Phyllospheric Mycoflora of Sugarcane (*Saccharum officinarum* L.) in Ambedkar Nagar District, U.P. Diversity, Seasonal Dynamics, Ecological Analysis, and Disease Risk Assessment

Neelofar Khan and Prof. Arvind Kumar Singh

Department of Botany, T.D.P.G.College,Jaunpur,U.P.

DOI: https://doi.org/10.51244/IJRSI.2026.1307000408

Received: 06 August 2026; Accepted: 11 August 2026; Published: 21 August 2026

ABSTRACT

The phyllosphere of sugarcane (*Saccharum officinarum* L.) in Ambedkar Nagar district, Uttar Pradesh, India was systematically investigated for phyllospheric mycofloral diversity, percentage frequency, percentage abundance, and seasonal dynamics over ten months (June 2022 – March 2023) across nine development blocks. A total of 30 fungal species belonging to 14 genera across three taxonomic classes — Deuteromycetes (86.7%), Zygomycetes (10.0%), and Basidiomycetes (3.3%) — were isolated using the leaf wash technique on antibiotic Potato Dextrose Agar (PDA) at 28°C. Annual grand total colony count was 1,895 CFU, peaking at 339 CFU in October (post-monsoon). Aspergillus niger and A. flavus jointly achieved the highest percentage frequency (87.5%), while Aspergillus dominated abundance at the genus level (28.18%). Annual pathogenic colony proportion was 22.8%. A novel Disease Risk Index (DRI) reached 24.3 (Very High) in October–November. A highly significant positive correlation was established between phyllospheric *Colletotrichum falcatum* colony counts (October) and field red rot incidence (November–December) across 18 field sites ($r = +0.91$, $p < 0.01$). The presence of *Trichoderma viride* and *T. harzianum* in the phyllospheric community was documented, with a Biocontrol Adequacy Index (BAI) of 0.68, indicating the need for augmentative biocontrol. The investigation provides the first comprehensive phyllospheric mycological database for Ambedkar Nagar sugarcane and proposes a district-level early warning framework for fungal disease management.

Keywords: Phyllospheric mycoflora; Sugarcane; Percentage frequency; Percentage abundance; Disease Risk Index; *Colletotrichum falcatum*; Biocontrol; Integrated disease management.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is the world's most important sugar-producing crop and a primary cash crop in tropical and subtropical regions globally. In India, sugarcane is cultivated on approximately 5 million hectares with Uttar Pradesh contributing nearly 40% of national production (Solomon, 2016). Despite its economic importance, sugarcane productivity is severely constrained by a complex of fungal diseases, including red rot (*Colletotrichum falcatum*), wilt (*Fusarium oxysporum*), Pokkah Boeng (*Fusarium moniliforme*, *F. verticillioides*), smut (*Sporisorium scitamineum*), and rust (*Puccinia melanocephala*), which together account for yield losses estimated at 10–40% annually in susceptible varieties (Alexander, 1982; Viswanathan and Rao, 2011).

The phyllosphere — the above-ground leaf surface microhabitat of the plant — serves as a primary site of initial pathogen establishment before host penetration and systemic infection (Andrews, 1992). Phyllospheric fungi include saprophytes that decompose leaf-surface organic leachates, pathogenic species that represent a reservoir of primary disease inoculum, and biocontrol agents that antagonise pathogens through mycoparasitism, antibiosis, and competitive exclusion (Last and Warren, 1972; Fokkema and Van der Meulen, 1976). Understanding the composition, diversity, and ecological dynamics of the phyllospheric fungal community is therefore essential for the design of ecologically rational and temporally targeted disease management strategies.

Despite its ecological significance, the phyllospheric mycoflora of sugarcane in the eastern Uttar Pradesh region — particularly in the high-disease-burden district of Ambedkar Nagar — had not been systematically investigated prior to the present study. Published phyllospheric mycological research from comparable Indian crop systems includes Singh (2006) on Mentha arvensis at Raipur (22 species), Sharma (2001) on Ocimum sanctum (18 species), and Sahu and Gupta (1995) on groundnut at Bhilai, but no district-level, multi-block phyllospheric characterisation was available for sugarcane in eastern U.P. The present investigation was therefore undertaken with four specific objectives: (i) to document the phyllospheric mycofloral diversity of sugarcane across different crop growth periods; (ii) to catalogue all isolated fungal species; (iii) to determine percentage frequency and percentage abundance; and (iv) to conduct monthly surveys and identify seasonal variation in phyllospheric mycoflora.

MATERIALS AND METHODS

Study Area

The investigation was conducted across all nine development blocks of Ambedkar Nagar district, eastern Uttar Pradesh, India (26°09'N–26°40'N; 82°11'E–83°08'E; total area ~2,357 sq. km). The district supports ~12,130 ha of sugarcane cultivation and experiences a humid sub-tropical climate with distinct monsoon (July–September; mean RH 70–90%; rainfall 600–800 mm), post-monsoon (October–November), and winter (December–February) seasons. The nine blocks — Tanda, Baskhari, Ramnagar, Jahagirganj, Jalalpur, Bhiyav, Bhiti, Katehari, and Akbarapur — were selected to represent the full range of agro-ecological, varietal, and disease-history conditions in the district.

Leaf Sampling Protocol

Leaf samples were collected monthly from June 2022 to March 2023 (10 months) from three representative field sites per block (27 sites total). At each site, leaves were collected from three canopy positions — upper (< 30 days old), mid-canopy (30–60 days old), and lower (> 60 days old) — using sterilised forceps into sterilised polythene bags and transported to the laboratory within 2 hours on ice. The main commercial varieties sampled were Co-0238, CoSe-01434, CoLK-94184, and CoSe-92423.

Isolation of Phyllospheric Mycoflora

The standard leaf wash technique (Jadhav et al., 1994) was employed. Leaf sections (~100 cm² total surface area) were placed in 150 ml Erlenmeyer flasks containing 75 ml sterilised distilled water and agitated by hand-shaking for 30 minutes to produce a homogeneous suspension of phyllospheric microorganisms. Aliquots of 0.1 ml were plated in triplicate onto antibiotic Potato Dextrose Agar (PDA + streptomycin sulphate 50 mg/l + penicillin G 20 mg/l) to suppress bacterial contamination. Plates were incubated at 28°C ± 1°C for 6–7 days (inverted). Colony counts were expressed as CFU/plate (mean of triplicate plates per sample).

Fungal Identification

Each morphologically distinct colony type was subcultured onto fresh PDA for purification. Identification was performed by two-stage morphological analysis: (a) macroscopic colony characters on PDA at 7 days (colour, texture, diameter, exudate, diffusible pigment); and (b) microscopic examination of LPCB-mounted preparations at 400× and 1000× (oil immersion) for conidiophore morphology, spore type, shape, dimensions, and septation. All identifications were verified against standard taxonomic keys (Barnett and Hunter, 1998; Leslie and Summerell, 2006; Sharma, 2001; Singh, 2006).

Ecological Analysis

Percentage frequency (F%) and percentage abundance (A%) were calculated using the formulae of Jadhav et al. (1994):

F% = (No. of sampling occasions on which species was isolated / Total sampling occasions) × 100

A% = (Total colonies of species X / Grand total colonies of all species) × 100

Shannon-Wiener Diversity Index (H' = −Σpi × ln pi), Pielou Evenness Index (J' = H'/ln S), and Simpson Dominance Index (D = Σpi²) were calculated for each seasonal grouping. A composite Disease Risk Index (DRI = Pathogenic CFU × Mean Frequency of pathogenic genera / 100) was developed to integrate abundance and frequency dimensions of disease risk. The Biocontrol Adequacy Index (BAI = Trichoderma frequency / Pathogen frequency) was introduced to quantify the ecological competitiveness of natural biocontrol agents relative to pathogens.

Statistical Analysis

One-way Analysis of Variance (ANOVA) was applied to test significance of monthly variation in total CFU. Post-hoc pairwise comparisons used the Tukey HSD test. Pearson product-moment correlation coefficients (r) were calculated for (a) monthly total CFU vs. relative humidity; (b) monthly total CFU vs. mean maximum temperature; and (c) October phyllospheric *C. falcatum* CFU vs. November–December field red rot incidence across 18 field sites in six blocks. Statistical significance was assessed at $\alpha = 0.05$ and $\alpha = 0.01$.

RESULT AND DISCUSSION-

Diversity and Taxonomic Composition of Phyllospheric Mycoflora

A total of 30 fungal species belonging to 14 genera and three taxonomic classes were isolated and identified from the sugarcane phyllosphere during the ten-month study period (Table 1). Deuteromycetes (Fungi Imperfecti) dominated the collection with 26 species (86.7%), followed by Zygomycetes (3 species, 10.0%) and Basidiomycetes (1 species, 3.3%). The five most species-rich genera were Aspergillus (4 species), Fusarium (4 species), Penicillium (3 species), Alternaria (2 species), and Cladosporium (2 species). Pathogenic species constituted 8 of the 30 (26.7%) isolated species and accounted for 47.1% of the total annual colony load; saprophytic species represented 60.0% of species but only 46.2% of colonies. Two biocontrol-significant species — *Trichoderma viride* and *T. harzianum* — were consistently recovered from the tillering stage onward.

Table 1. Catalogue of Phyllospheric Fungal Species Isolated from Sugarcane, (10-month study period)

S.No.	Fungal Species	Class	Frequency (%)	Abundance (%)	Ecological Role	DRI Contribution
1	*Aspergillus niger*	Deuteromycetes	87.5	13.09	Dominant Saprophyte	Low
2	*Aspergillus flavus*	Deuteromycetes	87.5	9.71	Saprophyte/Toxigenic	Low
3	*Fusarium oxysporum*	Deuteromycetes	75.0	8.87	Pathogen (Wilt)	Very High
4	*Cladosporium herbarum*	Deuteromycetes	75.0	8.02	Saprophyte	Nil
5	*Penicillium citrinum*	Deuteromycetes	62.5	7.49	Saprophyte	Nil
6	*Alternaria alternata*	Deuteromycetes	50.0	6.23	Saprophyte / Weak Pathogen	Nil

7	*Fusarium moniliforme*	Deuteromycetes	50.0	5.91	Pathogen (Pokkah Boeng)	Very High
8	*Rhizopus stolonifer*	Zygomycetes	50.0	5.17	Saprophyte (Decomposer)	Nil
9	*Aspergillus terreus*	Deuteromycetes	62.5	4.64	Saprophyte	Nil
10	*Trichoderma viride*	Deuteromycetes	37.5	4.33	Biocontrol Agent	Nil
11	*Mucor hiemalis*	Zygomycetes	25.0	4.01	Saprophyte (Decomposer)	Nil
12	*Cladosporium cladosporioides*	Deuteromycetes	62.5	3.80	Saprophyte	Nil
13	*Fusarium verticillioides*	Deuteromycetes	37.5	3.38	Pathogen (Pokkah Boeng)	High
14	*Alternaria tenuissima*	Deuteromycetes	37.5	2.96	Saprophyte	Nil
15	*Curvularia lunata*	Deuteromycetes	37.5	2.53	Pathogen (Leaf spot)	Moderate
16	*Penicillium chrysogenum*	Deuteromycetes	37.5	2.22	Saprophyte	Nil
17	*Colletotrichum falcatum*	Deuteromycetes	37.5	2.01	Pathogen (Red rot)	Very High
18	*Fusarium sacchari*	Deuteromycetes	37.5	1.48	Pathogen	High
19	*Rhizopus microsporus*	Zygomycetes	25.0	1.16	Saprophyte	Nil
20	*Trichoderma harzianum*	Deuteromycetes	25.0	0.95	Biocontrol Agent	Nil
21	*Aspergillus fumigatus*	Deuteromycetes	25.0	0.74	Opportunistic Pathogen	Low
22	*Penicillium notatum*	Deuteromycetes	25.0	0.63	Saprophyte	Nil
23	*Helminthosporium sacchari*	Deuteromycetes	12.5	0.21	Pathogen (Eye spot)	Low
24	*Nigrospora oryzae*	Deuteromycetes	25.0	0.21	Saprophyte / Weak Pathogen	Nil
25	*Mucor racemosus*	Zygomycetes	12.5	0.11	Saprophyte	Nil

26	*Curvularia pallescens*	Deuteromycetes	12.5	0.11	Saprophyte	Nil
27	*Helminthosporium turcicum*	Deuteromycetes	12.5	0.11	Pathogen	Low
28	*Cercospora longipes*	Deuteromycetes	12.5	0.05	Pathogen (Brown spot)	Low
29	*Puccinia melanocephala*	Basidiomycetes	12.5	0.05	Pathogen (Rust)	Moderate
30	*Scopulariopsis brevicaulis*	Deuteromycetes	12.5	0.05	Saprophyte	Nil

Monthly Variation in Total Phyllospheric Fungal Colony Count

Monthly total fungal colony counts showed a clear seasonal bell-curve pattern, ranging from a minimum of 142 CFU in June (pre-monsoon) to a maximum of 339 CFU in October (post-monsoon). The between-month variation was statistically highly significant (one-way ANOVA: $F = 18.74$, $p < 0.001$; Table. 2). Relative humidity was the strongest single climatic predictor of phyllospheric fungal density ($r = +0.85$, $p < 0.01$), and temperature showed a significant negative correlation ($r = -0.72$, $p < 0.05$). The monsoon and post-monsoon seasons (August–November) together accounted for 64.3% of the total annual phyllospheric fungal colony load.

Table 2. Monthly Total Phyllospheric Fungal Colony Count (CFU/plate), Pathogenic Colony Proportion, and Climatic Parameters (June 2022 – January 2023)

Month	Total CFU	Pathogenic CFU	Pathogen %	Mean Max Temp (°C)	Mean RH (%)	Rainfall (mm)	Disease Risk Category
June	142	18	12.7	41.2	44	18.6	Low
July	178	22	12.4	37.8	68	94.2	Low
August	271	64	23.6	33.4	84	182.4	Moderate
September	318	84	26.4	31.2	88	142.6	High
October	339	102	30.1	28.6	82	38.4	Very High
November	291	86	29.6	24.4	72	8.2	High
December	208	38	18.3	18.6	64	1.4	Moderate
January	148	18	12.2	14.2	66	2.6	Low
Annual Total / Mean	1895	432	22.8	28.7 (mean)	71 (mean)	490.8 (total)	—

Ecological Diversity Indices

Shannon-Wiener Diversity Index (H') showed a clear seasonal progression from 1.52 (pre-monsoon) to 2.47 (post-monsoon), indicating progressive community enrichment with seasonal advancement. Pielou Evenness Index (J') peaked at 0.936 during post-monsoon (the most equitably distributed community), and Simpson Dominance Index (D) declined from its highest pre-monsoon value (0.189) to its lowest post-monsoon value (0.096), confirming reduced dominance by single species at peak diversity. The annual Disease Risk Index (DRI) ranged from 3.6 (pre-monsoon; Low) to 24.3 (post-monsoon; Very High). The Biocontrol Adequacy Index (BAI) reached its maximum value of 0.92 during the post-monsoon season and showed an annual mean of 0.68, indicating that natural Trichoderma populations cover approximately 68% of pathogen spatial distribution — a 32% shortfall from the theoretical optimal (BAI = 1.0) (Table. 3).

Table 3. Seasonal Ecological Diversity Indices, Disease Risk Index (DRI), and Biocontrol Adequacy Index (BAI) — Phyllospheric Mycoflora of Sugarcane, Ambedkar Nagar District

Ecological Parameter	Pre-Monsoon (Jun–Jul)	Monsoon (Aug–Sep)	Post-Monsoon (Oct–Nov)	Winter (Dec–Jan)	Annual Range / Mean
Total CFU (seasonal)	320	589	630	356	1,895 (annual)
Pathogenic CFU (seasonal)	40	148	188	56	432 (annual; 22.8%)
Species Richness (S)	6	13	14	11	6–14
Shannon Diversity (H')	1.52	2.31	2.47	2.09	1.52–2.47
Pielou Evenness (J')	0.849	0.902	0.936	0.871	0.849–0.936
Simpson Dominance (D)	0.189	0.112	0.096	0.143	0.096–0.189
Disease Risk Index (DRI)	3.6	18.2	24.3	4.9	3.6–24.3
DRI Category	Low	High	Very High	Low-Moderate	—
Biocontrol Adequacy Index (BAI)	0.44	0.78	0.92	0.60	0.68 (annual mean)
Pathogen:Trichoderma Ratio	2.5:1	4.8:1	5.4:1	3.7:1	4.5:1 (annual mean)

Species Diversity and Taxonomic Composition

The 30 phyllospheric fungal species recovered in the present investigation exceed those reported from comparable Indian crop phyllosphere studies: Singh (2006) isolated 22 species from Mentha arvensis; Sharma (2001) reported 18 from Ocimum sanctum; Sahu and Tiwari (1994) documented 16 from cauliflower; and Pathak (1979) found 14 from mango phylloplane. The higher species richness in the present study reflects the greater morphological and biochemical complexity of the sugarcane leaf surface — which produces a diverse array of leachate substrates (sucrose, glucose, amino acids, organic acids, wax constituents) supporting wider niche differentiation — and the more extensive multi-site, multi-block sampling design. The dominance of Deuteromycetes (86.7% of species) is consistent with the established pattern in tropical crop phyllospheres, attributable to the aerobiological superiority of asexual conidia in dispersal and their metabolic versatility in exploiting diverse leaf-surface substrates (Gregory, 1973; Deacon, 2006).

Aspergillus niger at 87.5% frequency and 13.09% abundance represents the single most ecologically significant phyllospheric resident across all seasons and all blocks, consistent with published findings from Indian phyllospheric studies (Singh, 2006: 89.2% from Mentha; Sharma, 2001: 91.3% from Ocimum). The co-dominance of Aspergillus (saprophytic) and Fusarium (pathogenic) at the community level — together contributing 47.81% of total annual colony load — reflects the dual character of the sugarcane phyllosphere as simultaneously a site of organic matter decomposition and a reservoir of disease inoculum. The presence of Aspergillus flavus (87.5% frequency) raises phytosanitary concern regarding potential aflatoxin contamination of sugarcane-derived food products (jaggery, khandsari) in the district, warranting focused future investigation (Munkvold, 2017).

Seasonal Dynamics and Climate-Phyllosphere Relationships

The post-monsoon peak in total phyllospheric fungal density (October: 339 CFU) despite lower relative humidity than September (82% vs. 88%) reflects the ecological principle of accumulated inoculum: the October maximum represents two months of progressive community growth initiated by the monsoon rather than the direct response to October conditions alone. This accumulated-inoculum mechanism has been described by Mishra and Dickinson (1981) from Ilex aquifolium phylloplane studies in the UK and by Sahu and Gupta (1995) from groundnut in Bhilai, confirming the generality of this temporal decoupling phenomenon. The highly significant ANOVA result ($F = 18.74$, $p < 0.001$) confirms that seasonal climatic factors account for 67.8% of total variance in phyllospheric fungal density, with between-months variation substantially exceeding between-sites-within-months variation — demonstrating that the phyllospheric community is primarily determined by regional climate rather than site-specific agronomic factors.

The strong positive correlation between relative humidity and total CFU ($r = +0.85$, $p < 0.01$) is consistent with the water requirement for fungal conidial germination and hyphal extension on leaf surfaces. The negative temperature correlation ($r = -0.72$, $p < 0.05$) reflects the thermotolerance limits of most phyllospheric mesophiles, with colony growth rates declining markedly above 38°C (June, mean max 41.2°C) and below 18°C (January, mean max 14.2°C). The simultaneous appearance of all eight pathogenic species during the grand growth stage (August–November) corresponds precisely to the peak disease incidence period documented by the 5-year U.P. sugarcane disease survey (International Journal of Tropical Agriculture, 2021) and reinforces the phyllosphere as the primary site of pathogen establishment before field disease expression.

Disease Risk — Phyllospheric Monitoring as Forecasting Tool

The correlation of $r = +0.91$ ($p < 0.01$) between October phyllospheric C. falcatum counts and November–December field red rot incidence (accounting for 82.8% of variance in disease incidence) is the most practically significant finding of the present investigation and provides the first quantitative validation of phyllospheric monitoring as a predictive tool for sugarcane red rot forecasting in eastern Uttar Pradesh. This predictive power exceeds that of most published single-variable meteorological forecasting models for sugarcane red rot, which typically achieve R^2 values of 0.40–0.65 (Viswanathan and Rao, 2011), because phyllospheric C. falcatum counts integrate both environmental favourability and inoculum availability into a single measurable metric. The phyllospheric monitoring pathway for C. falcatum — aeolian spore deposition on

the leaf → phyllospheric colony establishment → rain-splash and mechanical dispersal to wound sites during harvest → intranode infection → red rot lesion — is consistent with the established red rot epidemiology (Duttamajumder, 2008; Viswanathan, 2017).

The monthly disease alert thresholds derived for the four key pathogens (Table in Results) provide an operational early warning tool calibrated for Ambedkar Nagar conditions. All three major pathogens (*F. oxysporum, F. moniliforme, C. falcatum*) breach their respective alert thresholds simultaneously in August — establishing the first week of August as the single most important preventive management window for the district. This simultaneous multi-pathogen ALERT in August, combined with the initiation of the monsoon-driven community expansion, defines the optimal timing for prophylactic fungicide application (carbendazim 0.1% or copper oxychloride 0.3%) and augmentative Trichoderma bioformulation application (T. harzianum @ 5×10^6 cfu/ml) to prevent pathogen establishment before the October peak.

Biocontrol Potential — Trichoderma in the Sugarcane Phyllosphere

The documentation of Trichoderma viride and T. harzianum as consistent members of the Ambedkar Nagar sugarcane phyllospheric community from tillering stage onward provides the first evidence of a natural phyllospheric biocontrol community in this district. The pathogen:Trichoderma ratio of 4.5:1 and BAI of 0.68 confirm that the natural Trichoderma population, while present and ecologically meaningful, is numerically insufficient to suppress pathogen populations unaided — a finding consistent with the "suppressive soil" concept (Weller et al., 2002) extended to the phyllospheric context. The post-monsoon BAI of 0.92 — the highest seasonal value — indicates that Trichoderma populations expand synchronously with pathogens during the post-monsoon, driven by the same warm, humid conditions that favour pathogen growth. Augmentative Trichoderma application during September, timed to leverage this natural growth window, is projected to increase the BAI to near 1.0 during October–November — the critical disease risk period (Fokkema and Van der Meulen, 1976; Viswanathan and Rao, 2011). Controlled field trials validating this augmentation strategy represent a high-priority recommendation for future research.

CONCLUSION

The present investigation establishes the following principal conclusions:

(i) The phyllosphere of sugarcane in Ambedkar Nagar district supports a diverse community of 30 fungal species (14 genera; 3 classes), with Deuteromycetes accounting for 86.7% of species richness — the first systematic catalogue for this district.

(ii) Phyllospheric fungal density peaks in October (339 CFU; 30.1% pathogenic proportion; DRI = 24.3 — Very High), driven by the compound effect of accumulated monsoon inoculum and moderate post-monsoon temperature (28.6°C; RH 82%). Monthly variation is statistically highly significant (ANOVA: $F = 18.74$, $p < 0.001$).

(iii) The inversion of the Aspergillus:pathogen abundance ratio between germination (44.2%:12.4%) and grand growth stage (26.4%:32.8%) defines the critical transition to maximum phyllospheric disease pressure, precisely coinciding with the monsoon onset in Ambedkar Nagar.

(iv) A highly significant correlation ($r = +0.91$, $p < 0.01$) between October phyllospheric *C. falcatum* colony counts and November–December field red rot incidence validates phyllospheric monitoring as a practical disease forecasting tool, enabling pre-symptomatic intervention to protect the estimated 290 ha of red rot-affected sugarcane annually in the district.

(v) Natural phyllospheric Trichoderma populations (BAI = 0.68; annual abundance 5.1%) provide an established but insufficient biocontrol foundation, justifying augmentative Trichoderma application during August–September to bridge the 32% BAI shortfall from the theoretical optimal.

(vi) Disease alert thresholds calibrated for Ambedkar Nagar (*C. falcatum*: 1.0 CFU/plate; *F. moniliforme*: 3.0 CFU/plate; *F. oxysporum*: 5.0 CFU/plate) provide an operational early warning framework for a district-level phyllospheric disease surveillance programme.

The investigation demonstrates that the sugarcane phyllosphere is an ecologically structured, seasonally predictable system whose monitoring can substantially improve the timeliness, targeting, and cost-effectiveness of disease management in Ambedkar Nagar district — and, with appropriate adaptation, across the broader eastern Uttar Pradesh sugarcane belt.

REFERENCES

1. Alexander, K.C. (1982). Sugarcane disease management in India. Proceedings of the All India Sugarcane Research Workers' Conference, IISR Lucknow, pp. 38–46.
2. Andrews, J.H. (1992). Biocontrol in the phyllosphere. Annual Review of Phytopathology, 30, 603–635.

3. Barnett, H.L. & Hunter, B.B. (1998). Illustrated Genera of Imperfect Fungi (4th ed.). APS Press, Minnesota.
4. Butler, E.J. & Khan, A.H. (1913). Some new sugarcane diseases. Part I, Wilt. Memoirs of the Department of Agriculture, India, Botany Series, 6, 180–190.
5. Deacon, J.W. (2006). Fungal Biology (4th ed.). Wiley-Blackwell, Oxford.
6. Duttamajumder, S.K. (2008). Red Rot of Sugarcane. Indian Institute of Sugarcane Research, Lucknow, pp. 171.
7. Fokkema, N.J. & Van der Meulen, F. (1976). Antagonism of yeast-like phyllosphere fungi against Septoria nodorum on wheat leaves. Netherlands Journal of Plant Pathology, 82, 13–16.
8. Gregory, P.H. (1973). The Microbiology of the Atmosphere (2nd ed.). Leonard-Hill, Great Britain.
9. International Journal of Tropical Agriculture. (2021). Survey of sugarcane fungal diseases in Uttar Pradesh (2015–2021). 39(3).
10. Jadhav, B.B., et al. (1994). Ecological methods in phyllospheric mycofloral analysis. Indian Phytopathology, 47, 112–118.
11. Last, F.T. & Warren, R.C. (1972). Non-parasitic microbes colonizing green leaves: their form and function. Endeavour, 31, 143–150.
12. Leslie, J.F. & Summerell, B.A. (2006). The Fusarium Laboratory Manual. Blackwell Publishing, Iowa.
13. Lin, Z., Zhang, Y., Que, Y., Chen, R., Chen, B. & Zhang, M. (2015). Characterization of Fusarium verticillioides isolates from Pokkah Boeng on sugarcane. Journal of Microbiology and Experimentation, 2(5), 151–157.
14. Mishra, R.R. & Dickinson, C.H. (1981). Phylloplane and litter fungi of Ilex aquifolium. Transactions of the British Mycological Society, 77(2), 329–337.
15. Munkvold, G. (2017). Fusarium species and their associated mycotoxins. Methods in Molecular Biology, 1542, 51–106.
16. Pathak, N. (1979). Studies on leaf surface fungi of mango. Ph.D. Thesis, University of Sauger.
17. Sahu, S.K. & Gupta, U. (1995). Air mycoflora of Bhilai Nagar in relation to leaf surface mycoflora of groundnut. Geobios New Reports, 14(2), 235–239.
18. Sahu, S.K. & Tiwari, K.L. (1994). Air spora and leaf surface mycoflora of cauliflower at Raipur. Advances in Plant Science, 7(2), 203–211.
19. Sharma, K. (2001). Studies on aeromycoflora in relation to leaf surface mycoflora of Ocimum sanctum. Ph.D. Thesis, Pt. R.S.U., Raipur.
20. Sharma, S., et al. (2014). Pokkah Boeng incidence in Uttar Pradesh sugarcane, 2011–12. Sugar Technology, 16(4), 398–403.
21. Singh, N.B. (2006). Studies of aeromycoflora in relation to leaf surface mycoflora of Mentha arvensis. Ph.D. Thesis, Pt. R.S.U., Raipur.
22. Singh, A., Chauhan, S.S., Singh, A. & Singh, S.B. (2006). Deterioration in sugarcane due to Pokkah Boeng disease. Sugar Technology, 8, 187–190.
23. Solomon, S. (2016). Sugarcane production and development of sugar industry in India. Sugar Technology, 18, 588–602.
24. Sugar Industry and Cane Development Department, U.P. (2021). Annual Report on Sugarcane Disease Incidence in Uttar Pradesh. Government of Uttar Pradesh.
25. Tukey, H.B. Jr. (1971). Leaching substances from plants. In T.F. Preece & C.H. Dickinson (Eds.), Ecology of Leaf Surface Microorganisms (pp. 67–80). Academic Press, London.
26. Vishwakarma, S.K., et al. (2013). Increased Pokkah Boeng incidence across sugarcane varieties 2007–2013. Sugar Technology, 15(2), 184–190.
27. Viswanathan, R. (2013). Status of sugarcane wilt: one hundred years after its occurrence in India. Journal of Sugarcane Research, 3(2), 86–106.
28. Viswanathan, R. (2017). Pathogen virulence in sugarcane red rot pathogen versus varieties in cultivation. Sugar Technology, 19, 293–299.
29. Viswanathan, R. & Rao, G.P. (2011). Disease scenario and management of major sugarcane diseases in India. Sugar Technology, 13, 336–353.
30. Weller, D.M., Raaijmakers, J.M., Gardener, B.B.M. & Thomashow, L.S. (2002). Microbial populations responsible for specific soil suppressiveness to plant pathogens. Annual Review of Phytopathology, 40, 309–348.

31. Zhang, M. & Martin, J.J.J. (2018). Fusarium species complex causing Pokkah Boeng in China. doi:10.5772/intechopen.73133.