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## Indian Plant Virus Database – a platform for showcasing research on plant viruses in India

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*Indian Plant Virus Database (IPVdb) (<http://220.227.138.213/virusdb/>) hosts information on plant viruses reported from India. To develop this, basic information on plant viruses, their occurrence, particle morphology, transmission, symptomatology and host range were collected and compiled from published literature. Sequence information corresponding to each of the virus species was gathered from the GenBank. The information assembled was organized as a searchable database using MySQL and PHP. In the home page of the database, a general outline about viruses, their history, taxonomy, transmission and management are provided. An alphabetical index of all virus species reported from India is also given in the home page along with their corresponding genera and family names. For each virus species entry, a brief introduction about the virus, its particle morphology, transmission, its natural host range, symptomatology and detection methods are given. Key references and all available sequences (both complete and partial) of each of the virus species are also provided. Selected sequences can be directly downloaded from the website in FASTA format for downstream analysis. Provision for BLAST analysis (Viro Blast) provided in the database will help researchers in quick identification of their samples.*

In India, virus-like infections on plants were reported by many plant pathologists in the 19th century, but distinct viral problems were recognized in crops like cardamom, bhendi, sugarcane, tomato, legumes and others only by early part of the 20th century<sup>1,2</sup>. Mollison in 1900 reported *katte* or mosaic disease of cardamom in Uttara Kannada District of the present Karnataka State as a severe damaging disease<sup>1</sup>. Subsequently, mosaic of sugarcane and tobacco in Maharashtra, Karnataka, Gujarat and Deccan Plateau of Karnataka, Andhra Pradesh and Tamil Nadu with up to 50% infection were reported by Kulkarni in 1924 (refs 1, 2). While initial studies mainly focussed on biological characterization of viruses, virus detection and diagnosis slowly gained importance in the country during 1970s. Bioassay and serology-based methods were mainly used for virus identification during 1990s. However, currently, nucleic acid-based approaches such as cloning and sequencing of viral genome are commonly being employed for correct identification and differentiation of viruses and their strains infecting various crops in India. As a result, a large number of partial genome sequences of various viruses infecting different crops, and complete genome sequences of a few virus isolates are now getting accumulated in public databases. The Indian Plant Virus Database (IPVdb) aims to compile all these scattered information on Indian viruses into a single, searchable database

similar to the Descriptions of Plant Viruses (DPV) web<sup>3</sup>.

Literature on plant viruses was retrieved from secondary resources like Commonwealth Agricultural Bureau International (CABI) Direct<sup>4</sup>, DPV web<sup>3</sup> and books<sup>2,5</sup>. The sequence information pertaining to each of the virus species was downloaded from the National Center for Biotechnology Information's (NCBI's) GenBank<sup>6</sup>. The collected information was compiled, classified and organized as a database using the database management system, MySQL. In this database, PHP is used as the server side scripting language. A user friendly interface to the database was developed using HTML. Along with HTML, bootstrap technique was also used to provide mobile compatibility. The database is hosted on the ICAR-Indian Institute of Spices Research server with URL link, <http://220.227.138.213/virusdb/>.

The home page of IPVdb provides a simple and easy access to all webpages of the site. There are six major sections in the database, accessed from a navigation bar at the top of the page (Figure 1). The home page contains a brief introduction about the database and a search option which helps the user to search various Indian plant viruses based on the virus name or host name or diseases. Search results give details like genus, family and virus species name which contains a link that provides a detailed description of that particular species.

'About virus' section gives a brief general introduction about viruses, their history and the current taxonomic classification of viruses providing family, genera and type-species of all known plant viruses reported worldwide so far, as per the International Committee on Taxonomy of Viruses (ICTV)<sup>7</sup>. A brief information on the general modes of plant virus transmission and disease management is also provided in this section.

The 'Index' link contains three sub-links namely, Family index, Genus index and Name index, in which Family and Genus indices provide hierarchy details, Name index lists all the virus species reported from India along with its genus and family names ([Supplementary Figure S1](#)). There are 168 plant virus species belonging to 48 genera in 19 families including the 'unassigned' ones listed in this section. The brief information provided on each of the virus species includes introduction, disease caused, distribution, particle morphology, transmission method, detection methods, natural host range and symptomatology of that species and a few selected references (Figure 2).

The link 'Sequences' helps the user to select and download multiple sequences in a single FASTA file. All the available sequences of each virus species reported from India are grouped into 'partial' and 'complete' sequences ([Supplementary Figure S2](#)). The sequences can be accessed along with their GenBank database



Figure 1. A screenshot of homepage of the Indian Plant Virus Database (IPVdb).

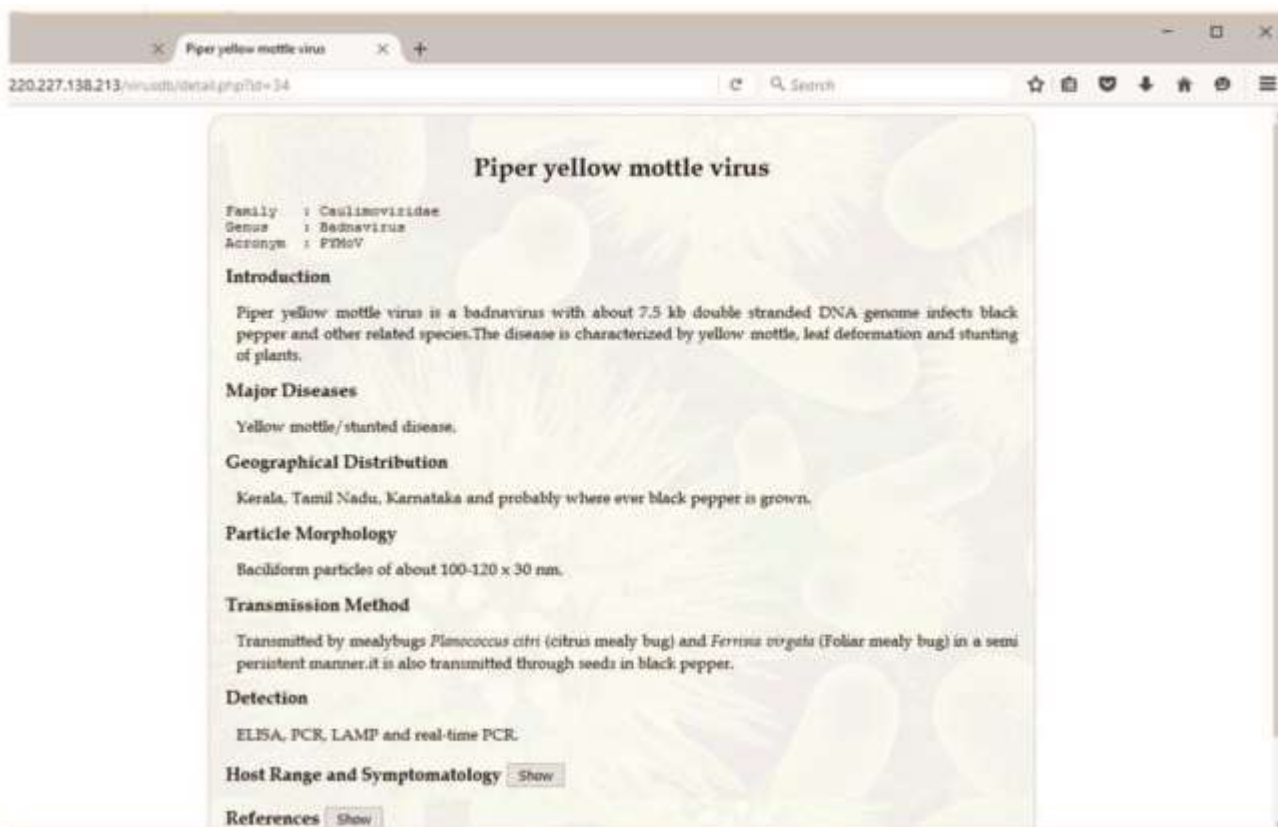


Figure 2. A screenshot showing description of a sample virus species.

accession number, host and geographical region from where it was reported. The single or multiple sequences can be selected and downloaded in FASTA format for any downstream analysis. A local blast named 'Viro Blast' incorporated in the database helps the user to search both protein and nucleotide query sequences against the available sequences in the database. The results of blast search will be in tabular form showing query-id, sequence-id (gi), sequence-id (gb), per cent identity, alignment length, mismatches, gap opens, query start, query end, subject start, subject end, e-value, bit score and organism name. 'Institutes' section lists institutes and universities actively engaged in plant virus research in India. In 'Feedback' section, the users can provide suggestions to improve the database.

Overall, this database will help in comparing different plant virus species in India by providing all available

resources at one place, thus making studies on these plant viruses simple and easy. This portal will be useful to researchers, students and officials engaged in plant quarantine and biosecurity activities.

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