The American Journal of Horticulture and Floriculture Research
ISSN 2689-0976 Volume 08 - 2026

Recent Machine Base Techniques and Trends for Plant Diseases Diagnosis: A Review

Shrikant B. Bhosale
Department of Botany,
Shikshan Maharshi Dnyandeo
Mohekar College Kalamb, Dist. Dharashiv,
(M.S. 413507) India

Received: 19 Feb 2026 | Received Revised Version: 22 Mar 2026 | Accepted: 18 Apr 2026 | Published: 25 May 2026

Volume 08 Issue 05 2026 | DOI: 10.37547/tajhfr/Volume08Issue05-01

Abstract

In light of exploratory information from lab and field, various authors and inquiries about have raised worry that the diverse kinds of plant diseases additionally, exceptionally unsafe to trim yield. These days extremely control completely system, for example, lab-based strategies such as Polymerase Chain Reaction (PCR), Enzyme-Linked Immunosorbent Assay (ELISA) and Fourier-Transform Infrared Spectroscopy (FTIR) is a part of the immediate and accurate identification techniques. Application utilized for the distinguishing proof and finding of illnesses at beginning periods previously pathogen destructiveness is low intensity. In this study survey, we recognize and assess ongoing patterns and strategy for plant diseases determination. Future advance will best be accomplished when agriculturists will show signs of improvement practices and strategies that limit the infections force and acknowledgment illnesses. When agriculturists are delivering better harvest yield for our developing populace with the assistance of new strategy.

Keywords: Plant Diseases, Diagnosis, PCR, ELISA, FTIR, Microbes

Cite This Article: Bhosale, S. B. (2026). Recent Machine Base Techniques and Trends for Plant Diseases Diagnosis: A Review. The American Journal of Horticulture and Floriculture Research, 8(05), 07-15. https://doi.org/10.37547/tajhfr/Volume08Issue05-01.

Introduction

Plant diseases caused microorganism, for example, microscopic organisms, growths, infections etc. finding is finished by utilizing different connected and late strategies like FTIR, ELISA microarray, PCR, distinctive spectroscopy techniques. As of late, molecular markers generally utilized like PCR, ELISA and FTIR based to create infections safe plant. DNA sequencing is use for recognizable proof of diseases with a correlation of solid and tainted examples. Each microorganism indicates distinctive side effects, yet we can't distinguish by general pathological strategy at beginning times of contamination. Creating late connected and bio-strategies are a great apparatus to anticipate future more dangers of plant pathogen.

PCR (Polymerase Chain Reaction)

The PCR system is use for location and recognizable proof *Clostridium* from clinical segregates and in addition biogas. In this examination ruminant creature

mortality happen high because of essence of *Clostridium* sp. *Clostridium* sp. enters in creature stomach by brushing as spores. At the point when purification is happening recognition it by PCR technique which is autonomous and quicker strategy. Close around 25 muscles and blood test were utilized for PCR location and 114 compost also 84 soil tests from biogas process. PCR test integral to the spacer area 16S-23S rRNA quality was utilized. Analyst closed PCR appeared to be speedier less complex and safe for recognizable proof of pathogen and additionally decide the hazard. [5] That *Fusarium* Head Blight (FHB) influenced to the grain trim misfortune because of 10 to 30 % misfortune. Microorganisms utilized against FHB as a bio-control specialist. Amid this investigation both microbial network (FHB and bacterium) was contemplated by PCR-DGGE demonstrating endophytic conduct of pathogen. 16S RNA sequencing and amplification was finished by PCR technique approach. [4] Tomato DNA was evaluated in the creepy crawly utilizing PCR. *Solanum lycopersium* hereditary data empowering to configuration tests for PCR enhancement. Positive and negative control utilizing tomato DNA and DNA molecular weight markers (100bp) were appearing by PCR amplification strategy. [13] Reported that is forthcoming approach for distinguishing proof of plant pathogen. Sustenance misfortune because of activity of pathogen is limiting the nourishment misfortune by recognition of pathogen at beginning time, for example, PCR, and ELISA. Aberrant technique additionally utilized as a part of research, for example, thermography, fluorescence imaging, and hyper spectral strategy. [16] Reverse-transcription PCR (RT-PCR) is highly sensitive system to identification plant pathogen [31, 2] and in addition continuous PCR utilized for quick determination plant pathogen in light of nucleic acid identification proof [28, 53]. Rice tainting infections' pathogen discovery by RT-PCR used to measuring the objective example pathogen and progression of an infections. It is exceptionally particular and sensitive systems which are adding to determination of ailments in rice. Two sorts of RT-PCR multiplex RT-PCR and real time RT-PCR. In multiplex RT-PCR quality particular groundwork sets inside single PCR and identify in excess of two items. Real Time RT-PCR observed straightforwardly extent to the measure of PCR item in response. [57] HIV, RNAs location utilizing spinach RNA aptamer. PCR utilized for confirmation of articulation of HIV-Spinach RNAs in human cell. Scientists at long last revealed that PCR based strategies are exceedingly quantitative. RNA aptamers were increased by PCR to supplant ATG to AAG. [8] Droplet digital PCR amplification is for location *Spiroplasma citri* correlation with RTPCR performing in view of water oil emulsion bead innovation. That is the way to deal with measure completely duplicate number of nucleic corrosives of *Spiroplasma citri* pathogen of citrus stubborn disease (CSD). Tissue concentrates of *Citrus* for evaluation of ailment contrast with PCR. That is possibility of ddPCR contrast with qPCR. Low duplicate number of *Spiroplasma citri* distinguished utilizing housekeeping gene helps to detection to location of illness in beginning period. The ddPCR is more powerful technique for disease detection in moderate or idle time of disease. [34] Validation of multiplex reverse transcriptase PCR for recognition of papaya infections. Multiplex RT-PCR assessed by indicating plasmid containing every one of the viral target quality and duplicates of infections identified effectively. RT-PCR amplified all the while in excess of one target arrangement. [6] Accurate recognition of infections in wild plants RT-PCR discovery of infections in wild plants was done by RT-PCR. RT-PCR showed that how inhibitors in tissue infections however can defeat with technique and item enhances amplification of nucleic acid. Scientists announced that ELISA and PCR is intense apparatus in environmental developmental discovery of disease. [27] One stage reverses transcriptase circle intervened isothermal intensification for tomato infection's location Torrado illness for the most part happens on tomato extensively yield misfortune. Thus, one step reverse transcript circle interceded isothermal RT-PCR measurement was effective done. This is the primary report watching the utilization of RT-LAMP test to distinguish TOTV in tomato plant. [7] Microarray advancement for identification of various tospo- viruses of tomato spotted wilt viruses infections. For this situation of research RT-PCR intensification serogroup tospovirus' gene sequencing this is planned by reverse primer. Viruses Infections oligonucleotide test hybridizes with PCR item. At long last infections distinguished on chips by hybridization of PCR product. The PCR product increased from plasmid (PTOPO-TSWV-N) serially diluted which is traditional cluster for identification of viral disease in tomato spotted withers. [32] Plant nourishing in Triatomines creepy crawly assessed by the PCR and hereditary data empowering us to configuration tests for PCR recognition. [13] Rapid and precise identification of plant pathogen by RT-PCR. RT-PCR

straightforwardly evaluates the amplicon amid DNA amplification. Compact PCR framework creates by utilizing microchip PCR framework yet shockingly it is helper instruments. DNA was removed from six parasitic and bacterial disconnects which is progressive rate 100 percent. [36] Phytoplasma contamination convey wide verity of microorganisms which is yield loss causing operator identify by utilizing PCR succession utilizing 16S-23S rRNA locus. PCR intensified Chaperonin-60 (cpn60) which is sensitive strategy were investigation with the assistance of PCR and gel electrophoresis. [14] *Xanthomonas arboricola* is located on bacterial spot disease of stone fruit and almond. Fast and particular disease was diagnosis and infection management. Result acquired by plate isolation compared and RT-PCR. It demonstrates that high relationship happen sum both strategies. [30] Control of *Fusarium graminearum* in view was RNAi through showering of long dsRNA. qPCR measurement at contagious DNA level in view of the proportion between parasitic tubulin and plant ubiquitin. Fungal DNA was determining by qPCR. [25] Develop multiplex RT-PCR for discovery of garlic virus infection contamination recognition. Twelve sort of garlic contaminated example were tried and partitioned into two sets for multiplex RT-PCR. Multiplex RT-PCR was identified focus up to similar dilution arrangement. [40] To accomplish an early infection analysis on plant-got test autonomously from sign development, sub-atomic procedures in view of PCR have been embraced. Particular traditional PCR assay is exceedingly detailed for a solitary disease. The explanatory plan might be gifted to help its separation control amongst fiery and contaminated examples. The offer was a snappy screening of tests and improves case and asset commitment in the finding of pathogens. [10] The primary PCR convention focusing on *X. arboricola pv. pruni* was produced by Pagani [11] and as of late a few new conventions of PCR and Bio-PCR [2], duplex PCR [46], multiplex PCR [24], real time SYBR Green I examine and Bio-PCR [6], and constant Taq-Man PCR [43] have been distributed. PCR altered pathogen acknowledgment and discovery of germ pathogens in wheat, with the exception of these strategies have not yet totally supplanted regular and phenotypic practice. [35] Molecular diagnostics started to develop a true energy after the presentation of PCR in the mid-1980s. Exhibit advances, for example, Q-PCR, require a modestly colossal amount of goal tissue and depend on various measures to precisely perceive particular plant pathogens. An amazing a valid example is the small-scale PCR where 40 cycles of PCR can be performed in less than 6 minutes. [23]

ELISA (Enzyme-Linked Immunosorbent Assay)

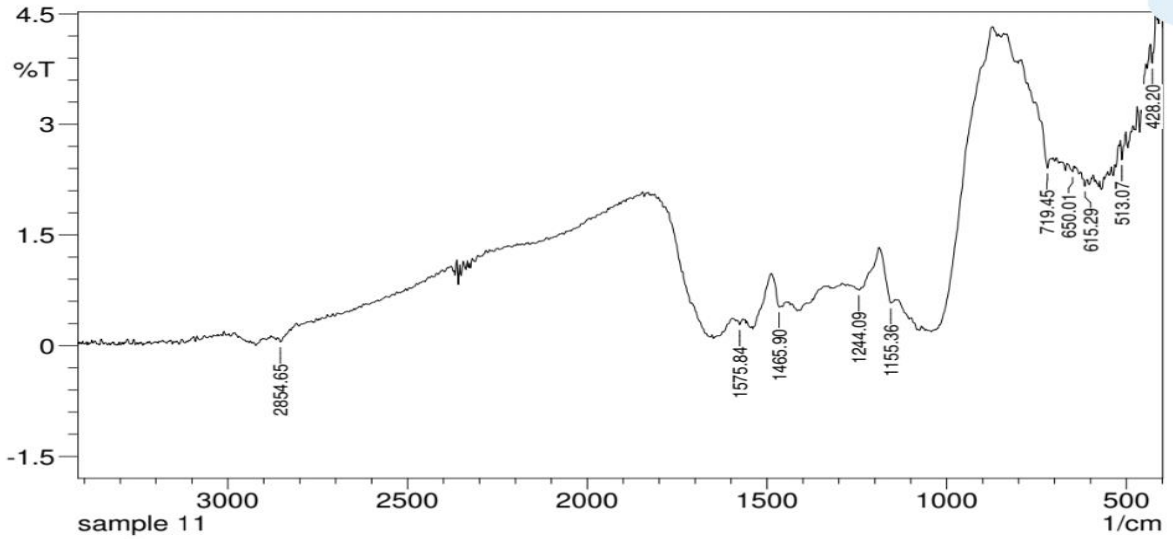
Basic protein VP2 were composed, combined, and utilized as ELISA antigens to watch against AMDV antibodies in the serum of polluted minks. Serum tests were collected from 764 minks in ranches from five unique areas, and dissected by both CIEP (a highest quality level) and peptide ELISA. A novel ELISA was produced utilizing ovalbumin-connected peptide P1 to identify against AMDV antibodies in mink. The affectability and specificity of the peptide ELISA was 98.0% and 97.5%. ELISA likewise identified 342 beginning time tainted examples. Result demonstrated that the peptide ELISA would be advised to affectability. [33] Development and Application is finished by Dot-ELISA test for conclusion rice dark streaked diminutive person infection. It is a sensitive and reliable examine for research facility hone determination; a dot enzyme-linked immunosorbent assay (dot-ELISA) strategy was produced for testing rice plants contaminated by SRBSDV. In light of hostile to SRBSDV rabbit antiserum; this new dot- ELISA was very reliable, sensitive and specific toward SRBSDV. A dot-ELISA approach was produced for the recognizable proof of novel serologically responsive SRBSDV antigens got from contaminated rice plants. This is the principal concentrate to analyze SRBSDV illness by utilizing speck ELISA technique in field. This dot-ELISA test gave another fast location framework. Agricultural specialists or even farmers themselves could test their own particular products for overshadow rice ailment. [58] Indirect ELISA and Dot-Blot measure for recognition of rice Tungro sickness. The backhanded ELISA indicated 97.5% and 96.6%, while the dot-blot test demonstrated 97.5% and 86.4% affectability and specificity, individually, when contrasted with built up PCR strategy. Specialist had created two straightforward serological examines, a plate based circuitous ELISA and a film-based dot-blot measure. The outcomes demonstrate that both tests have high sensitivity. While the specificity for the ELISA was likewise decided at 98%, the dot-blot measures have somewhat brought down estimation at around 86%. Both two tests additionally demonstrated a decent understanding contrasted and the set-up PCR technique with a Kappa file of 0.92 and 0.80 for the ELISA and the dot-blot, separately. [19] ELISA method was utilized for the quantitative and subjective investigation secondary

metabolites of plant. Indeed, even today, after 50 years, immunoassays are generally used with a few changes from the initially proposed framework, e.g., radioisotopes have been supplanted with catalysts in light of wellbeing concerns in regards to the utilization of radioactivity, which is alluded to as ELISA. Advance has been made in ELISA with the ongoing advances in recombinant DNA innovation, prompting increment in the scope of antibodies, tests, and even frameworks. It is illustrative of different explanatory strategies in view of its few points of interest over other expository techniques as far as effortlessness, cost productivity, and selectivity. A wide range is of ELISA display pretty much favorable circumstances and inconveniences. ELISA would be more recognizable to us if the immune response or counter acting agent emulating tests that are on the other hand utilized as a part of ELISA could be gotten all the more effortlessly. [49] Diseases finding of plant viral pathogens happens by ELISA. The adjustment of ELISA named volt metric catalyst immunoassay, identifies the change in electrical conductivity of the substrate, as opposed to a shading change, when followed up on by a chemical appended to an optional counter acting agent. Tissue blotching, similar to ELISA, uses antibodies raised against infections. [59] A monoclonal immunizer based triple counter acting agent sandwich ELISA was produced to uniquely recognize *Phaeomoniella chlamydospora* from grapevine wood tissues. ELISA is ready to detect particularly *P. chlamydospora* from grapevine wood, with potential to be utilized as a part of extensive scale without pathogen confirmation programs. Normally tainted grapevine plants come about TAS-ELISA were affirmed by settled PCR. [9] ELISA, first being used in the 1970s, is by a wide margin the most broadly utilized immunodiagnostic strategy as a result of its high throughput potential. Sensitivity of ELISA differs relying upon the creature, test freshness. Microscopic organisms distinguished by ELISA units are generally accessible in view of their low gear costs contrasted and other recognition techniques. This strategy has great unwavering quality, albeit false negatives are conceivable. [37] Relatively little work was done on serological discovery of plant microorganisms and parasites before the development of ELISA and monoclonal counter acting agent innovations. Mixes of ELISA and PCR strategies are utilized to enhance affectability of location and to stay away from issues with inhibitors or PCR much of the time found in plants. [36] The improvement and the adjustment were effective and fast strategies for analysis and control of plant infections. The ELISA strategy depends on the fundamental standard in which the virus antigens are perceived by their particular antibodies (IgG) in affiliation. Various serological strategies have been created for distinguishing proof and portrayal of plant virus and the appearance of the ELISA have encouraged the utilization of serology for infection recognizable proof in substantial scale. [29] ELISA tests were completed for maize streak virus, maize predominate infection, cucumber mosaic virus, sugarcane mosaic virus, maize chlorotic mottle virus and bland begomovirus. [1] Combination of nucleic corrosive tests and ELISA has the capability of its appropriation for extensive scale ordering of spreading stocks. Dependability of ELISA comes about relies upon antibodies of high fondness. [44] Microarray-based multiplex ELISA is being adjusted for disease analysis [12].

FTIR (Fourier-Transform Infrared Spectroscopy)

FTIR spectroscopy taken after by chemo metrical information treatment for the separation of growths contaminated perpetual ryegrass (*Lolium perenne*) from non-tainted grass. FTIR was utilized to quickly segregate method between contaminated by a parasitic entophyte and uninfected takes off. Just drying and granulating of the tested leaves by mortar and pestle, no other readiness steps were required. Its estimations were performed in the constricted aggregate reflection ATR. Tests were set on a Zn Se crystal and the spectra collected by chemo metrical investigation (multidimensional factor examination, various leveled group examination). ATR-FTIR permitted a quick identification of parasitic contaminations and examination complex synthetic process in the plant material and a quick and dependable device for the separation of the plant without of tedious example arrangement. [18, 55] FTIR spectroscopy: techniques, challenges in biophysics contemplate demonstrated that adaptation of basic structure of protein and peptide layer. In FTIR is enhancing the ghastly and determination as of late. Survey demonstrated that history of connected examined test IR. Dynamic wonders was neglected in this article and FTIR of protein and peptide contemplates. [22] FTIR application for ID is the yeast and dermatophytes. Conventional technique for distinguished was numerous burdens. Some yeast and dermatophytes were distinguished by FTIR procedure. Diverse range and indistinguishable to other example did not indicate likeness. FTIR were use as molecular

fingerprinting of growths. Database must reach out with consideration of various strains of uncommon species. [50] FTIR spectroscopy connected for wood rot spoils and mould fungi organisms' recognition. ATR-FTIR spectroscopy procedure is the intense instrument for fungal identification. ATR-FTIR strategy was utilized for the fluid gas and strong state material. KBR pellet was executing as customary FTIR technique for investigating and separation. Test was called from field which is wood rot spoil and form mould fungi ATRFTIR strategy is in future turn into its appropriateness, unwavering quality, restriction and potential conceivable outcomes. [21] FTIR utilized for quick dispersal strategy for recognizable proof of fungal pathogen. Soil conceived organisms were chosen for the example since it is essential and basic for control. As of late we utilized strategy as like PCR (polymerase chain reaction) and serological test is a tedious and not specific. ATR-FTIR technique is exceptionally indicated and delicate and complete strategy for identification. Results indicate distinctive spectra between different parasitic genera and demonstrate plausibility between these growths up to class level. [51] FTIR strategy for exploring cell segments of organisms. They contemplated biochemical piece and changes at atomic level inside cell by utilizing FTIR. Starches, protein, and lipids likewise examined and recognize growths changes amid various unusual conditions. In this examination complex compound process were explored and furthermore contemplated lipid, protein and poly-saccrrides of phyto-pathogenic growths. Result demonstrates that *Sclerotium rolfsii* and *Colletotrichum gloeosporiodes* expanded at 32 ^{0}C temperature and the two parasites upgrade movement of contagious digestion pathway. Discovering demonstrates that *Sclerotium rolfsii and Colletotrichum gloeosporiodes* survival at higher temperature and increment biomass and lipid creation. [54] Python-pathogen was recognizable proof by FTIR system. Fungi were making extreme harm financial plants. Location distinguishing proof and control of Fungi is an imperative for counteractive action of harm. Introduce examination utilizing FTIR is sensitive and powerful measure for fungal genera discovery and segregation. Unearthly distinction appeared by different fungal genera and result acquired amid brief timeframe. [15] Ectomycorrhizal (ECM) was recognizable proof by FTIR spectroscopy. ECM likewise connected with the base of trees and it includes in nourishing trade inside soil and plant component. ATR FTIR additionally serves to understanding the unpredictable synthetic process inside the cell level. *In situ* root tip gathered examples were utilized for FTIR examination.



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	428.2	3.8273	0.6728	433.98	418.55	21.4495	0.8218
2	513.07	2.5172	0.2967	516.92	501.49	24.2034	0.3415
3	615.29	2.1591	0.1268	626.87	609.51	28.6329	0.2016
4	650.01	2.3548	0.0856	665.44	646.15	31.2064	0.1388
5	719.45	2.4034	0.3241	754.17	707.88	71.7997	0.578
6	1155.36	0.5768	0.2334	1188.15	1143.79	92.2085	1.735
7	1244.09	0.7541	0.0222	1247.94	1238.3	20.4197	0.0805
8	1465.9	0.5224	0.1044	1489.05	1460.11	62.1724	0.2904
9	1575.84	0.2826	0.0737	1583.56	1568.13	38.4068	0.6283
10	2854.65	0.05	0.0746	2862.36	2839.22	70.6418	3.8635

Fig: - *Rhizoctonia solani* FTIR peak shows chemical composition of fungal diseases for analysis.

Result indicates otherworldly area related with sugars, protein and lipids. The date came about FTIR spectra contain data about physiology and practical treats of ECM. [45] Bacterial was portrayal by FTIR spectroscopy. They worked out by two distinct methodologies mesopillic and thermophilic microscopic organisms were examined. First approach came about emotional distinction amongst mesophilic and thermophilic life forms. Second approach was come about essentially otherworldly distinction amongst *Bacillus* and *Micrococcus* sp. [17] Pollen identification by FTIR spectroscopy just two taxa were utilized as an example from Malvaceae family for pollen grain separation. Molecular level profiling demonstrates unwavering quality for segregating pollen grain and concentrated for restorative, legal and scientific classification. [3] Infected organisms recognized by FTIR spectroscopy and application taken after by chemometrical information treatment of parasites. Samples were collected from the *Lolium perenne* and tainted and non-contaminated leaves were separate. Just drying and pounding leaves and ATR look at and test were getting ready for FTIR. ATR-FTIR is the quick segregating strategy with tedious recognized the fungal pathogen. [18] FTIR and factual examination is fast segregation growths. Result contrasted and the characterization of parasites according to the contemporary phylogenetic examinations. Spectroscopic fingerprinting gave IR cling to utilitarian synthetic gathering at the parasites Hierarchical Cluster Analysis (NCA) measurable examination technique was utilized and species arrangement in view of the reneges of IR range. Dendrogram demonstrates the connection between the organisms. [39] FTIR is intense method for portrayal of filaments fungi. Complex synthetic tests were done of microorganism described by FTIR of fungi and yeast. [52] Silver nanoparticle instigated by the fungi *Penicillium citrinum*. Research came about that FTIR utilized for molecule size, shape and nearness of various synthetic capacity gatherings. In the midst of linkage assemble was seen in parasitic example. [20] Chitin isolated from nearby sources and its identification by FTIR Spectroscopy. In the nature chitin consider alongside the cellulose biopolymer in living cells. Arthropods, nematodes, green growth and organism's content significant segment chitin. Chitin disengaged from various species and concentrated by utilizing FTIR and pinnacle fit form for data examination. [48] FTIR spectroscopy utilized for investigation of pythochemical constitutes from dissolvable for *Lentana aculeate*. Study demonstrated that pythochemical profiling of fluid leaf concentrate of *Lentana aculeate* by FTIR spectroscopy. Carbohydrates glycoside, flavonoids saponin and phenolic compound examined by FTIR. [41]

Conclusion

Plant disease identification is exceptionally shattering and proficient research field. The paper reason for existing is to display a framework of built-up technique for plant disease recognition and investigation of ongoing development. Amid review it is recognized that the real methods for discovery of plant diseases. Polymerase chain reaction (PCR), FTIR (Fourier transform infrared spectroscopy), immunofluorescence (IF), fluorescence *in-situ* hybridization (FISH), enzyme-linked immunosorbent assay (ELISA), flow cytometry (FCM) and gas chromatography-mass spectrometry (GC-MS) which are immediate location strategies. The investigation of above order procedures we have thought of following conclusion. In this survey, we assessed the right now existing techniques for recognition of plant diseases caused by pathogens, for example, microscopic organisms, infections and parasites. Albeit set up techniques, for example, PCR, FISH, ELISA, IF, FCM and GC-MS are as of now accessible and generally utilized for plant infection recognition, they are moderately hard to work, require master experts and are tedious for information investigation.

Acknowledgement

Author is thankful to Principal, Shikshan Maharshi Dnyandeo Mohekar Mahavidyalaya, Kallamb, Dist Dharshiv, for providing necessary facilities to this work.

References

1. Adamsa I. P., D.W. Mianob, Z.M. Kinyuab, A. Wangaib, E. Kimanic, N. Phirid, R. Reedere, V. Harjua, R. Glovera, U. Hanya, R. Souza-Richardsaf, P. Deb Nathag, T. Nixona, A. Foxa, A. Barnesa, J. Smitha, A. Skeltona, R. Thwaitesa, R. Mumforda and N. Boonhama (2013) Use of next-generation sequencing for the identification and characterization of Maize chlorotic mottle virus and Sugarcane mosaic virus causing maize lethal necrosis in Kenya. *Pla Pathology*. 62, 741–749.

2. Ark S.Y, Lee Y.S, Koh Y.J, Hur J.S and Jung J.S (2010) Detection of *Xanthomonas arboricola* pv. *pruni* by PCR using primers based on DNA

sequences related to the HRP genes. *J Microbiol.*48: 554-558.

3. Aror Komal (2014) Pollen identification of *Hibiscus rosa-sinensis* and *Sida acuta* through FTIR spectroscopy. *Ind J of Fund and App Life Sci*. 4(4): 141-144.
4. Baffoni L., F. Gaggia, N. Dalanaj, A. Prodi, P. Nipoti, A. Pisi, B. Biavati and D. Di Gioia (2015) Microbial inoculants for the biocontrol of *Fusarium* spp. in durum wheat. *BMC Microbiology* 15:242: 1-10.
5. Bagge E, S. S. Lewerin and K-E Johansson (2009) Detection and identification by PCR of *Clostridium chauvoei* in clinical isolates, bovine faeces and substrates from biogas plant. *Acta Veterinaria Scandinavica*, 51:8, 1-9.
6. Ballard E.L, Dietzgen R.G, Sly L.I, Gouk C, Horlock C, Fegan M (2011) Development of a Bio-PCR protocol for the detection of *Xanthomonas arboricola* pv. *pruni*. *Plant Dis*. 95: 1109-1115.
7. Budziszewska M., P. Wieczorek, A. Obre palska-Ste plowska (2016) One-step reverse transcription loop-mediated isothermal amplification (RT-LAMP) for detection of tomato torrado virus. *Arch Virol* 161:1359–1364.
8. Burch B.D., C. Garrido and D. M. Margolis (2018) Detection of Human Immunodeficiency Virus RNAs in living cells using spinach RNA aptamers. *Virus Research.* 15; 228: 141–146.
9. Cardoso F., T. Nascimento and H. Oliveira (2014) Development of a monoclonal antibody TASELISA assay for detection of *Phaeomoniella chlamydospora*. *Phytopathologia Mediterranea.* 53(1): 194−201.
10. Cellini A., S. Blasioli, E. Biondi, A. Bertaccini, I. Braschi and F. Spinelli (2017) Potential applications and limitations of electronic nose devices for plant disease diagnosis. *Sensors*. 17, (2596): 2-13.
11. Chen D.H and Ronald P.C. (1999) A rapid DNA minipreparation method suitable for AFLP and other PCR applications. *Plant Mol Biol Rep*. 17:53-57.
12. Crowther J.R. (2009) The ELISA Guidebook. 2nd edition, Springer Protocols: Methods in Molecular Biology. (516): 566
13. Díaz-Albiter H.M, T.N. Ferreira, S.G. Costa, G.B. Rivas, M. Gumiel, D.R. Cavalcante, M.G. Pavan, M.S. Gonzalez, C.B. de Mello, V.M. Dillon, R.V. Brun, E. de Souza Garcia, M.M Lima, D.P. de Castro, R.J. Dillon, P. de Azambuja and F.A. Genta (2016) Everybody loves sugar: first report of plant feeding in triatomines. *Parasites and Vectors*. 9,114: 1-8.
14. Dumonceaux TJ, Green M, Hammond C, Perez E, Olivier C (2014) Molecular diagnostic tools for detection and differentiation of *phytoplasmas* based on chaperonin-60 reveal differences in host plant infection patterns. *PLoS ONE* 9(12) 1-21: e116039.
15. Erukhimovitch V., L. Tsror, M. Hazanovsky, M. Talyshinsky, I. Mukmanov, Y. Souprun and M. Huleihel (2005) Identification of fungal phyto-pathogens by Fourier-Transform Infrared (FTIR) microscopy. *J of Agri Tech* 1(1): 145-152.
16. Fang Yi and R. P. Ramasamy (2015) Current and prospective methods for plant disease detection. *Biosensors,* 4*,* 537-561.
17. Garip Sebnem (2005) the characterization of bacteria with Fourier transforms infrared (FTIR) spectroscopy. Thesis M. Sc. in biology, The graduate school of natural and applied sciences middle east technical university.
18. Helmut Brandl (2013) Detection of fungal infection in *Lolium perenne* by Fourier transform infrared spectroscopy. *Journal of Plant Ecology* 6:265-269.
19. Henry Sum M.S., S.F. Yee, L. Eng, E. Poili and J. Lamdin (2017) Development of an indirect ELISA and dot-blot assay for serological detection of rice Tungro disease. *Bio Med Research International* 1-7.
20. Honary S., H. Barabadi, E. Gharaei-Fathabad and F. Naghibi (2013) Green synthesis of silver nanoparticles induced by the fungus *Penicillium citrinum*. *Tro J of Pharma Res.* 12 (1): 7-11.
21. Jelle B. P. and P. J. Hovde (2012) Fourier Transform Infrared radiation spectroscopy applied for wood rot decay and mould fungi growth detection. *Adv in Mat Sci and Eng,* 1-6. doi:10.1155/2012/969360.
22. Jessica J. Li b, Christopher M. Yip (2013) Super-resolved FT-IR spectroscopy: Strategies, challenges, and opportunities for membrane biophysics. *Biochimica et Biophysica Acta* (1828): 2272–2282.
23. Khiyami M.A., H. Almoammar, Y.M. Awad, M.A. Alghuthaymi and K.A. Abd-Elsalam (2014) Plant pathogen nanodiagnostic techniques: forthcoming changes? *Biotec and Biotec Equip*, 28:5, 775-785.
24. Kiselinova M, Pasternak AO, De Spiegelaere W, Vogelaers D, Berkhout B, Vandekerckhove L. (2014) Comparison of droplet digital PCR and seminested real-time PCR for quantification of cell-associated HIV-1 RNA. *PloS one*. 9(1): 85999.

25. Koch A., D. Biedenkopf, A. Furch, L. Weber, O. Rossbach, E. Abdellatef, L. Linicus, J. Johannsmeier, L. Jelonek, A. Goesmann, V. Cardoza, J. McMillan, T. Mentzel, K.H. Kogel (2016) An RNAi- based control of *Fusarium graminearum* infections through spraying of long dsRNAs involves a plant passage and is controlled by the fungal silencing machinery. *PLoS Pathog* 12(10): 1-22.

26. Koo C., M. Malapi-Wight, H.S. Kim, O.S. Cifci, V.L. Vaughn-Diaz, Bo Ma, S. Kim, H. Abdel-Raziq, K. Ong, Young-Ki Jo, D. C. Gross, Won-Bo Shim, A. Han (2013) Development of a realtime microchip PCR system for portable plant disease diagnosis. *PLoS ONE* 8(12): e82704.

27. Lacroix C, Renner K, Cole E, Seabloom EW, Borer E.T, Malmstrom C.M (2016) Methodological guidelines for accurate detection of viruses in wild plant species. *Appl Environ Microbiol*. 82:1966 – 1975.

28. Lievens, B. Brouwer, M. Vanachter, A.C.R.C. Cammue, B.P.A. Thomma, B.P.H.J. (2006) Realtime PCR for detection and quantification of fungal and oomycete tomato pathogens in plant and soil samples. *Plant Sci.* 171, 155–165.

29. Lima J.A.A., A. Kelly Q. Nascimento, P. Radaelli and D. E. Purcifull (2012). Serology Applied to Plant Virology, Serological Diagnosis of Certain Human, Animal and Plant Diseases.

30. LoÂ pez-Soriano P., P. Noguera, M.T. Gorris, R. Puchades, A.A. Maquieira, E. Marco-Noales, M. M. Loapez (2017) Lateral flow immunoassay for on-site detection of *Xanthomonas arboricola* pv. *pruni* in symptomatic field samples. *PLoS ONE* 12(4): 1-13.

31. Lopez, M.M., Bertolini, E. Olmos, A. Caruso, P. Corris, M.T. Llop, P. Renyalver, R. Cambra, M. (2003) Innovative tools for detection of plant pathogenic viruses and bacteria. *Int. Microbiol.*, 6, 233–243.

32. Lu-Yuan Liu, He-Yi Ye, Tsang-Hai Chen and Tsung-Chi Chen (2017) Development of a microarray for simultaneous detection and differentiation of different tospoviruses that are serologically related to Tomato spotted wilt virus. *Virology Journal* 14:1 1-10.

33. Ma F., L. Zhang, Y. Wang, R. Lu, B. Hu, S. Lv, X. Xue, X. Li, M. Ling, S. Fan, H. Zhang, X. Yan (2016) Development of a peptide ELISA for the diagnosis of Aleutian mink disease. PLoS ONE 11(11): 1-13.

34. Maheshwari Y, Selvaraj V, Hajeri S, Yokomi R (2017) Application of droplet digital PCR for quantitative detection of *Spiroplasma citri* in comparison with real time PCR. *PLoS ONE* 12(9): 0184751.

35. Majumder D., T. Rajesh, E. G. Suting and A. Debbarma (2013) Detection of seed borne pathogens in wheat: recent trends. *Austr J Crop Sci*. 7(4): 500-507.

36. Martin R.R., D. James and C. A. Levesque (2000) Impacts of molecular diagnostic technologies on plant disease management. *Annu Rev Phytopathol*. 38:207–239.

37. Martinelli F., R. Scalenghe, S. Davino, S. Panno, G. Scuderi, P. Ruisi, P. Villa, D. Stroppiana, M. Boschetti, L.R. Goulart, C.E. Davis and A.M. Dandekar (2015) Advanced methods of plant disease detection: A review. *Agro for Sust Devt*. 35(1): 1-25.

38. Mendoza LG, McQuary P, Morgan A, Gangadharan R, Brignac S, et al. (1999) High throughput microarray-based enzyme-lniked immunsorbent assay (ELISA). Biotechniques 27(4): 780-787.

39. Mularczyk-Oliwa M., A. Bombalska, M. Kaliszewski, M. Włodarski, M. Kwasny, K. Kopczyński, M. Szpakowska, E. A. Trafny (2013) Rapid discrimination of several fungus species with FTIR spectroscopy and statistical analysis. 62 (3): 71-80.

40. Nam M., Yeong-Hoon Lee, C.Y. Park, Min-A Lee, Yang-Soo Bae, S. Lim, J.H. Lee, J.S. Moon, and Su-Heon Lee (2015) Development of multiplex RT-PCR for simultaneous detection of garlic viruses and the incidence of garlic viral disease in garlic genetic resources. *Plant Pathol J. 31(1):90-96.*

41. Narendhran, S. and R. Sivaraj (2015) Fourier transforms infrared spectroscopy analysis of phytochemical constituents of various solvent extracts from *Lantana aculeate* L. and its antibacterial activity. *Inter J of Cur Res.* 7(7): 18177-18180.

42. Pagani M.C. (2004) An ABC transporter protein and molecular diagnoses of Xanthomonas arboricola pv. Pruni causing bacterial spot of stone fruits. *Raleigh, North Carolina, USA*: North Carolina State University, Ph.D. thesis.

43. Palacio-Bielsa A, Cubero J, Cambra M.A, Collados R, Berruete I.M, LoÂpez M.M (2011) Development of an efficient real-time quantitative PCR protocol for detection of *Xanthomonas arboricola* pv. *pruni*

in *Prunus* species. *Appl Environ Microbiol*. 77: 89-97.

44. Patel R.N., D.R. Patel, R. Bhandari, N. Silawat, U. Homkar and J. Sharma (2016) Upcoming plant pathological techniques in the disease diagnosis. *J Microbiol Exp* 3(2): 1-11.

45. Pena R., C. Lang, A. Naumann and A. Polle (2014) Ectomycorrhizalidentificationinenvironmentalsamplesoftreerootsby Fourier transforminfrared (FTIR) spectroscopy. *Fron in pla sci*. 5: 229, 1-9.

46. Pothier J.F, Pagani M.C, Pelludat C, Ritchie D.F, Duffy B (2011) A duplex-PCR method for species and pathovar level identification and detection of the quarantine plant pathogen *Xanthomonas arboricola* pv. *pruni*. *J Microbiol Meth*. 86: 16-24.

47. Pothier J.F, VorhoE lter FJ, Blom J, Goesmann A, PuEhler A, Smits THM *et al.* (2011) The ubiquitious plasmid pXap41 in the invasive pathogen *Xanthomonas arboricola* pv. *pruni*, complete sequence and comparative genomic analysis. *FEMS Microbiol Lett*.; 323: 52-60.

48. Prabu K. and E. Natarajan (2012) Isolation and FTIR spectroscopy characterization of chitin from local sources. *Adv in App Sci Res*. 3(2): 1870-1875.

49. Sakamoto S., W. Putalun, S. Vimolmangkang, W. Phoolcharoen, Y. Shoyama, H. Tanaka, S. Morimoto (2018) Enzyme-linked immunosorbent assay for the quantitative and qualitative analysis of plant secondary metabolites. *J of Natu* Medi. 72:32–42.

50. Salem E Z., M.D, I. M. I. Shahin M.D, Y. F. Mohammed M.D, H. M. Abdo M.D, M. F. Abdel Hamid M.D, H. E. Emam M.D and M. F. Abdel Salam M.D. (2010) Applicability of Fourier Transform Infrared (FT-IR) spectroscopy for rapid identification of some yeasts and dermatophytes isolated from superficial fungal infections. *J. Egypt Women Dermatol Soc.* 7(2): 105-110.

51. Salman A., L. Tsror, A. Pomerantz, R. Morehc, S. Mordechai and M. Huleihel (2010) FTIR spectroscopy for detection and identification of fungal phytopathogenes. *Spectroscopy.* (24): 261–267.

52. Santos C., M. E. Fraga, Z. Kozakiewicz, N. Lima (2010) Fourier transform infrared as a powerful technique for the identification and characterization of filamentous fungi and yeasts. *Res in Micro* 161: 168-175.

53. Schaad N.W, Frederick R.D. (2002) Real-time PCR and its application for rapid plant disease diagnostics. *Can. J. Plant Pathol*. *24*, 250–258.

54. Sompong M., K. Thumanu, I. Prakhongka, B. Burapatpong, D. Athinuwat, S. Prathuangwong and N. Buensanteai (2013) Infrared spectroscopy: Methods for investigating cellular components of phytopathogenic fungi response to temperature stress. *Afri J of Micro Res* 7(34): 4331-4337.

55. Szeghalmi A., S. Kaminskyj and K.M. Gough. (2006) A synchrotron FTIR micro spectroscopy investigation of fungal hyphae grown under optimal and stressed conditions. *Anal Bioanal Chem.*

56. Tuo D., W. Shen, Y. Yang, P. Yan, X. Li and P. Zhou (2014) Development and validation of a multiplex reverse transcription PCR assay for simultaneous detection of three papaya viruses. *Viruses* 6, 3893-3906.

57. Uehara-Ichiki T., T. Shiba, K. Matsukura, T. Ueno, M. Hirae and Takahide Sasaya (2013) Detection and diagnosis of rice-infecting viruses. *Frontiers in microbiology*. 4, 289, 1-7.

58. Wang Z., D. Yu, X. Li, M. Zeng, Z. Chen, L. Bi, J. Liu, L. Jin, D. Hu, S. Yang and B. Song (2012) The development and application of a Dot-ELISA assay for diagnosis of southern rice black-streaked dwarf disease in the field. *Viruses*, *4*, 167-183.

59. **59.** Webster C. G., S.J. Wylie, and M.G. K. Jones (2004) Diagnosis of plant viral pathogens. *Current Science,* 86, 12, 1604-1607.