**Figure 5.** Photographs of (***a***) fresh tomatoes, (***b***) after 12 days of cold storage and (***c***) after 20 days of cold storage.

**Table 2.** Economic analysis of solar-powered cold storage system

| Item | Cost (Rs) | Useful life (yrs) | Cost (Rs)/yr |
|---|---|---|---|
| AC | 20,000 | 10 | 2,000 |
| Solar panels (210 W × 8 = 1680 W) | 72,000 | 20 | 3,600 |
| Battery (4 × 12V) | 65,000 | 5 | 13,000 |
| Inverter 3 kVa | 15,000 | 10 | 1,500 |
| Total cost | | | 20,100 |
| Power cost saving (7 units @Rs 7) | 49/day | | 17,885 |
| Net cost/yr | | | 2,215 |
| Net cost/day | | | 6.07 |
| Cost/day/kg produce | | | 0.006 |

temperature inside the storage structure compared to the outside ambient temperature. Temperature and relative humidity inside the system ranged from 9.5°C to 11°C and 73% to 92% respectively. This environment helps in keeping the perishables fresh for significantly more time ranging from 1 to 20 days. As the storage structure is movable, it can be used at different places in the rural farmlands. Also, this is useful in rural areas where there is shortage of electricity or its supply is erratic for storage of fresh fruits and vegetables. Thus it provides an opportunity to preserve or to extend the shelf-life of fresh produce.

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# MangoDB: a database of mango varieties and landraces of the Indian subcontinent

Mango (*Mangifera indica* L.) is the most important commercially grown fruit crop in India, available throughout the length and breadth of the country and aptly acknowledged as the 'national fruit of India'. It enjoys a prominent place in the Indian fruit market, contributing more than 20% of total fruit production from 36% of the total fruit area. In Kerala, this crop covers an area of 77,158 ha with a production of 457,067 tonnes[1]. Commercially grown cultivars in this state are Alphonso, Bangalora, Banganappalli, Kalapady, Neelum, Bennet Alphonso, Mulgoa and Prior, whereas the local types mainly include Muvandan, Chandrakaran, Olour, Varikka and Vellaikolamban, apart from a large number of landraces[2].

Different regions of India, including the Western Ghats, bear huge genetic variability for this crop[3,4]. According to Chadha[5], India holds more than 1000 mango types. Most of the commercially popular ones, around 30 in number, have originated as chance seedlings, subsequently selected for fruit traits. Though evaluation of this genetic variability has been carried out in different parts of the country by surveys and data collection, systematic documentation of the varietal variation, including morphological, flowering and fruiting characterization is


**Figure 1.** Screenshots of the web-interface of MangoDB. ***a***, Homepage; ***b***, Alphabetical list of mango cultivars; ***c***, International Board for Plant Genetic Resources descriptor for selected variety; ***d***, Photo gallery.

largely missing. This is especially important from the plant breeding point of view to select the most suitable mango cultivars for different climatic zones and for further crop improvement programmes.

The programme for collecting and evaluating the mango variability in India was initiated at the Kerala Agricultural University (KAU), Thrissur with the objective to characterize maximum amount of variability in this crop, mainly including the popular and widely cultivated cultivars/landraces, and to use the same to develop an on-line readily retrievable database. The characterization and evaluation were performed using the morphological descriptors established by the International Board for Plant Genetic Resources (IBPGR), Rome, Italy. Currently, National Mango Database (http://mangifera.res.in/index.php) is the only source available exclusively for mango. This database includes the fruit characteristics of only 18 commercial varieties and 12 hybrids, whereas general horticultural database FAO-Hortivar (http://www.fao.org/hortivar) accommodates only one Indian variety (Alphonso). None of the available databases presents the mango germplasm in detail, following the standard IBPGR descriptors. Here we present the first comprehensive IBPGR descriptor-based database (MangoDB) (Figure 1) of mango varieties/landraces from India, with special reference to the southern parts of the country, contributing insights into the regional diversity and to develop future genetic resource conservation strategies. This database is exhaustive as far as the South Indian cultivars are concerned, whereas the scope for further additions is not ruled out with respect to cultivars from other parts of the country.

The establishment of the gene sanctuary at KAU was initiated during 1992 and is being treated as a continuous process till date. Major planting was carried out during 1992–93 with about 120 varieties and the standard crop production strategies as recommended by KAU were followed[6]. During the subsequent years additions to the germplasm collection were effected based on the availability of varieties and the present number amounts to 160. Plants of more than 10 years of age were subjected to evaluation using the standard descriptors for presenting in MangoDB[7]. The database also accommodates the complete descriptor. Additionally, data from the surveys conducted in the southern and central parts

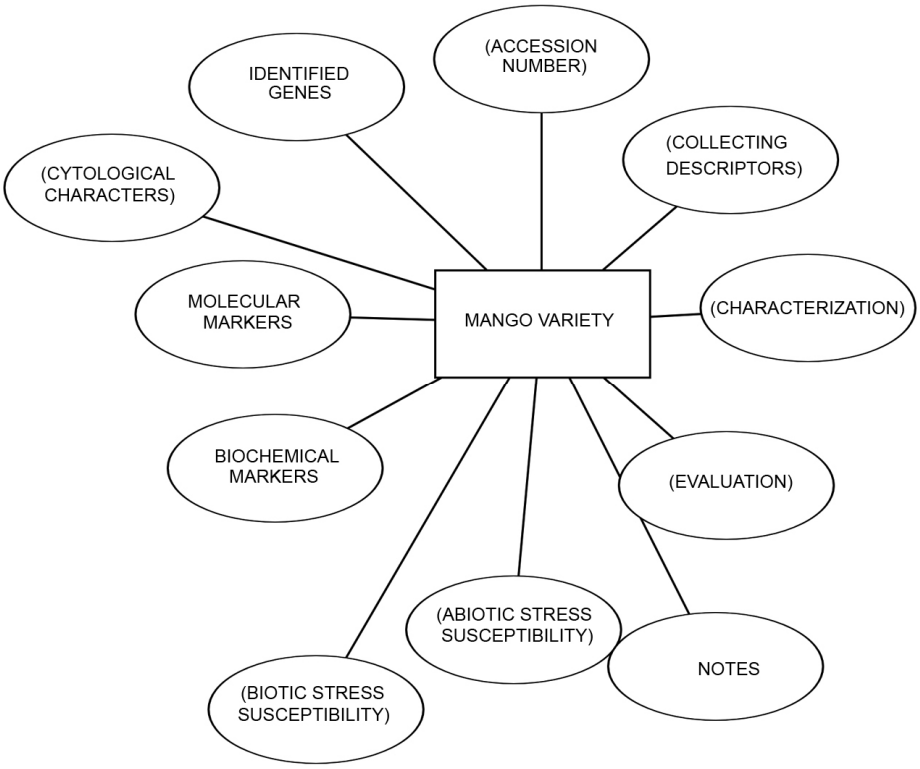


**Figure 2.** Entity relationship diagram for MangoDB. The parameters in bracket represent composite attributes having sub-divisions.

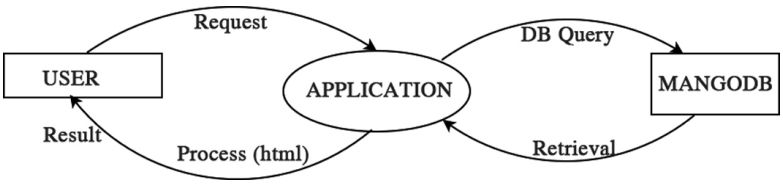


**Figure 3.** Data flow diagram for MangoDB.

of Kerala and other tracts of the country are included. Thus, descriptions for a total of 40 varieties are included in the database at present.

The database has been designed with a user-friendly interface, enabling users to retrieve the information easily. MangoDB was developed using MySQL as back-end and php as the front end. Field names have been defined according to standard IBPGR descriptors. Data type for a particular field has also been defined based on these descriptors. The database has been designed using a single table (Figure 2). It is deployed on Apache HTTP server and runs on a server managed by the Linux operating system. The database can be accessed from http://bic.kau.in/mango/.

As an introduction, MangoDB presents brief information on commercial and popular varieties and hybrids in India and their agro-techniques, pest and disease management, harvest, etc. The list of 40 major mango cultivars has been alphabetically indexed in the database. The user can select a particular variety and click on the submit button for detailed IBPGR descriptors of the same. Figure 3 represents the information retrieval system for MangoDB. An entry in the database contains information regarding accession number, collecting descriptors, characterization, evaluation, morphological description, floral description, fruiting characters, fruit quality aspects, etc. Varietal differences in fruit, crown and leaf characters are made easily understandable by providing corresponding images. Photographs on mango cultivars are provided separately in the Gallery folder (Figure 1).

MangoDB will enable the plant breeders and horticulturists to access information on the mango cultivars of India with special reference to southern parts of the country. India being the centre of origin and the primary centre of diversity of mango – the 'king of fruits', accommodates maximum amount of genetic diversity. The amount of variability for this crop is enormous and the cultivars could be precisely classified into table types, pickling types, juice types, multipurpose, etc. For every trait, the germplasm collection shows enormous variability and this is made available to the plant breeders for crop improvement throughout the world.

With the addition of new varieties/landraces, growth of MangoDB has been a continuous process and update is effected by the administrator at regular

intervals. Resources on new varieties/ landraces and feedback to enhance the usability of the web interface are welcome. Resources and suggestions received through e-mail shall be reviewed and considered in the update process.

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# Mobile-based agro-advisory for tribals of Meghalaya, India

The source of livelihood and income of the North Eastern Hill Region (NEHR) is largely rural and principally agrarian. Likewise, economy of Meghalaya is also agrarian as 81% of its population depends on agriculture[1]. The state is not self-sufficient in food grains. It shows a deficit of 1.22 lakh tonnes per year to feed a population of 2.3 million[2]. The climate of the state is favourable to grow all types of the crops, viz. rice, maize, pulses, oilseeds, spices and fruits. Meghalaya is well-known for its pineapple, turmeric, ginger, black pepper, areca nut, betel vine and tapioca. The state also has ample potential to earn livelihood and income from minor forest produce. Hence, agriculture and animal husbandry are complementary in the region and do not compete with each other. Farmers grow crops and rear animals, thus ensuring economic advantages. Cattle and pigs are the major livestock. Cattle constitute 905,753 and pigs add up to 569,301 out of the total livestock population[3]. Meghalaya is predominantly a tribal state. The present functional literacy rate is 74.43, with males accounting for 75.95% and females 72.89% (ref 4). Exhibited backwardness of Meghalaya is coupled with inadequate information support and huge technological gap. Hence application of Information Technology and Communications (ITCs) in the state may benefit the tribal farming community. Various programmes on Information Technology (IT) have been launched in Meghalaya. An agro-advisory system under m4agriNEI is an innovative initiative launched in order to make available right advisory as and when required by the tribal farmers of the state. The agro-advisory was launched in June 2012 and started functioning in 2013 at the Central Agricultural University at Umiam. The Agro-advisory system is an application that is designed to run on a mobile, web and toll-free IVRS. The farmers need to register under the advisory laboratory with their complete profile, including details of fields and households. The beneficiary must have a mobile phone and good connectivity. The advisory laboratory is equipped with trained agricultural experts (level-I) who can provide information to the farmers according to their requirements. Level-II experts are scientists in respective fields who provide answers to queries beyond the capacity of level-I experts. The system also allows dissemination of information through voice, text and images between the farmers and the experts. The advisory has an automatic information repository system which stores all the necessary information like date, image and reply to a query; this can be accessed as and when needed for authentication.

A farmer/livestock rearer who lives in remote area with mobile connectivity is registered under the initiative (Table 1).

The registered farmers used their mobile phone to raise queries related to agriculture, animal husbandry, fisheries schemes, etc. using a toll-free number. A total of 5825 queries had been received and accordingly agro-advisory was provided to the registered farmers (Table 2). The queries made were about improved crop cultivation, diseases and pest management of different crops, source of seeds, livestock management, etc. The data revealed that the highest number of queries was about the project, followed

**Table 1.** Number of registered farmers under the agro-advisory

| District | No. of registered farmers |
|---|---|
| Ri-Bhoi | 4217 |
| East Khasi Hills | 1193 |
| West Jaintia Hills | 915 |
| West Garo Hills | 504 |
| Total | 6829 |