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Design and implementation of web-based database of rapeseed-mustard germplasm using Linux - Apache - MySQL - PHP (LAMP) technology

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Rapeseed-mustard are major crops used for producing edible oil and are grown in nearly 6 million hectares in India. Germplasm collection is valuable gene pool providing diverse genetic material that may be applied for the improvement of cultivars. As more information is available about the germplasm, the wider selection and diversity of materials can be utilized for varietal improvement. The large number of rapeseed-mustard germplasm collected and evaluated is being maintained without computer databases. There is therefore a great need to develop Web-based germplasm database to store and access the large amounts of rapeseed-mustard plant genetic resource data. We have developed a web-enabled database of rapeseed-mustard germplasm using open source platform Linux - Apache - MySQL - PHP (LAMP). Web-enabled germplasm database allows users to interactively search and locate information in real time. This system is also configured to permit designated users who can remotely add, delete, or update information. This system can assist in decision-making activities that are related to germplasm documentation, conservation and management. The system facilitates to store and edit data on different characteristics as per the distinctiveness, uniformity and stability (DUS) descriptors and passport data for rapeseed-mustard. Presently, the database contains data on 40 characters which include 24 DUS characters that have been evaluated under Indian agro climatic conditions and others are relevant passport data. The system is accessible from any machine having web browser with internet connectivity.

Key words: Germplasm, database, rapeseed-mustard, Linux - Apache - MySQL - PHP (LAMP), distinctiveness, uniformity and stability (DUS).

INTRODUCTION

Rapeseed-mustard is an important multipurpose perennial edible oil crop and is grown in nearly 6 million hectares in India (Chauhan and Jha, 2011). The major producing states in India are Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, West Bengal, etc. (Figure 1). Crop improvement requires systematic monitoring of parameters that are essentially important for making large production. Germplasm materials are the building blocks for any crop for the construction of improved varieties. Crop genetic resources are being used by breeders, researchers and farmers for varietal improvement to meet the production challenge for the growing population. The rapeseed-mustard germplasm materials have been collected from around the country, conserved, characterized and evaluated regularly at Directorate of Rapeseed-Mustard Research (DRMR),

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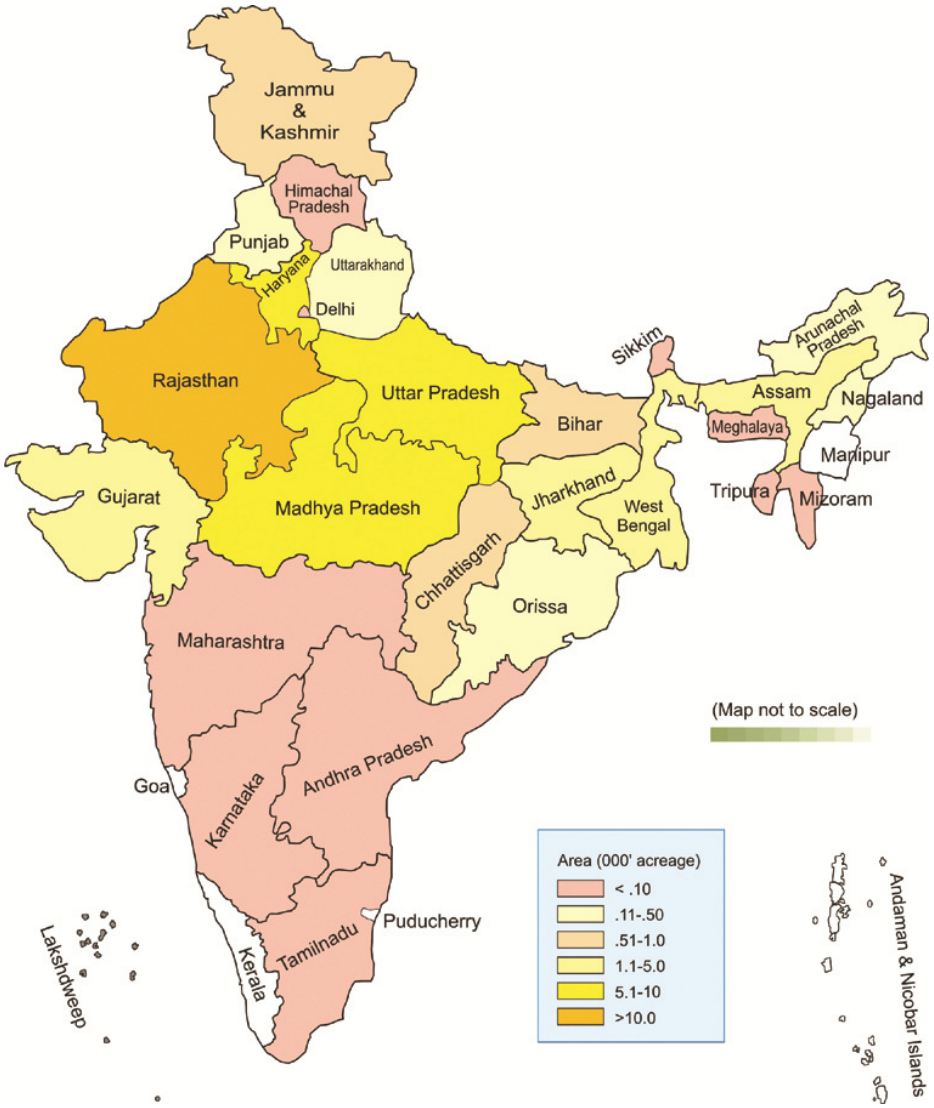

Figure 1. Rapeseed-mustard producing area in India.

Bharatpur, which is mandated with the research and development of rapeseed-mustard crop in India, and is one of the constituent institutes of ICAR, New Delhi. The germplasm materials also distributed to users locally on request. Passport and agro-morphological data on germplasm accessions, breeding lines and notified varieties are available from country wide in various electronics formats (doc, excel, pdf, etc.). This can be collated into a standard database format to enable strategic interrogation to make the best use of data for effective germplasm use and enhancement (Arllet et al., 2007). Therefore proper management and better accessing oflarge amounts of plant genetic resource data requires the development of germplasm databases to store and retrieve the information (Fox et al., 1996; Fox and Skovmand, 1996; Bruskiewich et al., 2003; Christopher et al., 2005; Chen and Huang, 2007; Agrawal et al., 2007; Mundankar and Karibasappa, 2008). Few databases are developed earlier which are International based or country based or crop based such as AVRDC Vegetable Genetic Resources Information System (AVGRIS; http://203.64. 245.173/avgris/), the Biodiversity Directory of Germplasm Collections database (http://www.bioversityinternational.org/index.php?id= 168), the System-Wide Information Network for Plant Genetic Resources (SINGER; http://singer.grinfo.net/), Centre for Genetic Resources, Plant Genetic Resources (CGN-PGR), the Netherlands (www.cgn.wur.nl/UK/CGN+Plant+Genetic+Resources), Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany (http://gbis.ipk-gatersleben.de/gbis_i/), etc. These database systems provide online access to the germplasm data (Ravisankar et al., 2009). No specific online database is available which can be used as such for rapeseed-mustard crop germplasm that can meet the requirement of information

Table 1. Descriptor selected for rapeseed-mustard germplasm.

Plant part	Characteristics
Leaf	Hairiness
	Colour
	Lobes
	Leaf: Number of lobes
	Dentation of margin
	Length
	width
Flower	Time of flowering
	Colour of petals
	Length of petals
	Width of petals
Plant	Main shoot length
	Height
Siliqua	Length
	Length of beak
	Number on main shoot
	Density on main shoot
	Angle with main shoot
	texture
	Number of seeds per siliqua
Maturity	Period
Seed	Seed colour
	Size (weight of 1000- seed)
	Oil content

retrieval need of local users as well as at the country level. In this paper, we present design and implementation of web-based rapeseed-mustard plant germplasm information system (R-MPGIS) using open source LAMP technology. The broad objective of the work is to develop the user friendly database to store, update and retrieve the germplasm information. Thus, R-MPGIS is developed for the community of rapeseed-mustard researchers, growers and facilitate to store and edit data on different characteristics as per the DUS descriptors and passport data. Presently, the database contains data of released varieties on 40 characters which include 24 DUS characters that have been evaluated under various agro climatic conditions and remaining others relevant passport data. The system is accessible from any machine having web browser with internet connectivity.

MATERIALS AND METHODS

System design and development usually proceeds through several phases of software development life cycle (SDLC) that includes feasibility study (problem identification), requirement analysis (user's requirements), system design, testing, implementation and evaluation (Suwarno et al., 2004). Various discussion sessions have been organized with the stakeholders involved in germplasm management and researchers at the Directorate of Rapeseed-Mustard Research (DRMR), Bharatpur, Rajasthan, a premier institute working for rapeseed-mustard research under Indian Council of Agricultural Research (ICAR), New Delhi, India. Data requirements and various parameters were identified which are essentially required to the researchers through phase wise discussions.

Germplasm database

The database of R-MPGIS has been built based on information collected during the exploration, evaluation, conservation and distribution management at DRMR. The database facilitate to store passport data and phenotypic data on agro-morphological traits characterized and evaluated as per DUS descriptor of three type accessions germplasm, advance breeding lines and notified varieties.

Passport data

Passport data are the information accompanying an accession and are the core of the plant genetic resource (Agrawal et al., 2007). To identify individual accession, accession number is assigned to every accession when passport data are entered into the database. Rapeseed-Mustard in India comprise traditionally grown indigenous crops namely toria, brown sarson, yellow sarson, Indian mustard, black mustard and taramira along with non-traditional crops like gobhi sarson and Ethiopian mustard or karan rai (Chauhan et al., 2011). Each germplasm entity in the database is identified by a unique id created by assigning CropID, accession type and accession number. The passport data of notified varieties are contain cultivar name, pedigree, breeding methods, propagation methods, originating institute, developer institute, developer team, year of release, year of notification, level of release, notified So. No. , recommended area and adopted area.

Morphological data

In addition to passport data, the database also contains morphological descriptors developed for test of distinctiveness, uniformity and stability (DUS) under the Protection of Plant Varieties and Farmers Right Act (PPV&FRA) 2001. Government of India constituted the Protection of Plant Varieties and Farmers' Rights Authority to recognize and protect the rights of plant breeders and farmers in respect of their contribution made at any time in conserving, improving, generating and making available plant genetic resources to the development of the new varieties. Under DUS, PPV&FR authority, has also decided certain parameters for different descriptors for different crops in India (PVV&FRA; http://www. http://plantauthority.gov.in/index.htm). The detail of these descriptors and distinguishing characteristics are shown inTable 1 and detail of characteristics for different species of oilseed brassica presented in Table 2 (Singh and Chauhan 2010).

Image data

Images have been used as a research tool and are the rich source of data for the researchers and interpreters. The high quality digital images are captured using modern digital technology that can play

Table 2. Descriptor's characters and their states in different rapeseed-mustard species.

Characteristics	States in different species		
	Indian mustard (*B. juncea*) + karan rai (*B. carinata*)	**Gobhi sarson (*B. napus*)**	**Toria, yellow sarson, brown sarson (*B. rapa*)**
Leaf: Hairiness	Absent Sparse Dense	Absent Sparse Dense	Absent Sparse Dense
Leaf: Colour	Light green Medium green Dark green	Light green Medium green Dark green	Light green Medium green Dark green
Leaf: Lobes	Absent Present	Absent Present	Absent Present
Leaf: Number of lobes	Low (≤ 5) Medium (6- ≥8) High (>8)	Low (≤5) Medium (6-≥8) High (>8)	Low (≤5) Medium (6- ≥8) High (>8)
Leaf: Dentation of margin	Entire Dentate Serrate	Entire Dentate Serrate	Entire Dentate Serrate
Leaf: length (cm)	B. juncea Short (< 25) Medium (26- < 30) long (>30) B.carinata Short (< 30cm) Medium (31-< 35) Long (> 35)	Short (< 30) Medium (31-< 35) Long (> 35)	Short (< 12) Medium (12-15) Long (> 15)
Leaf: Width (cm)	Narrow (10.0) Medium (10-12) Broad (> 12)	Narrow (10.0) Medium (10-12) Broad (> 12)	Narrow (4.0) Medium (4-6) Broad (> 6)
Flower: Time of flowering (days)	***B. juncea*** Early (≤ 40) Medium(41-≤50) Late (> 50) ***B. carinata*** Early (≤50) Medium(51-≤60) Late (>60)	Early (≤50) Medium (51-≤60) Late (> 60)	Early (≤ 35) Medium (36-<45) Late (>45)
Flower: Colour of petals	White Light yellow Yellow Orange	White Light yellow Yellow Orange	White Light yellow Yellow Orange
Flower: Length of petals	Short (<1.2) Medium (1.2-1.5) Long (>1.5)	Short (<1.2) Medium (1.2-1.5) Long (>1.5)	Short (<1.2) Medium (1.2-1.5) Long (>1.5)
Flower: Width of	Narrow (<0.6)	Narrow (<0.6)	Narrow (< 0.6)

Table 2. Contd.

petals	Medium (0.6-0.7) Broad (>0.6)	Medium (0.6-0.7) Broad (>0.6)	Medium (0.6-0.7) Broad (>0.6)
Plant: Main shoot length	Short (≤ 40) Medium (41- ≤ 50) Long (51-≤60) Very long (>60)	Short (≤40) Medium (41-≤50) Long (51-≤60) Very long (>60)	Short (≤40) Medium (41- ≤50) Long (51-≤60) Very long (>60)
Plant: Height	Short (≤130) Medium (131- ≤150) Tall (1 51-≤170) Very long (>170)	Short (≤20) Medium (121- ≤140) Tall (1451-≤160) Very long (>160)	Short (≤80) Medium (81- ≤90) Tall (91-≤100) Very long (>100)
Siliqua: Length	Short (<4.5) Medium (4.5-5.5) Long (>5.5)	Short (<4.5) Medium (4.5-5.5) Long (>5.5)	Short (<4.5) Medium (4.5-5.5) Long (>5.5)
Siliqua: Length of beak	Short (<0.8) medium (0.8-1.2) Long (>1.2)	Short (<0.8) Medium (0.8-1.2) Long (>1.2)	Short (<0.8) Medium (0.8-1.2) Long (>1.2)
Siliqua: Number on main shoot	Very few (40) few (41-≤50) Medium (51-≤ 60) Many (> 60)	Very few (≤40) few (41- ≤50) Medium (51-≤60) Many (>60)	Very few (≤40) few (41-≤50) Medium (51-≤60) Many (>60)
Siliqua: Density on main shoot	Low (< 0.7) Medium (0.7-0.8) High(> 0.8)	Low (< 1.2) Medium (1.2-1.5) High(>1.5)	Low (< 0.7) Medium (0.7-0.8) High (> 0.8)
Siliqua: Angle with main shoot	Appressed Semi appressed Open	Appressed Semi appressed Open	Appressed Semi appressed open
Siliqua: Texture	Smooth Undulated Constricted	Smooth Undulated	Smooth Undulated
Siliqua: Number of seeds per siliqua	Very few (≤40) Few (13- ≤16) Medium (17-≤20) Many (>20)	Very few (≤ 40) few (13- ≤ 16) Medium (17-≤ 20) Many (> 20)	Very few (≤40) few (13- ≤16) Medium (17-≤20) Many (>20)
Maturity period (days)	***B. juncea*** Early (≤110) Medium (111-≤130) Late (131-≤150) very late (>150) ***B. carinata*** Early (≤ 120) Medium (121-<140) Late (141-<160) very late (>160)	Early (≤120) Medium (121-≤140) Late (141-≤160) Very late (>160)	Early (≤81) Medium (82-≤100) Late (101-≤120) Very late (>120)

Table 2. Contd.

Seed: Seed colour	Yellow Reddish brown Brown Dark brown Black	Yellow Reddish brown Brown Dark brown Black	Yellow Reddish brown Brown Dark brown
Seed: Size (weight of 1000 seed) (g)	***B. juncea*** Small (< 5.0) Medium (5.0-6.0) Bold (> 6.0) ***B. carinata*** Small (<4.0) Medium (4.0-6.0) Bold (> 6.0)	Small (<3.5) Medium (3.5-4.0) Bold (> 4.0)	Small (<3.5) Medium (3.5-4.0) Bold (> 4.0)
Seed: Oil content (%)	Low (<38) Medium (38-<42) High (42-46) Very high (>46)	Low (>38) Medium (38-42) High (42-46) Vvery high (>46)	Low (>38) Medium (38-42) High (42-46) Very high (>46)

a very important role in identification of shape and size of different characters (Villordon et al., 2007; Kumar et al., 2008). In DUS descriptors for rapeseed-mustard crop some of the characters e.g. leaf: Hairiness (Absent, Sparse and Dense), Leaf: Dentation margin (Entire, Dentate and Serrate), Siliqua: Angle with main shoot (Appressed, Semi-appressed and Open) and Siliqua: Texture (Smooth, Undulated and Constricted) have been descried pictorially as shown in Figure 2 (PPV&FRA, 2009). Therefore, beside above text data, passport and morphological, the R-MPGIS database contains the image data that presently includes the photos of germplasm accessions of different stages of the plant which are essentially needed for identification of varieties based on these characters.

System design and implementation

An open source platform consists of LAMP (Linux, Apache, MySQL and PHP/Perl/Python) has been deployed with the standard web based three tier architecture to design and implement the system (Lee and Brent, 2002). The system architecture and E-R diagram designed to develop an efficient rapeseed-mustard germplasm information system is shown in Figure 3a and b. The system architecture contains three layers namely, database, application and user interface.

The database layer stores the data of the germplasm. Application logic layer was used to provide the interface between user and database. The queries are implemented in this layer for inserting, modifying and accessing data. The access rights are also specified in the application logic layer. Last the user interface layer that contains the browser based platform to access the desired information from the database using a input entry form. LAMP, an open source platform is getting popularity day by day because it has been made by the user and for the user without incurring any cost. In R-MPGIS, the database has been created using world's most popular open source database MySQL database for storing the data in back-end, the tables needed were created using phpMyAdmin (Graphical user interface for MySQL administration) (Villordon et al., 2007). The Apache web server has been for bridging the gap between database server and user in retrieving the information remotely. PHP (recursive acronym for PHP: Hypertext Preprocessor or Personal Home Page) is an open-source server-side scripting language. PHP scripts are used to develop the dynamic web application, where the content displayed is generated from information accessed in a database. Hypertext Markup Language (HTML) is used in conjunction with PHP to give aesthetically pleasing web interface for users.

For access of the system globally, it has been developed in “English” language. The hardware specifications include high end servers and storages devices.The system operates in sharing mode on a server running Linux kernel 2.6.18-194 operating system. MySQL version 5.1.56 and Apache 2.2.21 have been used for database management server and web server, respectively. PHP version 5.1.17 for server side scripting and Java script for client side scripting has been used in developing the system.

RESULTS AND DISCUSSION

R-MPGIS is the DRMR’s system for managing rapeseed-mustard germplasm information. The system is web based interactive user-friendly and allows users without any specific training or knowledge of Structured Query Language (SQL) to perform record searches, insertions, updates, and deletions conveniently (Jensen, 2001; Agrawal et al., 2007). Thus, researchers can perform remote database queries for search desired accessions and determine if likely duplicates exist in their respective germplasm collections.

INSERT, UPDATE and DELETE (IUD) records operation

The system operates in administrator and user mode.

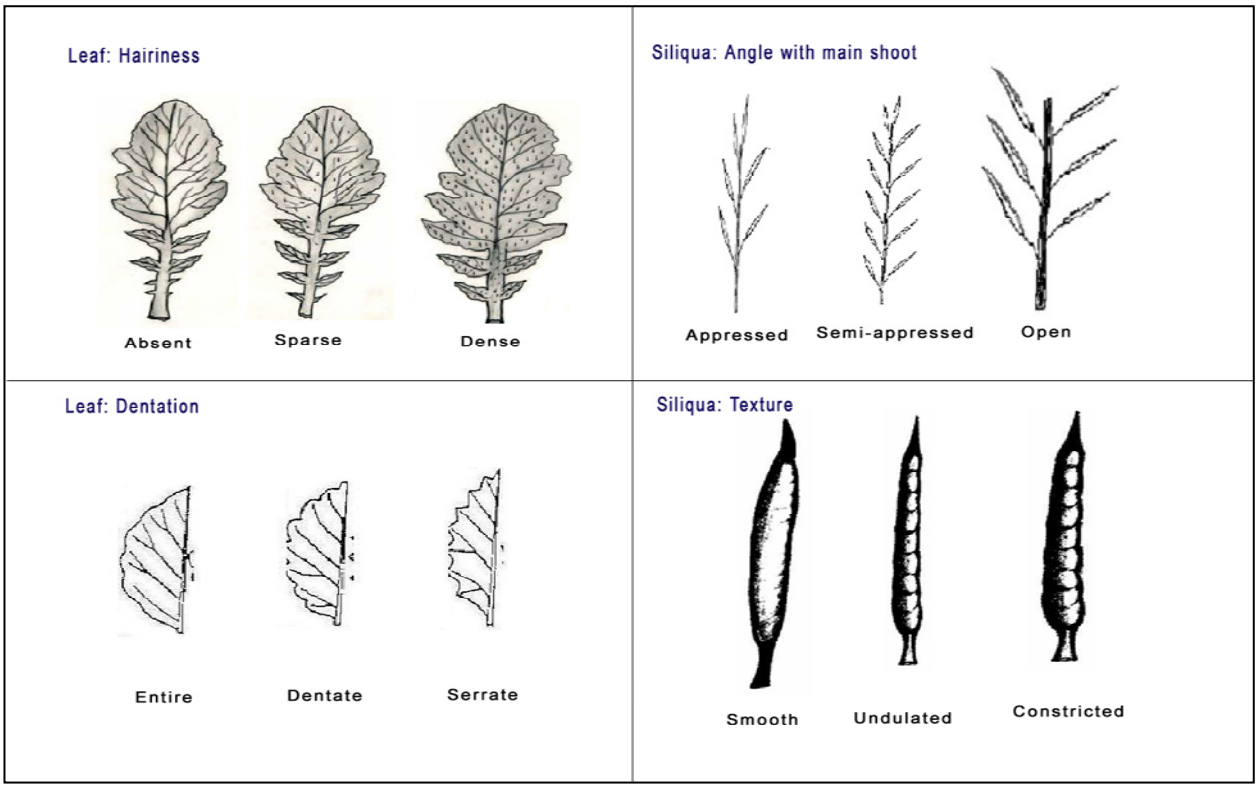

Figure 2. Pictorial description of some characters of rapeseed-mustard plant.

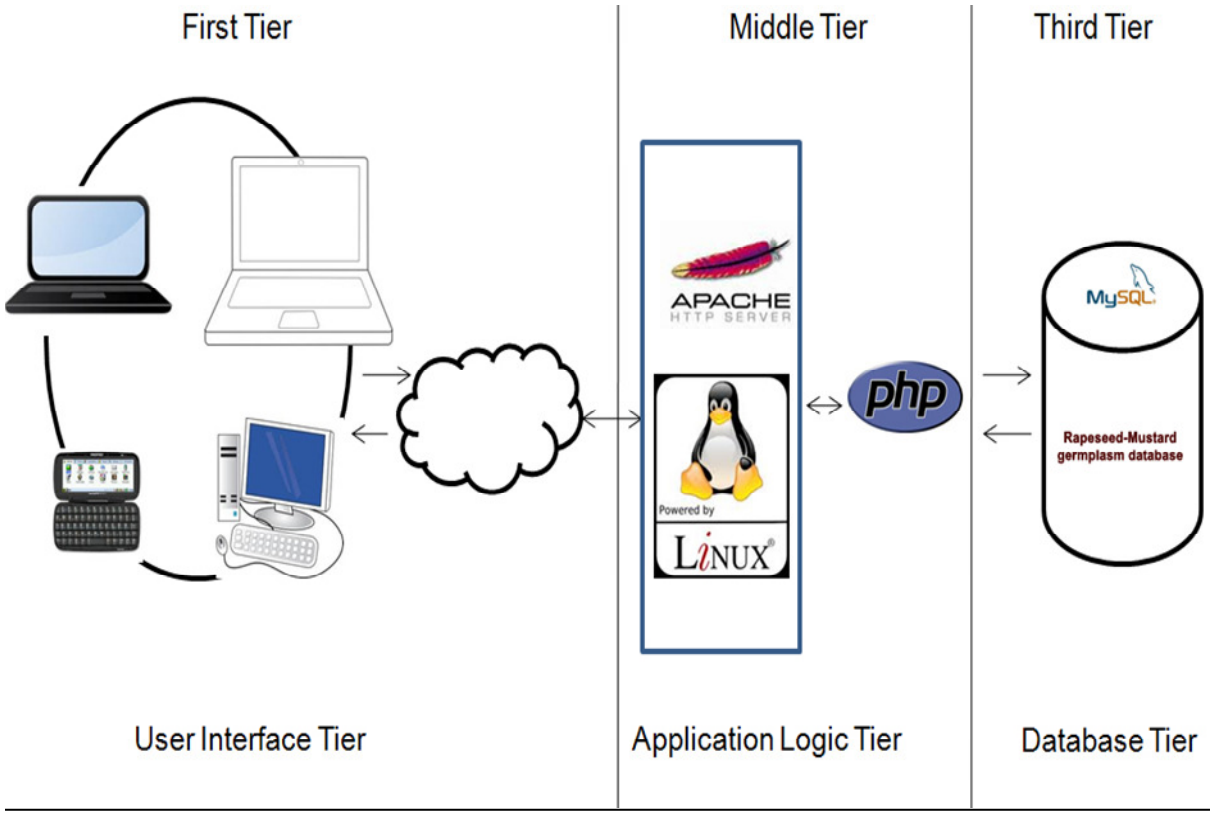

Figure 3a. Three tier web based system architecture.

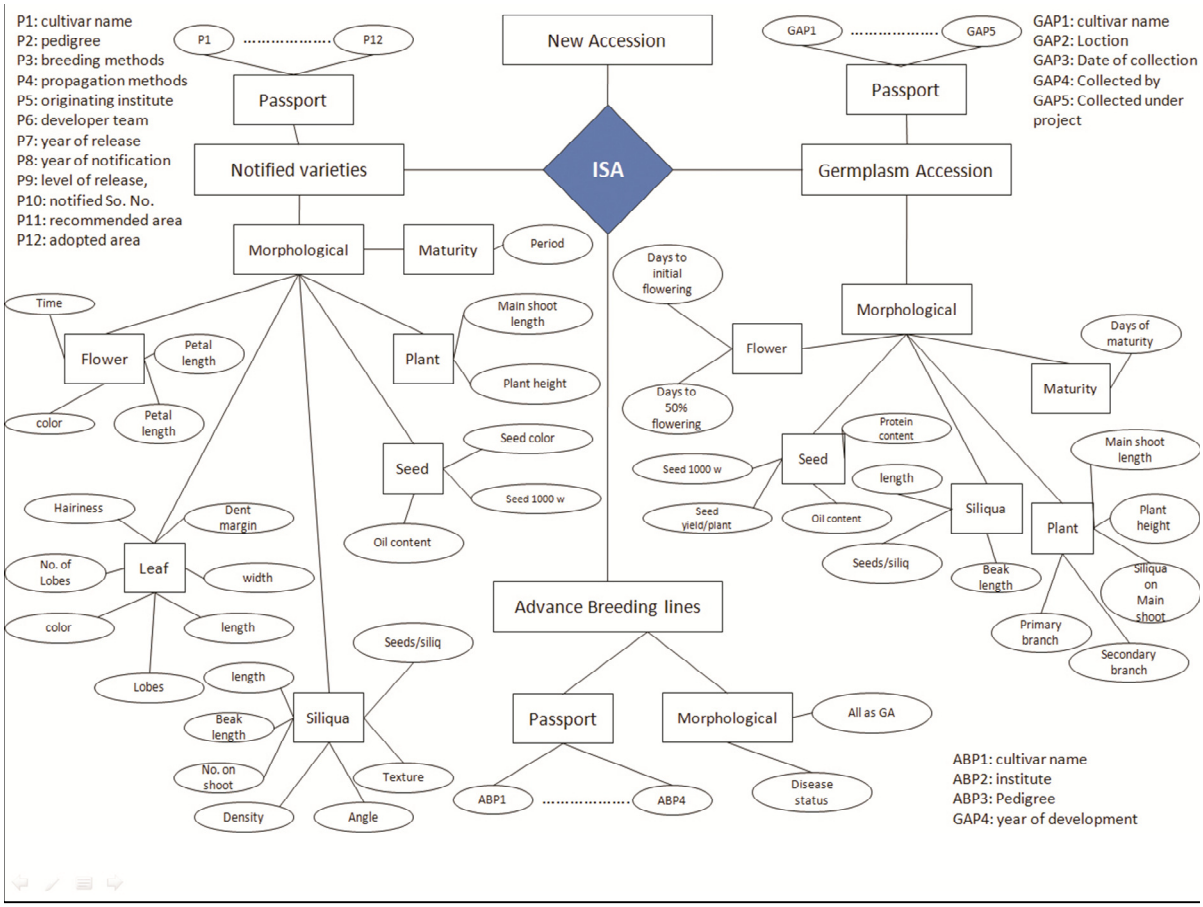

Figure 3b. Entity relationship diagram.

After loging in as administrator the INSERT, UPDATE and DELETE (IUD) of records can be performed (Villordon et al., 2007). A sample screen-shot provides the interface to insert records of new germplasm into the database (Figure 4). Before saving the record, the system also provides the option to check the duplicity of records by simply clicking the check duplicate option. To avoid the typographic error of descriptors data, the system provides the drop down menu options for selecting the different characters.

Searching facility

Searching is the key feature of any system, the R-MPGIS developed an user interface to query the database in user friendly environment by making conditional queries on various field combinations and by free text query(Takeya et al., 2011). The system provides the options to select the descriptors, for specific and generalize of search result on various characters the system provides AND and OR option also. The result of query displays the matching records sowing the different characters of selected descriptor, by clicking ID or name the complete data for a particular accession can be viewed (Figure 5).

The germplasm stock at DRMR, Baratpur collected from traditional and non-traditional area of India and different countries (Canada, Japan, Russia, Germany, Jordon, Iraq, USA, Australia, etc.) includes about 77% of Indian mustard species and other remaining 6 species are 23%. Presently the R-MPGIS database contains passport and morphological descriptors data of notified rapeseed-mustard varieties which are important for researchers as shown in the evaluation of germplasm accession, advance breeding lines and their insertion into database are in under way.

Conclusion

The Rapeseed-Mustard Plant Germplasm Information System (R-MPGIS) is a web based interactive user-friendly system that can be used by various users namely researchers, breeders, pathologists, extension professionals and farmers. The user can access the system from any place. The user need web browser and internet connectivity to access the system. The

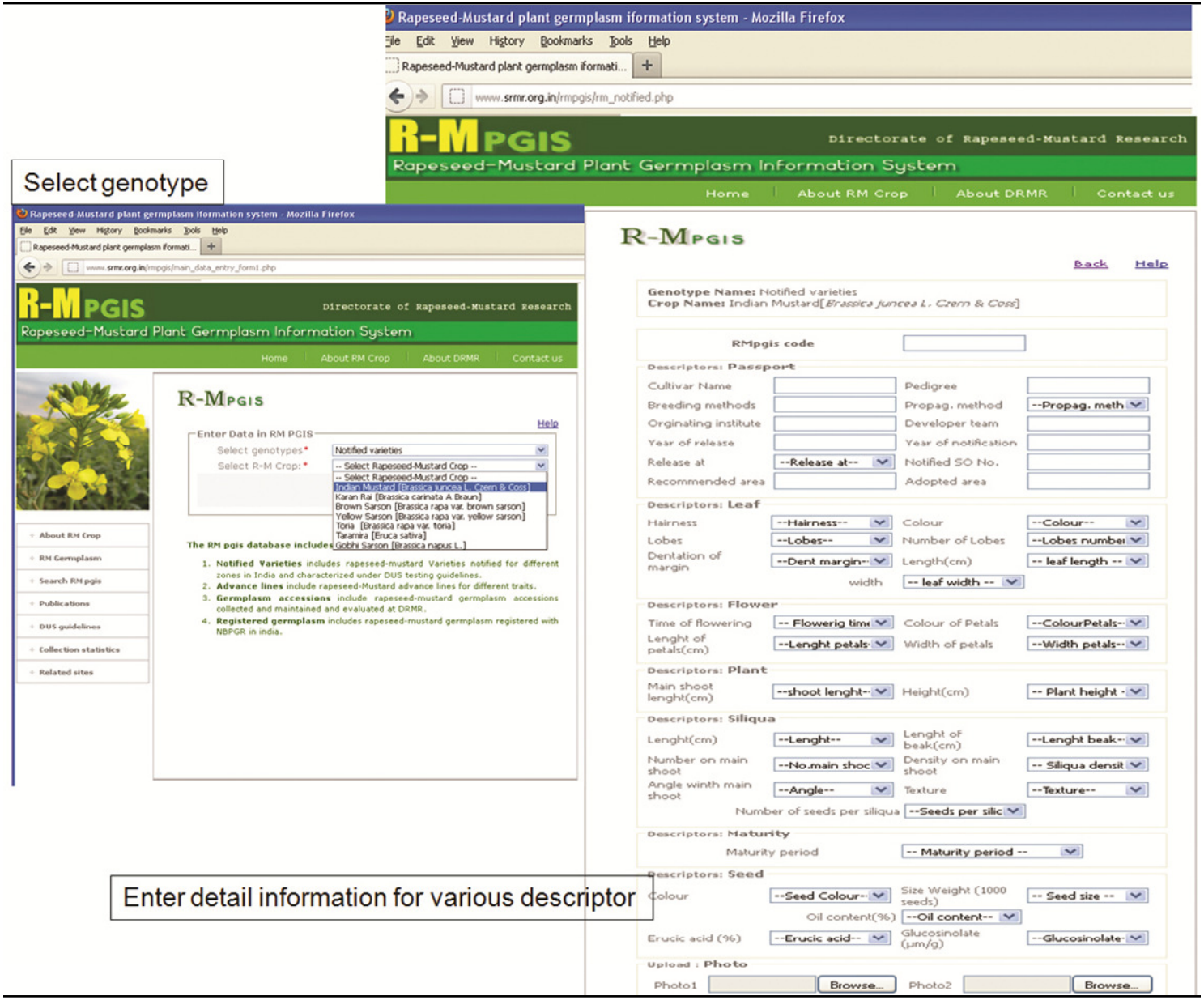

Figure 4. Screenshot of web page used for record operations.

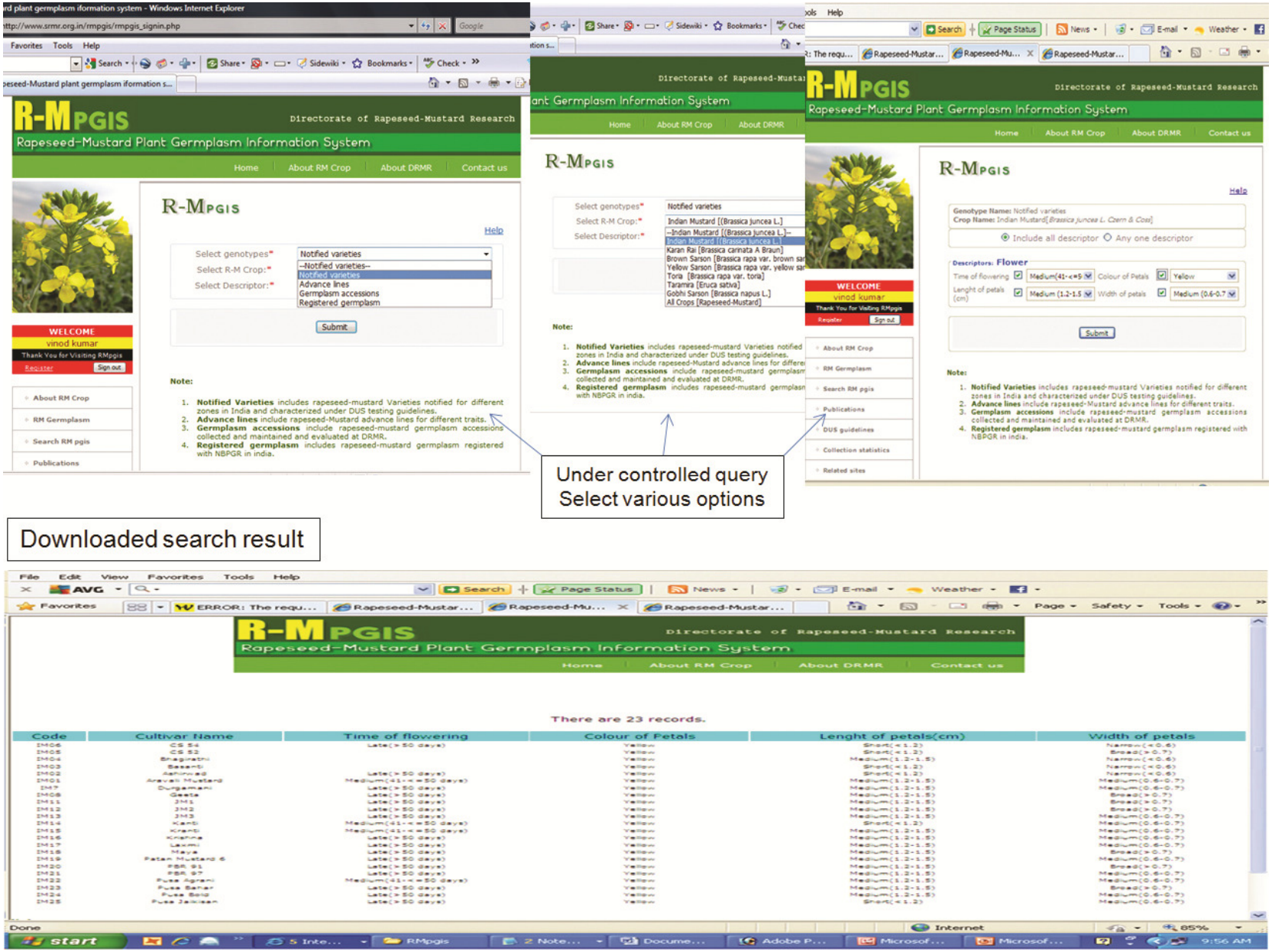

Figure 5. Germplasm search with user-support options.

germplasm information can also be updated by the authentic users who are registered and having the admin rights. The system contains information on germplasm accession, advance breeding materials and varieties released or notified, including passport data, morphological descriptors with images of various stages. Images will be quite useful in analyzing the growth pattern of a particular accession. It helps in locating the alternative sources of rapeseed-mustard germplasm by identifying the most appropriate accessions with particular traits of interest.

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