et al. (2010) isolated four endophytic bacteria (OS-9, OS-10, OS-11 and OS12) from healthy leaves of Ocimum sanctum and screened against Rhizoctonia solani, Sclerotium rolfsii, Fusarium solani, Alternaria solani and Colletotrichum lindemuthianum in dual-culture. OS-9 strain was found to be antagonistic to R. solani, A. solani, F. solani and C. lindemuthianum whereas OS-11 was found antagonistic towards A. solani. The strains OS-10 and OS-12 were not found to be antagonistic to any of the tested fungus. The strain OS-11 was characterized by 16s rRNA sequencing and the strain exhibited 100 per cent similarity with Bacillus subtilis.

King et al. (2013) evaluated endophytic bacteria from black pepper roots for antagonistic activity against Fusarium solani f.sp. piperis. Five isolates (EB1, EB2, EB3, EB4 and EB5) were found to be promising in dual culture technique. The isolates EB1 and EB2 showed the maximum antagonism with an inhibition percentage of 43 per cent and 41 per cent. The isolates were found to be related to Bacillus megatherium, B. cereus, Enterobacter sp. and Bacillus sp. based on 16S rDNA sequencing.

Abla et al. (2015) isolated endophytic bacteria from the roots of Mentha and the bacteria were tested for antifungal activity against F. oxysporum, Aspergillus niger and B. cinerea. Two Bacillus strains (M21 and M23) and one Pseudomonas strain (M12) induced inhibition of 70 per cent on mycelial growth of F. oxysporum and A. niger while four strains of Bacillus and one strain of Pseudomonas were effective in inhibiting mycelial growth of B. cinerea by more than 60 per cent.

Yi et al. (2015) isolated an endophytic bacterium, BT4 from healthy tomato plants that exhibits antifungal activity against Alternaria solani. The antifungal activity of BT4 was compared with Iprodione which is a contact fungicide. The results revealed that BT4 had shown maximum antifungal activity compared to iprodione.

Phuakjaiphaeo et al. (2016) isolated an antifungal compound from an endophytic actinomycete, Streptomyces sp. CEN26 found in the root nodes of Centella asiatica L.

The compound was purified and identified as 2, 5-bis (hydroxyl methyl) furan monooacetate. The compound was tested against A. brassicola. It was found that the compound deformed the conidia germination of A. brassicola at a minimal inhibitory concentrations of MIC90 and MIC50. Concentrations of MIC90
and MIC<sub>50</sub> suppressed the appresorium formation in the pathogen.

Prasom et al. (2017) evaluated forty three endophytic bacterial isolates from tomato plants against Fusarium oxysporum. Out of forty three isolates, only seven isolates have shown inhibition more than 30 per cent. The highest inhibition per cent was shown to an extent of 71.94 per cent by the isolate SuRW02. Most of the bacteria did not affect the seedling growth of tomato.

Mushtaq et al. (2018) isolated bacterial endophytes from citrus leaf midrib and were evaluated for antifungal activity against Alternaria solani. Inhibition was shown by different bacteria to an extent of 35 per cent by Pantoea sp. and Ensifer adhaerens, 33.03 per cent by Citrobacter diversus and 31.56 per cent by Azotobacter nigricans. Minimum inhibition was recorded by Enterobacter cloacae, Kurthia sp. and Azomonas azilis to an extent of 19.33 per cent, 19 per cent and 17 per cent respectively.

**Molecular characterization of endophytic bacteria**

Lata et al. (2006) isolated IAA producing endophytic bacteria from micro propagated Echinacea plants. The microbiological tests and 16S rRNA sequencing revealed that the bacteria belong to several genera: Bacillus, Pseudomonas, Ralstonia and Stenotrophomonas.

Kaga et al. (2009) isolated endophytic bacteria from the roots and shoots of rice seedlings that were cultivated in vitro. Based on 16S rRNA sequencing, the isolates were found to be closely related to Bacillus sp, Caulobacter sp, Micrococcus sp, Methylobacterium sp, Pantoea sp and Kocuria sp.

Yang et al. (2011) isolated seventy two endophytic bacteria from tomato leaves and stems and screened for antagonistic activity against B. cinerea Pers. The strain W4 exhibited strong inhibitory effect against the pathogen. Based on 16S rRNA sequencing, the strain was identified as Brevibacillus brevis W4.

The strain exhibited an inhibition rate of 78 per cent in dual culture assay against the pathogen.

Romero et al. (2014) isolated endophytic bacteria from tomato leaves and analyzed by 16S rRNA pyrosequencing in comparison with rhizosphere communities. Most of the endophytic bacteria from leaves belong to the Phyla Proteobacteria. Bacillus, Stenotrophomonas, Acinetobacter were found specifically colonizing the leaf in comparison to root. The lower diversity of bacteria was found in leaves compared to roots.

Upreti and Thomas (2015) isolated endophytic bacteria associated with tomato roots and characterized by 16S rRNA sequencing. The isolates belonging to different genera namely, Pseudomonas, Bacillus, Pantoea, Citrobacter, Staphylococcus, Enterobacter, Arthrobacter.

Ribau et al. (2016) isolated an endophytic bacterium PAC BNM0522 and evaluated its role in controlling southern blight disease (Sclerotium rolfsii) of tomato. The strain was identified as Pseudomonas based on 16S rRNA sequencing and ACCD gene amplification. The strain was effective in controlling Sclerotium rolfsii in vivo.

Iqbal et al. (2018) isolated endophytic bacteria from a local cultivar of tomato for evaluation of plant growth promoting traits. Two isolates NgE3 and NgE4 were found to be effective in plant growth promotion. These isolates were identified as Bacillus subtilis and Paenibacillus sp. on the basis of 16S rRNA sequencing. Both the strains were also found to be effective against fungal pathogens.

**II. REFERENCES:**


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