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ARTICLE

Diversity of Endophytic Fungi in Banana Cultivars of Assam India

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ABSTRACT

Endophytic fungal isolates (139 no.) were obtained from 143 (62 roots, 18 fruits and 54 leaves) samples of 15 different varieties of banana collected from 10 sites in Assam, India during 2018-2019. Overall isolation frequency from surface-sterilized tissue ranged from 10%-80% (as per site) and 6%-70% (as per variety of banana). All isolates were segregated into 40 different types on the basis of macromorphological and micro morphological characteristics. Forty different fungal taxa were isolated belonging to 14 genera including *Absidia, Arthrinium, Aspergillus, Bipolaris, Cladosporium, Curvularia, Dendrophion, Fusarium, Humicola, Mortierella, Mucor, Penicillium, Paecilomyces, Verticillium* and one mycelium sterile. Among them, *Cladosporium cladosporioidies* and *Paecilomyces* sp. frequently occurred in most of the sites surveyed whereas *Cladospoirum cladosporioides* and *Aspergillus* sp. 8, *Fusarium graminseram* were most frequently isolated from different varieties. However, all sites differed in their fungal diversity. Banana samples from Narigoan and Jorhat have been found with maximum fungal species followed by marigoan samples so as to Banana varieties Amrit Sagar endowed 27 no. of fungi followed by Jehaji and Honda which were associated with a maximum 14 fungal sp. Isolation frequency and relative abundance of *Cladosporium cladosporiodes* (80%, 4.6), *Paecilomyces farinosus* (80%, 4.6) followed by *Penicillium ruburm*, *Aspergillus* sp. 8 & 9 (70%, 4.02) were recorded as maximum comparatively in different sites. However, Aspergillus sp. 8, Mortieralla sp. and *Pacilomyces farinosus* are isolated frequently from different banana varieties (73.33%, 4.93).

Keywords: Banana; Fungi; Endophytes; Assam; Phyllosphere; Rhizosphere

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1. Introduction

Bananas are important agricultural products in most tropical countries and are consumed all over the world. It is a staple food and a source of income in many countries [1,2]. But nowadays, productivity is decreasing due to many diseases and attacks by a variety of pests. Nematodes are the main organism, which is responsible for causing many serious diseases. These plant parasites infect the banana roots and work as a barrier to the transpiration of macronutrients into the plant. This situation makes an adverse environment for the growth of plants [1]. *Pratylenchusgoodeyi, Radopholussimilis, P. coffeae, Helicotylenchusmulticinctus,* and *Meloidogyne spp.* are the most nematodes responsible for many diseases in banana variety, because banana varieties are the host of root-knot nematodes [3]. Although the nematodes or root-knot nematodes have a short life period, affecting host plants they can reduce yield capacity by 20-30% as well as make a rupture in the root, which helps the secondary pathogens enter [4,5].

Endophytes with a wide variety were found to be associated with a banana tree [6]. Recently, many workers are perusing an interest in endophytes and their major role in the plant. Endophytic microbes are used as biological agents to control most of the disease. These microorganisms also play an important role in plant growth as well as the bio-remediation of many pollutes [7-9]. Such bioagents may also use instead of synthetic fertilizers and pesticides, due to their cost-effective contribution to sustainable agriculture [10].

Since the last six decades, it has been found that many endophytic bacteria are associated with trees maintaining the symbiotic relationship and it was coming to exitance for the first time in the case of banana trees in the 1990s onwards. Gradually, research has been made for the diversity study of these endophytic bacteria as well as the properties and functions of bananas. A few genera of such bacteria also was reported in bananas like *Azospirillum, Bacillus, Burkholderia, Citrobacter, Enterobacter, Klebsiella, Ochrobactrum, Pantoea, Serratia and Staphylococcus* [11,12]. As bacterial endophytes there are many fungal endophytes also found. Few of them remain in dormant condition and carry forward their life cycle only in a suitable environment i.e., the stress condition of the host plant [13]. As bacterial endophytes there are many fungal endophytes also found. Few of them remain in dormant condition and carry forward their life cycle only in a suitable environment i.e., the stress condition of the host plant [14].

Recently, it has been observed that endophytes help in plant growth and also act as antinematicidal against plant parasitic nematodes [15]. Endophytes isolated from banana roots were found to be effective against the disease *Fusarium* wilt [16]. There are many findings of a variety of beneficial endophytes from banana tissue. There are different community structures of endophytes for the different disease levels of a banana tree [17]. Investigating the distribution of culturable endophytes in roots and effective screening for endophytes could improve our knowledge of the antagonistic ability against root-knot nematodes at different disease degrees of banana roots. In the north-east, India, mainly in the state of Assam banana cultivation is preferred by many cultivars due to its climatic and commercial demand. A wide range of banana varieties is cultivated, which directly influences the climatic zone as well as the economical strategy. Therefore, in the present study an attempt has been made to find out the endophytic diversity associated with the banana cultivar of Assam.

2. Materials and methods

Banana samples were collected from a different banana cultivar of Assam. Root, leaf and fruit samples were collected from banana trees. For root sampling, 3-4 cm of upper layer soil was removed with the help of small digging material or a knife to find out the target roots. Then roots were cut with the help of a sharp knife, and excess soil present on the root in a sticky condition was removed and kept in zip-locked poly bags. For obtaining leaf samples, dust present on a leaf was washed initially. Then leaves were cut randomly by using a knife or scissors and kept in air tight sampling bag to avoid contamination. In the case of fruit sampling, samples were collected randomly from the banana bunch. Fruits

were detached from the bunch by cutting and kept in a sampling bag. After all sampling, samples were labelled properly and brought forward for the next step of the study.

Samples were brought to the laboratory of plant pathology and microbiology division, Regional Plant Resource Centre, Bhubaneswar and a surface sterilization procedure was followed [16,18,19]. A series of solvents were prepared like 70% ethanol, and 2.5% sodium hypo-chlorite along with sterile distilled water was also prepared. At first, all the samples were cleaned with running tap water to avoid unwanted materials from the surface. After that different plant sample was cut into pieces and placed in 70% ethanol for 3 minutes to the removal of surface microbe. After 3 min, a sample was transferred into a container containing 2.5% sodium hypochlorite solution and kept for 5 min then treated with 70% ethanol again for 1min. The sterilized sample was washed three to four times with sterile distilled water.

After surface sterilization, all root samples were macerated separately by adding sterile distilled water as required and kept in a sterile sample container. So that, all the endophytes will come out from the cell. All the leaf samples were macerated separately to obtain a maximum number of endophytes. But in the case of the fruit samples, the cover (peel) of fruits was cut into thin and 1-3 cm long pieces for the endophytic isolation.

Potato dextrose agar (PDA), Sabouraud agar (SDA) and Nutrient agar (NA) plates were made in duplicate. Two plates of PDA, SDA and NA each were used for one root sample. Macerated root samples were spread over the media plate and kept in an incubator at 30 °C. After an incubation period of 2-3 days, microbial growth was found in the form of mixed culture (fungal & bacterial culture). The same process was followed for the macerated leaf samples and microbial growth was observed in mixed culture. In the case of the fruit, pre-sterilised cover (peel) of the fruit was inoculated in the media plate. In one plate five to seven pieces of peel were placed and kept for an incubation period. After an incubation period, endophytic (bacterial and fungal) growth was observed. From these mixed cultured plates, the process of purification was started. From the mixed plate, each fungal endophyte was reinoculated in a media plate containing an antibiotic agent (Streptomycin sulphate) to avoid bacterial contamination, while same time bacterial endophytes were inoculated in the Nutrient agar media without an antibiotic agent. This purification process was followed 3-4 times till the pure culture was obtained.

Pure cultures of fungal isolates were identified on the basis of macromorphological and micromorphological characteristic features. Cultural characteristics such as colony shape, the shape of the spore, attachment of the spore and pigmentation were taken into consideration for identification. Microscopic observation was performed by preparing slide culture through a light microscope [20-24]. Isolation frequency (IF) of all endophytes was expressed from the point of view of location as well as variety wise. Relative abundance (Ra) and similar index of endophytes were also determined both for locations and varieties.

3. Results and discussion

A documentary survey was conducted in Assam, in which 10 different sites including Jorhat, Golaghat, Shivsagar, Nagaon, Narigoan, Mali, Marigoan, Kahikuchi, Boko and Golpara were covered. All total 15 variety of banana species Manohar, Big Jehaji, Athiya, Assam malbhog, Dwarf Jehaji, Malbhog, Hoanda, SeniChampa, Kashkol, Gobintulshi, Garndnaine, Amrut sagar, Bhim, Jehaji and Seni were found namely. Around 143 (62 roots, 18 fruits and 54 leaves) samples were collected and 139 fungal endophytes were isolated. All isolates were segregated into 46 different types on the basis of macromorphological and micromorphological characteristics, which includes *Aspergillus* sp. (11 no.), 14 types of *Fusarium* sp. (14 no.) and *Penicillium* sp. (6 sp.), *Cladosporium* sp. (3 no.), 2 no. Of *Curvularia* sp., *Hemicola* sp., and one of *Curvularia* sp., *Mucor* sp. and *Tricoderma* sp. obtained. The occurrence of the endophytes was expressed in terms of the location from where the samples were collected (**Table 1**) and sample variety (**Table 2**).

Table 1. Distribution of endophytic fungi in different samplings sites covered from banana plantations of Assam.

S.No.	Endophytic fungi	Sampling Sites									
		1	2	3	4	5	6	7	8	9	10
1	*Absidia sp.*	•			•	•	•				•
2	*Arthrinium phaecosporum*			•		•					
3	*Aspergillus niger*	•	•		•	•	•	•			
4	*Aspergillus sp. 1*							•			
5	*Aspergillus sp. 2*							•		•	
6	*Aspergillus sp. 3*										•
7	*Aspergillus sp. 5*		•		•	•		•			
8	*Aspergillus sp. 7*				•			•		•	
9	*Aspergillus sp. 8*	•		•	•	•		•	•	•	
10	*Aspergillus sp.4*				•						
11	*Aspergillus sp.6*	•		•	•	•	•	•			
12	*Aspergillus sp.9*	•	•	•	•	•		•		•	
13	*Aspergillus terreus*				•						
14	*Bipolaris australiensis*	•			•	•		•		•	
15	*Cladosporium cladopsoroides*	•	•	•	•	•	•	•	•	•	•
16	*Cladosporium herbarum*		•					•		•	
17	*Cladosporium oxysporum*	•		•	•	•		•			
18	*Cladosporium sp.*							•		•	
19	*Curvularia lunata*	•		•	•	•	•				
20	*Curvularia trifoli*	•									•
21	*Dendryphion inserminatum*							•		•	
22	*Fusarium avenaceum*								•		
23	*Fusarium ciliatum*			•	•	•					
24	*Fusarium graminearum*	•		•	•	•	•				
25	*Fusarium incarnatum*							•		•	
26	*Fusarium oxysporum*	•		•	•	•					
27	*Fusarium poi*							•		•	
28	*Fusarium udum*	•						•	•	•	•
29	*Humicola dimorphospora*							•		•	•
30	*Mortierella chlamydosporium*	•	•		•	•		•			
31	*Mortierella sp.*		•	•	•	•		•		•	
32	*Mucor fragalis*	•			•	•					
33	*Myceloid*			•	•	•		•		•	
34	*Paecilomyces farinosus*	•		•	•	•	•	•		•	•
35	*Penicilliuim vinaceum*							•			
36	*Penicillium citronigram*		•	•	•	•					
37	*Penicillium funiculosum*			•	•	•	•				
38	*Penicillium glabarum*		•					•			
39	*Penicillium rubrum*	•	•	•	•	•	•	•			
40	*Verticillium lecanii*			•	•		•				

Abbreviations: • = presence of fungi, sites of sampling: 1-Kahikuchi, 2-Shivsagar, 3-Narigoan, 4-Nagaon, 5-Marigoan, 6-Mali, 7-Jorhat, 8-Golpara, 9-Golaghat, 10-Boko.

Table 2. Distribution of endophytic fungi in different varities of banana grown in Assam.

S.No.	Fungi	Varities of banana														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	*Absidia sp.*	•	•							•			•	•	•	•
2	*Arthrinium phaecosporum*					•									•	
3	*Aspergillus niger*	•		•	•	•	•		•	•				•		•
4	*Aspergillus sp. 1*		•						•							
5	*Aspergillus sp. 2*	•									•					
6	*Aspergillus sp. 3*													•		
7	*Aspergillus sp. 5*	•		•	•		•			•						
8	*Aspergillus sp. 7*	•			•			•			•					
9	*Aspergillus sp. 8*	•		•	•	•	•	•	•	•		•		•		•
10	*Aspergillus sp..4*															•
11	*Aspergillus sp.6*	•	•			•			•	•		•	•			
12	*Aspergillus sp.9*	•		•	•	•	•		•	•	•			•		•
13	*Aspergillus terreus*				•											
14	*Bipolaris australiensis*	•			•		•		•		•					
15	*Cladosporium cladopsoroides*	•	•	•		•		•	•	•	•	•	•	•	•	•
16	*Cladosporium herbarum*			•							•					
17	*Cladosporium oxysporum*	•		•			•		•	•				•		
18	*Cladosporium sp.*	•							•					•		
19	*Curvularia lunata*	•	•					•		•			•		•	•
20	*Curvularia trifoli*	•			•											
21	*Dendryphion inserminatum*	•		•					•	•	•			•		
22	*Fusarium avenaceum*													•		
23	*Fusarium ciliatum*	•		•			•		•							
24	*Fusarium graminearum*	•	•	•	•			•	•	•		•	•	•	•	•
25	*Fusarium incarnatum*	•		•					•							
26	*Fusarium oxysporum*	•				•		•				•				•
27	*Fusarium poi*	•	•	•						•				•		
28	*Fusarium udum*	•			•			•			•			•	•	
29	*Humicola dimorphospora*	•									•					
30	*Mortierella chlamydosporium*					•	•		•							•
31	*Mortierella sp.*	•		•	•	•		•	•	•	•	•		•		•
32	*Mucor fragalis*												•		•	
33	*Myceloid*	•			•	•		•			•	•				•
34	*Paecilomyces farinosus*	•	•					•	•	•	•	•	•	•	•	•
35	*Penicilliuim vinaceum*										•					
36	*Penicillium citronigram*	•			•							•				
37	*Penicillium funiculosum*					•		•		•			•		•	•
38	*Penicillium glabarum*								•	•						
39	*Penicillium rubrum*	•	•	•		•		•	•	•		•	•			•
40	*Verticillium lecanii*				•	•				•			•			

Abbreviations: • = presence of fungi, varieties of banana: 1-Amrut Sagar, 2-Assam Malbhog, 3-Bhim, 4-Athiya, 5-Big Jehaji, 6-Seni, 7-Dwarf Jehaji, 8-Jehaji, 9-Honda, 10-Grandnine, 11-Gobintulshi, 12-Kashkol, 13-Malbhog, 14-SeniCahampa, 15-Manohar.

Isolation frequency (IF) was determined for all locations where endophytes were obtained. A total ten number of locations were observed, where many varieties of endophytes were isolated (**Table 3**). The rate of IF was estimated highest i.e. 80% in the case of *Penicillium* sp. and *Fusarium* sp. 9. Just below to it, 70% of IF was recorded for *Fusarium* sp. 10, *Aspergillus* sp. 1 and *p. digitatum.* Apart from this most of the endophytes were recorded with an average IF rate of 20%-60% and 10% which was the least IF, was estimated the case of *Aspergillus* sp. 4, *Aspergillus* sp. 7, *Fusarium* sp. 13, *Penicillium* sp. 2, etc. **Relative abundance (Ra)** was calculated for all endophytes found in these ten locations (**Table 3**) and a relative picture came to that of IF. *Fusarium* sp. 9 and *Penicillium* sp., these two are found with the highest Ra rate of 4.60%. *Fusarium* sp. 10, *Aspergillus* sp. 1, *Aspergillus* sp. 2 and *P. digitatum,* these four endophytes were observed with a Ra rate of 4.02%. *Aspergillus* sp. 9 and *Hemicola*sp. 1, were recorded with an average range of 3.45%. Most of the endophytes were found within this rate of Ra. Few endophytes such as *Aspergillus* sp. 4, *Aspergillus* sp. 7, *Fusarium* sp. 13, *Penicillium* sp. 2 were noted with a very low rate and that rate is determined to be 0.57%. It is obtained from the above analysis that, *Penicillium* sp. and *Fusarium* sp. 9 are high in IF rate as well as Ra rate. At the same time *Aspergillus* sp. 4, *Aspergillus* sp. 7, *Fusarium* sp. 13, *Penicillium* sp. 2 were found with a low rate of Ra and IF.

Isolation frequency (IF) was studied for the presence of endophytes from 15 different varieties (**Table 3**). It is found that the rate of IF ranges from 6.67% to 73.33% in the form of many endophytes found in all varieties. *Aspergillus* sp. 2, *Hemicola* sp. 1, *Penicillium* sp. were found with the highest percentage of IF rate and were estimated at about 73.33%. *Aspergillus* sp. 1 and *p. digitatum*these two species were observed to have the 2nd highest value of 66.67%. *Aspergillus* sp. 9 and *Fusarium* sp. 10 each recorded with IF rate of 60% and the same time another two species, *Curvularia*sp. 1 and *Fusarium* sp. 8 were each found with an equal rate of IF, 46.67%. Few endophytes noted with very least rate of IF (6.67%) obtained in case of *Aspergillus* sp. 4, *Aspergillus* sp. 6, *Aspergillus* sp. 7 and *Fusarium* sp. 13. **Relative abundance (Ra)** was calculated by the available number of endophytes obtained from the 16 different varieties (**Table 3**). As found in case of IF, highest Ra (4.93%) was determined in *Aspergillus* sp. 2, *Hemicola*sp. 1 and *Penicillium* sp. Apart from this, *Aspergillus* sp. 1 and *p. digitatum*are the species found to be a Ra value of 4.48% less than the 1st one. Two species, *Aspergillus* sp. 9 and *Fusarium* sp. 10 each recorded with an IF rate of 60% and at the same time another two species, *Aspergillus* sp. 4, *Aspergillus* sp. 6, *Aspergillus* sp. 7, *Penicillium* sp. 2 and *Fusarium* sp. 13 which were found with very low Ra values i.e., 0.45%. All the findings reflect that, *Aspergillus* sp. 2, *Hemicola* sp. 1 and *Penicillium* sp. are the species having both high rates. Some *Aspergillus* sp. and *Penicillium* sp. were also found with a very low rate of IF and RA.

Index of Similarity or Similar Index (SI)

There are many numbers of endophytes were obtained from all ten locations and 16 different varieties studied. One endophyte may have been obtained from one or two or so many locations. On the basis of the principle, Similar Index (SI) were estimated using the standard formula of $SI = 2C/(S_1 + S_2)$, where SI = similar index, C = Common species in the site, S_1 = site 1/location1 and S_2 = site 2/location2. SI was estimated both for the location (**Table 4**) and varieties (**Table 5**) wise. If we put a view on the SI value obtained from the location analysis, ten locations Jorhat, Golaghat, Shivsagar, Nagaon, Narigoan, Mali, Marigoan, Kahikuchi, Boko and Golpara were studied and most SI found in case of endophytes obtained from Jorhat and Golaghat i.e., 0.78 **(Table 4**). But the highest SI value (0.85) was obtained in both Nagaon and Marigoan. Marigoan and Kahikuchi are the two places where the index of similarity was found to be 0.74 and 0.71 was estimated in the case of Nagaon and Narigoan. The lowest value for SI was obtained between Nagaon and Boko i.e., 0.11 and a value of 0.12 was recorded in Mali and Golpara.

Table 3. Isolation frequency (IF) and Relative abundance (Ra) of endophytes found all locations studied.

		Sampling Sites			Varieties of Banana		
S. No.	**Fungi**	**No of endophytes**	**Isolation frequency (IF)**	**Relative abundance (Ra)**	**No of endophytes**	**Isolation frequency (IF)**	**Relative abundance (Ra)**
1	*Absidia sp.*	5	50	2.87	7	46.67	3.14
2	*Arthrinium phaecosporum*	2	20	1.15	2	13.33	0.9
3	*Aspergillus niger*	6	60	3.45	9	60	4.04
4	*Aspergillus sp. 1*	1	10	0.57	2	13.33	0.9
5	*Aspergillus sp. 2*	2	20	1.15	2	13.33	0.9
6	*Aspergillus sp. 3*	1	10	0.57	1	6.67	0.45
7	*Aspergillus sp. 5*	4	40	2.3	5	33.33	2.24
8	*Aspergillus sp. 7*	3	30	1.72	4	26.67	1.79
9	*Aspergillus sp. 7*	7	70	4.02	11	73.33	4.93
10	*Aspergillus sp.4*	1	10	0.57	1	6.67	0.45
11	*Aspergillus sp.6*	6	60	3.45	7	46.67	3.14
12	*Aspergillus sp.8*	7	70	4.02	10	66.67	4.48
13	*Aspergillus terreus*	1	10	0.57	1	6.67	0.45
14	*Bipolaris australiensis*	5	50	2.87	5	33.33	2.24
15	*Cladosporium cladopsoroides*	8	80	4.6	9	60	4.04
16	*Cladosporium herbarum*	3	30	1.72	2	13.33	0.9
17	*Cladosporium oxysporum*	5	50	2.87	6	40	2.69
18	*Cladosporium sp.*	2	20	1.15	3	20	1.35
19	*Curvularia lunata*	5	50	2.87	7	46.67	3.14
20	*Curvularia trifoli*	2	20	1.15	2	13.33	0.9
21	*Dendryphion inserminatum*	2	20	1.15	6	40	2.69
22	*Fusarium avenaceum*	1	10	0.57	1	6.67	0.45
23	*Fusarium ciliatum*	3	30	1.72	4	26.67	1.79
24	*Fusarium graminearum*	5	50	2.87	5	33.33	2.24
25	*Fusarium incarnatum*	2	20	1.15	3	20	1.35
26	*Fusarium oxysporum*	4	40	2.3	5	33.33	2.24
27	*Fusarium poi*	2	20	1.15	5	33.33	2.24
28	*Fusarium udum*	5	50	2.87	6	40	2.69
29	*Humicola dimorphospora*	3	30	1.72	2	13.33	0.9
30	*Mortierella chlamydosporium*	5	50	2.87	4	26.67	1.79
31	*Mortierella sp.*	6	60	3.45	11	73.33	4.93
32	*Mucor fragalis*	3	30	1.72	2	13.33	0.9
33	*Myceloid*	5	50	2.87	7	46.67	3.14
34	*Paecilomyces farinosus*	8	80	4.6	11	73.33	4.93
35	*Penicilliuim vinaceum*	1	10	0.57	1	6.67	0.45
36	*Penicillium citronigram*	3	30	1.72	3	20	1.35
37	*Penicillium funiculosum*	4	40	2.3	6	40	2.69
38	*Penicillium glabarum*	2	20	1.15	2	13.33	0.9
39	*Penicillium rubrum*	7	70	4.02	10	66.67	4.48
40	*Verticillium lecanii*	3	30	1.72	4	26.67	1.79

As compared to location data, it is found that the rate of SI was slightly low in the case of varieties (15 nos.) investigated (**Table 5**). The rate of SI found to be highest between Big Jehaji and Manohar was estimated at 0.69 and the lowest rate of SI was 0.11 in the case of Gobintulshi and Seni. Jehaji and Bhim showed a better rate of SI of 0.67 at the same time 0.64 SI was found to be in Honda and Amrut sagar. Amrut sagar was recorded with the same type of SI rate with many varieties. 0.61 and 0.60 SI rate was observed in Amrut sagar with Malbhog and Jehaji, respectively. Kashkol was recorded with the same SI value of 0.15 for Grandnine and Malbhog. One most common variety i.e., Assmamalbhog found with SI

rate of 0.17 for Big jehaji.

The highest Index of Similarity (SI) value (0.85) was obtained in both of Nagaon and Marigoan among the all locations and the lowest value for SI were obtained in between Nagaon and Boko i.e., 0.11 and a value of 0.12 was recorded in Mali and Golpara. But from a variety of points of view, the rate of SI was found to be the highest between Big Jehaji and Manohar estimated at 0.69 and the lowest rate of SI was 0.11 in the case of Gobintulshi and Seni.

Table 4. Similarity index of the fungal communities colonizing in different banana cultivars of Assam.

		Sampling sites									
		1	2	3	4	5	6	7	8	9	10
1	Kahikuchi										
2	Shivasagar	0.27									
3	Narigaon	0.50	0.33								
4	Nagaon	0.67	0.37	0.71							
5	Marigaon	0.74	0.39	0.28	0.85						
6	Mali	0.56	0.27	0.56	0.55	0.53					
7	Jorhat	0.54	0.47	0.42	0.54	0.56	0.30				
8	Golpara	0.32	0.00	0.16	0.06	0.19	0.12	0.24			
9	Golaghat	0.37	0.29	0.37	0.39	0.36	0.20	0.78	0.26		
10	Boko	0.37	0.00	0.15	0.11	0.18	0.32	0.23	0.33	0.32	

Abbreviations: 1-Kahikuchi, 2-Shivasagar, 3-Narigaon, 4-Nagaon, 5-Marigaon, 6-Mali, 7-Jorhat, 8-Golpara, 9-Golaghat, 10-Boko.

Table 5. Index of similarity of endophytes found in all 15 varieties.

	Varieties of Banana														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Amrut Sagar															
Assam Malbhog	0.38														
Bhim	0.55	0.16													
Athiya	0.52	0.00	0.41												
Big Jehaji	0.40	0.17	0.43	0.44											
Seni	0.35	0.00	0.52	0.45	0.38										
Dwarf Jehaji	0.45	0.45	0.30	0.38	0.56	0.10									
Jehaji	0.60	0.29	0.67	0.38	0.45	0.54	0.27								
Honda	0.64	0.52	0.61	0.29	0.47	0.34	0.48	0.56							
Grandnine	0.58	0.23	0.39	0.40	0.28	0.17	0.43	0.35	0.38						
Gobin tulshi	0.47	0.48	0.23	0.32	0.42	0.11	0.81	0.34	0.44	0.30					
Kashkol	0.33	0.50	0.16	0.08	0.43	0.00	0.45	0.21	0.52	0.15	0.38				
Malbhog	0.61	0.37	0.50	0.39	0.27	0.32	0.28	0.51	0.58	0.48	0.29	0.15			
Seni Cahampa	0.29	0.50	0.08	0.08	0.26	0.00	0.55	0.07	0.39	0.31	0.19	0.60	0.30		
Manohar	0.55	0.31	0.39	0.33	0.69	0.33	0.64	0.47	0.59	0.38	0.52	0.54	0.42	0.38	

Abbreviations: 1-Amrut Sagar, 2-Assam Malbhog, 3-Bhim, 4-Athiya, 5-Big Jehaji, 6-Seni, 7-Dwarf Jehaji, 8-Jehaji, 9-Honda, 10-Grandnine, 11-Gobin tulshi, 12-Kashkol, 13-Malbhog, 14-Seni Cahampa, 15-Manohar.

Conflict of Interest

There were no conflict of interest in the publication of this content.

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