

Musa Information Resources: Biodiversity, disease and pest management database

Vasu Arora¹, Neera Kapoor², Samar Fatma¹, Sarika Jaiswal¹, Mir Asif Iquebal¹, Anil Rai¹, Dinesh Kumar¹

1 Centre For Agricultural Bioinformatics, ICAR-Indian Agricultural Statistics Research Institute,
Library Avenue, PUSA, New Delhi, 110012, India.

2 School of Sciences, Indira Gandhi National Open University (IGNOU), Maidan Garhi, New Delhi, 110068, India.

E-mail : Dinesh.Kumar@icar.gov.in

Contact No. : +91-9540953253

Submitted : 13.05.2017

Accepted : 21.07.2017

Published : 30.08.2017

Abstract

Genus *Musa* is of great importance worldwide due to the commercial and nutritional value of cultivated varieties belonging to the family *Musaceae* of order *Zingiberales* that includes bananas and plantains which are monocotyledonous, herbaceous flowering plants. Banana has valuable nutritional content of vitamin C, B6, minerals and dietary fibre and is considered to be rich energy source. We have designed a comprehensive web-based database, *Musa* Information Resources to provide comprehensive information available world-wide at a single platform. The database provides access to the morpho-taxonomic data, geographical location, economic status and usage of the various *Musa* varieties, passport data for 3630 accessions of banana available worldwide. Varieties can be classified based on the morphological features. The database also provides disease and pest management information, in order to protect the crop from harmful infections. The sophisticated web-based graphical user interface allows efficient and desired retrieval of data, making it a comprehensive and intricate tool. *Musa* Information Resources can be accessed at http://webtom.cabgrid.res.in/Musa_resources/

Key words :

INTRODUCTION

After rice, wheat and corn, Banana (*Musa* spp.), an edible fruit crop, is the fourth most important crop widespread in tropical and subtropical regions around the world. Because of its high nutritional value, the banana fruit is an essential food for human life in many developing countries^[1]. It is rich in carbohydrates, vitamins and minerals, and also possesses potential applications in industries as well as therapeutics. Banana flower as well as pseudostem are used as food supplements for diabetics as they are having anti-diabetic and anti-advanced glycation end-products (AGEs) properties^[2]. Banana is a source of natural antioxidants also with high free radical scavenging activities, and is used in the production of baby food, alcohol, and confectionary items and also used as a drug binder and disintegrant in various pharmaceutical products^[3]. Banana fruit and its organic residues are commonly used for the production of ethanol^[4].

Genus *Musa*

Bananas and plantains are giant, herbaceous, monocotyledonous flowering plants belonging to the order *Zingiberales* and the family *Musaceae*, with upto 3 m in height, with no lignification or secondary thickening of stems^[5]. The centre of origin of banana is in South-East Asia, where they migrated from India to Polynesia^[6]. The centre of diversity has been placed in Malaysia or Indonesia^[7]. The plants are distributed mainly in tropical rainforests^[8]. India is one of the major centres of origin as well as diversity of banana at the global level along with Papua New Guinea and South-east Asian countries^[9]. Banana (*Musa* spp.) is divided in two main categories: dessert and culinary bananas^[10]. Dessert bananas are consumed raw when ripe and yellow, are distinguished by the sweet flavor and make up 43% of the world production, whereas the cooking banana or culinary fruits are generally used in cooking. They may be eaten

while ripe or unripe. Some cooking bananas are also referred to as plantains^[16].

Morphological data suggests that *Musa* is very diverse genus with well-defined characters^[11]. Cultures of about 3000 *Musa* cultivars and 180 *Musa* wild species are maintained at the Biodiversity International Transit Centre (ITC) in Belgium, representing most of the banana diversity. These numbers are constantly changing as many new species are yet to be identified. It is also believed that many more *Musa* species may be identified if new explorations are made within its center of diversification^[12]. The *Musa* crop suffers from many devastating diseases^[13], and there is a constant challenge provided by newly identified diseases and newly discovered virulent disease strains to existing varieties, which are met with practices to control disease spread on the crop, the application and development of chemical controls and search for new genetically resistant cultivars.

We have designed a comprehensive web-based database, *Musa* Information Resources to provide comprehensive information available world-wide at a single platform. As banana diversity is declining faster, the conservation strategies could be implemented effectively for the sustainable utilization, these resources will be quite helpful. The database provides access to the morpho-taxonomic data, geographical location, economic status and usage of the *Musa* varieties. World production of banana is seriously threatened by many biotic and abiotic diseases, nematodes, viruses and insect pests. Timely identification and control of these pests and diseases will help in efficient management and reduction of economic losses. So, preparation of a web based information system for *Musa* pest and disease management will help in the proper and timely identification of the diseases and/or infections. Additionally, the sophisticated web-based graphical user interface allows efficient and desired retrieval of data, making it a comprehensive and intricate tool. The web-interface will certainly be useful to the



Fig. 1: Three-tier architecture of the *Musa* Information Resources

users to interpret and extract the required information more effectively.

METHOD

Data Collection: For the development of database, phenotypic data for globally available *Musa* varieties was collected from Krishisewa: Agriculture information Hub: <http://www.krishisewa.com/>^[14]. Information pertaining to variety, origin, geographical distribution, plant characteristics, fruit volume, crop duration, bunch weight, pulp/peel ratio, acidity, total sugars, sugar/acid ratio and shelf life for 24 banana varieties was collected and stored in the database. Morpho-taxonomic passport data for 3630 accessions of banana available worldwide was downloaded from *Musa* Germplasm Information System (MGIS): <http://www.crop-diversity.org/mgis/>^[15] and deposited in database. Data viz. causal organism, damage, symptoms, part of plant affected, damage and management of disease, for 22 biotic banana diseases and symptoms, part affected, damage information about 14 abiotic diseases were downloaded from Pro *Musa*: <http://www.promusa.org/Pests+and+diseases+portal>^[17]

and put in the database. Information pertaining to scientific lineage, distribution, host range, damage caused, biological control and management was collected for the 28 insect pests that affect banana crop.

Database development: *Musa* Information Resources is an online relational database with “three-tier architecture” viz. a client tier, middle tier and database tier. Database is developed using MySQL, integrated with tables for *Musa* varieties, passport information, biotic diseases, abiotic diseases, and pests affecting the crop. The Database is linked to a user friendly web interface designed with an open source scripting language PHP and HTML. The front-end of the database is developed using PHP, HTML, and Javascript.

RESULTS

Web Interface: The web server comprises of five tabs viz. Home, Search, Management, Tutorial and Team. Home tab includes description and importance of database with its usage toward plant biologists and horticulturists. Search and Management are the main tabs of the Web server. Search tab

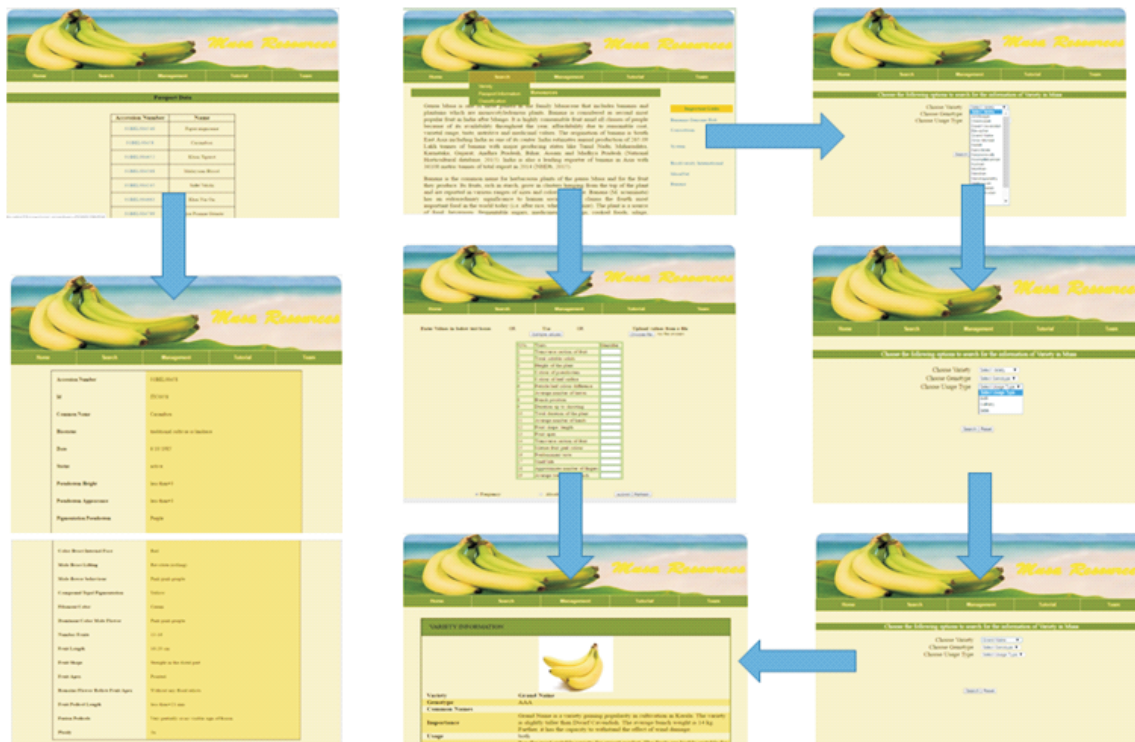


Fig. 2: Searching the *Musa* varieties

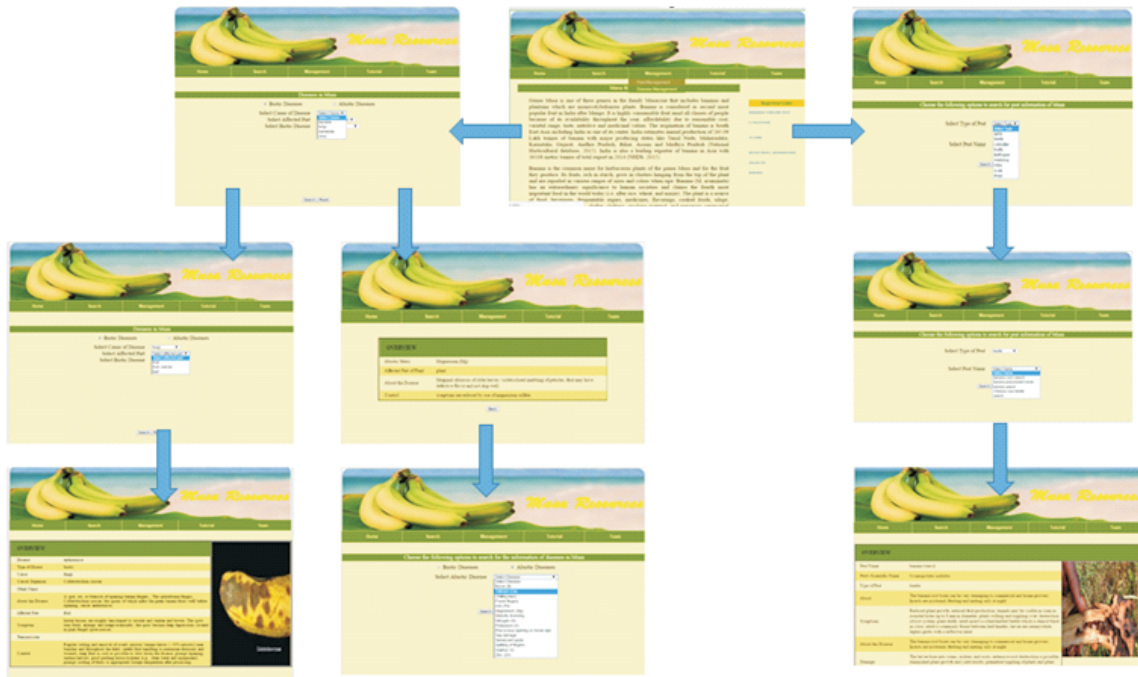


Fig. 3: Diseases and Pest Management

comprises of three submenus, Variety, Passport information and Classification whereas Management tab has two submenus - Disease Management and Pest Management.

Utility of Database

Using Variety Search, various *Musa* varieties can be searched either by selecting the name of variety from drop-down menu, or selecting the genotype of *Musa* whether AAA, AB, ABB etc., or by choosing the usage type - dessert or culinary. Information pertaining to variety including origin, geographical distribution, plant characteristics, fruit volume, crop duration, bunch weight, pulp/peel ratio, acidity, total sugars, sugar/acid ratio, and shelf life along with images can be obtained by selecting the name variety of banana. Passport Information search gives a list of 3630 accessions of banana available worldwide., On selecting the required accession, the complete information is displayed in accordance to the descriptors for Banana (*Musa* spp) published by IPGRI-INIBAP/CIRAD (1996). Classification tab is useful for classifying the varieties on the basis of Frequency and Absolute Distance. Where each feature corresponding to the varieties is converted into mathematical values, user assigns mathematical values to the features of variety in order to identify the variety he has. The tool compares the input values with the values stored in the database and classifies the varieties. Pest Management tab gives an option to select the type of pest amongst aphid, beetle, fruit fly, mites, thrips etc., on selecting the type of pest, the list with the names of pests is displayed, where user can select the desired pest and retrieve the information about scientific lineage, distribution, host range, damage caused, biological control and management. Disease Management tab gives option to choose between biotic and abiotic diseases, Among biotic stresses, user can select the type of infection, whether fungal, bacterial, viral or nematode, part of the plant affected, leaf, fruit or both, and select the disease to get the causal organism, damage, symptoms, part of plant affected, damage and management of disease. Similarly, information about various abiotic stresses like fused fingers,

chilling injury, sap damage, mineral deficiencies etc. affecting *Musa* crop can also be retrieved.

DISCUSSION

The webserver has a database of banana varieties comprising the phenotypic data alongwith photographs of 24 banana varieties and morpho-taxonomic passport data for 3630 accessions of banana available worldwide. The web resource has a disease and pest management database with information about 22 biotic banana diseases, 14 abiotic diseases and various mineral deficiencies. Information pertaining to scientific lineage, distribution, host range, damage caused, biological control and management has also been compiled for the 28 insect pests that affect banana crop. The database has a web interface to access the information along with customized query options for searching the desired content. The web server has a classification tool that compares the user assigned values with the values stored in the database and classifies the varieties. Classification is done on the basis of frequency and absolute distance where frequency of the variety is the maximum number of values matching with the database value and absolute distance is the absolute value of difference between input values and database values. There are over a thousand domesticated *Musa* cultivars having a good amount of genetic diversity, thereby indicating its multiple origins from different wild hybrids between two principle ancestral species.

Hence, an online genetic diversity database containing all the phenotypic and genotypic information related to all the *Musa* varieties will be a great help to *Musa* cultivars as well scientific community involved in related research. World production of banana is seriously threatened by many diseases, nematodes, viruses and insect pests. Timely identification and control of these pests and diseases will help in efficient management and reduction of economic losses. The web based information system for *Musa* pest and disease management will help in the proper and timely identification of the diseases and/or infections.

CONCLUSION

Among all the horticultural crops, banana has an important place. Because of monoculture of a selected few cultivars and destruction of habitats by human encroachment, banana resources are rapidly eroding. Thus, there is need for conservation, further exploration and documentation of these resources for future exploitation. Meanwhile, several diseases have greatly hampered banana production. There are major challenges to banana production from various biotic diseases, abiotic stresses, and pests. There are new demands for sustainability, quality, transport and yield. Databases retrieving comprehensive information on the *Musa* will be extremely useful to modern *Musa* researchers and plant breeders, and would enable new insights and discoveries concerning evolutionary relationships. So, in order to converge all information at one place and to allow the rapid dissemination of information to potential users, this database has been developed.

ACKNOWLEDGEMENTS

Authors are thankful to Indian Council of Agricultural Research, Ministry of Agriculture and Farmers' Welfare, Govt. of India for providing all facilities. Authors are also thankful to Director, ICAR-IASRI, New Delhi for providing computational facility, ASHOKA where all analyses were performed using public domain data.

REFERENCES:

- Pillay M, Ude G, Kole C: Genetics, Genomics, and Breeding of Bananas; Science Publishers, 2012.
- Bhaskar JJ, Shobha MS, Sambaiah K, Salimath PV. Beneficial effects of banana (*Musa* sp. var. elakki bale) flower and pseudostem on hyperglycemia and advanced glycation end-products (AGEs) in streptozotocin-induced diabetic rats. Journal of physiology and biochemistry. 2011;67(3):415-425.
- Eleazu CO, Eleazu KC, Awa E, Chukwuma S.C. Comparative study of the phytochemical composition of the leaves of five Nigerian medicinal plants Afr J Biotechnol. 2011;10:16948.
- Valasquez HI, et al. Int J of Thermodynamics. 2009;12:155.
- Tomlinson P. Anatomy of the monocotyledons. III. Commelinales Zingiberales. Oxford: Clarendon Press: 1969.
- Simmonds NW. Evolution of the bananas. London: Longmans, Green & Co: 1962.
- Daniells JW, Jenny C, Karamura DA, Tomekpe K, Arnaud E, Sharrock S, editors. Diversity in the genus *Musa*. Montpellier, France: INIBAP: 2001. *Musalogue*: A catalogue of *Musa* germplasm.
- Wong C, Kiew R, Argent G, Set O, Lee SK, Gan YY. Assessment of the validity of the sections in *Musa* (*Musaceae*) using AFLP. Annals of Botany. 2002;90:231238.
- Simmonds NW, Shepherd K. Taxonomy and origins of cultivated bananas. Botanical Journal of the Linnean Society. 1955;55:302312.
- Moore NY, Bentley S, Pegg KG, Jones DR. Montpellier, France: INIBAP: 1995. *Musa* Disease Fact Sheet No 5. Fusarium wilt of banana.
- Pollefeys P, Sharrock S, Arnaud E. Preliminary analysis of the literature on the distribution of wild *Musa* species using MGIS and DIVA-GIS. Montpellier, France: INIBAP: 2004.
- Häkkinen A., Rinne M, Vasankari T, Santtila M, Häkkinen K, Kyröläinen H. Association of physical fitness with health-related quality of life in Finnish young men. Health and quality of life outcomes. 2010; 8(1):15.
- Robinson JC. Bananas and plantains. Oxford: CAB International: 1996.
- Krishiseva: Agriculture information Hub: <http://www.krishiseva.com/>
- Musa* Germplasm Information System (MGIS): <http://www.crop-diversity.org/mgis/>
- Heslop-Harrison JS, Schwarzacher T. Domestication, genomics and the future for banana. Annals of botany. 2007;100(5):1073-1084.
- ProMusa: <http://www.promusa.org/Pests+and+diseases+portal>