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Development of Database of Maize Hybrids and Open Pollinated Varieties Released and Notified for Cultivation in India

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Abstract

The maize database, first of its kind in India, is a central repository for cultivars *i.e.* hybrids and open pollinated varieties (OPVs) notified for cultivation in India since the inception of All India Coordinated Maize Improvement Project (AICMIP) in 1957. The database includes the information on cultivars developed from public as well as private breeding programmes. Besides, information on registered germplasm is also given. The database carries image gallery showcasing photographs of cobs/standing crop of the public-bred cultivars released after 1993.The database also presents information about adaptability of cultivars, average yield and disease, and insect-pest resistance along with the parental materials used in breeding programmes. Information on 31 descriptors as per Distinctivity, Uniformity and Stability (DUS) tests in respect of parental lines and their hybrids that were filed for protection under "Protection of Plant Varieties and Farmers Rights Act, 2001" (PPVFRAct, 2001) has been supplemented. In addition, the database provides contact information on developers of the notified cultivars thereby facilitating interactions among the members of maize community. The information contained within maize database can be accessed at on-line expert system called maize AGRIdaksh (www.iimr.res.in/maizeexpertsystem/www.agridaksh.iasri.res.in/maize). Information on notified cultivars (1961-2010) parental lines and cultivars (1993-2012) filed under PPVFRAct, 2001 can also be accessed at www.iimr.res.in/maizeexpertsystem/maize hybrids and composite varieties released in India. Whereas, information about registered germplasm (2003-2012) can be accessed at www.iimr.res.in/publications.

Keywords: DUS descriptors, hybrids, maize database, OPVs, parental lines, registered germplasm

1. Introduction

Maize (*Zea mays* L.) is the most widely distributed crop of the world being grown in tropical, subtropical and temperate regions from sea level to more than 3000 m under irrigated to semi-arid conditions. Being a versatile crop, it adapts easily to a wide range of production environments. In India, maize is the third most important cereal after rice and wheat that provides food, feed, fodder, and serves as a source of basic raw material for the number of industrial products such as starch, protein, oil, alcoholic beverages, food sweeteners, cosmetics, etc. The unprecedented growth of maize in India has been attributed to its increasing use in poultry as feed, increasing interest of the consumers in nutri-rich products and availability of high yielding hybrids (Pingali & Pandey, 2001; Kumar, Srinivas, & Sivaramane, 2013; Yadav et al., 2016). In fact, latter has emerged as a major driving force behind the maize expansion in the country. Currently, Indian maize programme is completely focused on the development and deployment of single cross hybrids in various production ecologies of the country.

The Indian Institute of Maize Research (IIMR) is the premier institute that functions under the auspices of Indian Council of Agricultural Research (ICAR), New Delhi, the apex body governing agricultural R&D, in India. IIMR is mandated with increasing the production and productivity of maize through the development and deployment of genetically superior high yielding cultivars coupled with improved production/protection

technologies. The institute is supported by > 30 breeding and testing centres (with 30 additional need-based testing centres) located throughout the country for developing region-specific products and popularizing economically feasible and technically sound technologies among the farmers. The institute is also entrusted with overall policy in developing and disseminating maize technologies in different production ecologies; develop, implement and review strategies, and, offer viable options to augment maize-based farm incomes.

The introduction of IPRs in agriculture is an aspect that has serious implications for crop management, germplasm conservation and its documentation, development of new varieties, fulfillment of the basic right to food, and, ultimately affects economic development of the country. In 2001, India responded to the changed international scenario by adopting a *sui generic* system through the enactment of a unique legislation called "The Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001". The Act provides for registration of new and extant cultivars for a period of 15 years (for agricultural crops) besides documentation and conservation of genetic resources. IIMR has been identified as the nodal agency to file applications pertaining to public-bred cultivars (hybrids and OPVs), conduct DUS tests on new varieties including parental lines (public-bred as well as proprietary) and document crop genetic resources in maize.

2. Historical Background

2.1 Maize Breeding in India

A retrospective look reveals that systematic breeding efforts in maize began with the launch of All India Coordinated Maize Improvement Project (AICMIP) later re-christened as All India Coordinated Research Project on maize (AICRP on maize)—a first of its kind in 1957 at Pusa Campus, New Delhi. The project laid a strong foundation for research on different facets of maize despite many switch-overs in breeding strategy (Dass et al., 2012, Kumar, Srinivas, & Sivaramane, 2012; Yadav et al., 2015). The project facilitated planning, implementing and monitoring of research activities and hence aided in rapid generation of data on the performance and stability of experimental materials *i.e.* hybrids and OPVs across production ecologies. AICRP testing is a three-year coordinated programme during which the experimental hybrids/OPVs are tested at multi-locations and promoted to next higher level of testing only after fulfilling the stringent promotion criteria. The testing mechanism was further strengthened in due course of time and now is taken up as per the notified guidelines and performance data generated on phenology, agro-morphology, yield and yield-contributing traits, agronomy, resistance to diseases and insect-pests, biochemical traits, etc. The three-year performance data is critically examined by Variety Identification Committee (VIC) during maize workshops held annually. Only such proposals that fulfill all the requirements (scientific and technical) are identified for release. The Release and Notification proposals for such identified hybrids/OPVs are submitted to Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (CSCCSNRV) of Government of India. The committee scrutinizes each proposal on rigorous parameters and only the most suitable proposals meeting all the benchmarks are approved. The approved hybrids/OPVs are released and eventually notified for cultivation in the farmers' fields. AICRP testing is open to public-bred as well as proprietary materials. Besides, the provisions for state releases have also been specified under which the experimental hybrids/OPVs may also be released for specific state through State Variety Release Committee (SVRC).

The AICRP on maize was elevated as Directorate of Maize Research (DMR) in January, 1994 and eventually to IIMR in November 2014 with headquarters now in Punjab Agricultural university campus, Ludhiana and earlier in Pusa campus, New Delhi.

2.2 Germplasm Registration in Maize

Since 2003, in India, a system is in place whereby a breeder can opt for soft protection of the parental lines possessing unique combination of traits. A committee of experts called Plant Germplasm Registration Committee (PGRC) at ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi scrutinizes each proposal minutely drawing comparisons between the performances of new proposed line/s with already known lines in public domain. The approved proposals are granted protection for a period of 15 years. Each registered material is allotted two sets of numbers, a) Indian National Germplasm Registration (INGR) number, and b) Indigenous Collection (IC) number.

3. Maize Databases

A plethora of databases exist on various aspects of research across crop species, viz. cereals, legumes, fodder, fibre, horticulture, vegetables, etc. In maize, at international level, databases have been developed at many organizations notably FAO, USDA, CIMMYT, etc. The FAO databases cover a broad spectrum of topics including FAOSTAT that presents information on production, productivity, acreage, seed, etc of different crops

including maize (www.fao.org/faostat/en/#home). Likewise, UDSA feed grains database (www.ers.usda.goc/data) contains statistics like supply, demand, prices, quantities fed, etc. of four feed grains including maize. Whereas, the CIMMYT database (www.cimmyt.org/resources) among other parameters gives information on pedigree and characterization data of released CIMMYT Maize Lines (CMLs).Besides, a number of databases on maize genomics and proteomics, viz. maize GDB, PANZEA, Gramene, maize est,transposon, transcription factor, etc have been developed. In India, PGR portal (www.nbpgr.ernet.in/pgr_databases) hosting information on registered germplasm in different crops including maize has been developed at ICAR-NBPGR, New Delhi and is in public domain. The site presents information on INGR and IC numbers, unique traits and developers/ developing centres of registered germplasm.

The importance of databases can hardly be overstated. Maize database on released cultivars can act as a powerful tool in catering to the needs of rapidly expanding maize community. Among many things, it can throw light on cultivar development scenario enabling us to view patterns in operations, facilitate retrospective analysis and guide in trait- prioritization for future breeding strategies and finally assist in impact analysis. More importantly, such a database would augment efforts on documentation, conservation and effective utilization of crop genetic resources.

Under the extant category of PPVFRAct, 2001 filing of the applications necessitated the collection of information on the cultivars notified for cultivation prior to 2007, the year in which the process of varietal registrations began in India. A survey of literature revealed sporadic information on such a database in the country. Hence, in order to implement the provisions of the Act, it became pertinent to gather vital information on Indian maize varieties. Thus collecting the information and conserving it for posterity and finally putting in public domain assumed greater importance in view of complying with the different provisions of PPVFRAct, 2001. Accordingly, steps were initiated at DMR (now ICAR-IIMR) to develop an Indian Maize Cultivar Database (IMCDB) and regularly update it with new information (as and when it is received). In this manuscript we report the development of database on notified cultivars (hybrids and OPVs), parental lines of released hybrids and registered germplasm of maize.

4. Genesis of IMCDB

In 2007, we began to collect information in spreadsheets, by far the most comprehensive compilation, on hybrids and OPVs that were released and notified in India since 1961.

4.1 Sources of Information

Following sources of information were used:

(1) *In house* technical reports, annual reports, files and documents pertaining to maize cultivars at DMR (now IIMR), New Delhi;

(2) Minutes of the meetings of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (2003-4) giving information on notified hybrids along with diagnostic features and other attributes;

(3) Minutes of the meetings of VIC (2003-2007);

(4) Proceedings of Annual Maize Workshops held in different parts of the country (2001-2007);

(5) Gazette notifications published by Government of India (1969-2007);

(6) Literature on cultivar development scenario in India (Vaidya, Paliwal, & Dhawan, 1962; Bhandari, Bhatnagar, & Menon, 1963; Mukherjee, Gupta, S. B. Singh, & N. N. Singh, 1972; Singh, 1974, 1985, 1995; Dhillon & Singh, 1975; Dhillon, Kapoor, & Malhotra, 1984; Khera & Dhillon, 1984; Dhillon, Malhi, & Saxena, 1997; Singh & Morris, 1997; Sekhon, Dhillon, & Saxena, 1999; Dhillon & Prasanna, 2001; Pushpavalli, Sudan, Singh, & Prasanna, 2001; Prasanna, Vasal, Kassahun, & Singh, 2001; Joshi, N. P. Singh, N. N. Singh, & Pingali, 2005; Dhillon & Malhi, 2006; Anonymous, 2007; Gupta et al., 2009; etc.).

The IMCDB is updated regularly based on the information presented in VIC and CSCCSNRV proceedings (www.iimr.res.in; www.seednet.gov.in) and gazette notifications (www.seednet.gov.in), and, Release and Notification proposals pertaining to identified hybrids/OPVs submitted by the breeders/developers.

4.2 The Process

In 2007, the information on public-bred cultivars including hybrids and OPVs was compiled. This information was documented in 2008 (Kaul et al., 2008). Simultaneously information on parental lines of the released public-bred hybrids was also collected, compiled and documented (Rakshit et al., 2008). In 2008, we also started

gathering information on notified hybrids belonging to private sector and continued the compilation/updation of data regarding public-bred cultivars. The compiled information was cross-checked with AICRP centres/representatives of private organizations during Annual Maize Workshops (2008-2010). As a matter of fact, our efforts were focused towards compiling all the available information on the entire set of notified albeit old and obsolete cultivars spanning the four decades of 1960's, 1970's, 1980's, and 1990's. In this context we may like to mention that some of the public-bred cultivars notified during 1960's and early 1970's were found to lack complete information as most of these were no longer in seed production chain. Likewise, being proprietary, restricted information on pedigree and other details was available for most of the private sector -hybrids notified between 1978 and 2004. Moreover, some of the companies had closed shop and/or the cultivars were no longer in seed production chain having replaced by newer and better products. With the enactment of PPVFR Act, 2001 in India, the private sector began gradually disclosing information on pedigree and source germplasm of newly developed hybrids.

The compiled information on database was documented (Kaul, Dass, Sekhar, & Bhardwaj, 2009; Kaul et al., 2010a, 2010b, 2011, 2012a, 2012b, 2012c; Kaul & Kumar, 2012; Kaul, Kumar, Nara, Prakash, & Singh, 2015). The details of the notified cultivars from 2007-2014 were published bi-annually in DMR Newsletters and cultivars identified/notified from 2014 onwards are being published in IIMR Newsletters and widely circulated especially among maize researchers.

5. Components of Maize Database

IMCDB presents information on the hybrids and OPVs released in India since 1961 (the year in which the products started emanating from the project) besides having data on DUS descriptors in respect of registered germplasm (2003 onwards) as well as public-bred hybrids and their parental lines released after 1993 (Figure 1). The records contained within maize database can be grouped into three components of related information:

5.1 Varietal Component

This part presents general information on hybrids and OPVs, viz. denomination, pedigree, notification number/year and nature of cultivar *i.e.* whether it is a single cross hybrid, double cross hybrid, three-way cross or an OPV. The area of adaptation of each hybrid/OPV has been given in terms of Agro-Climatic Zone (ACZ) followed by the names of states covered under each zone. The database also gives addresses of the organizations/AICRP centres that have developed the cultivars. Besides, information on key traits namely average yield, maturity, kernel texture and kernel colour is also given. Information on resistance/tolerance to biotic and abiotic stresses has also been compiled. The database also carries information on Quality Protein Maize (QPM), sweet corn, baby corn, pop corn, high starch and fodder cultivars. The data on biochemical parameters like protein (%), tryptophan (%), total soluble solutes TSS (%) are recorded wherever applicable. This component also presents information on production ecology *i.e.* cropping season of each notified cultivar.

5.2 Registered Germplasm Component

This component gives information about registered germplasm/varietal registrations in maize. Currently103 germplasm comprising lines and pools/populations are registered in maize. Of these, six are the heterotic pools/populations and 97 are the inbred lines with unique traits. This part of the database also presents information on source germplasm that was used in evolving the inbred line/pool/population, AICRP centre that has developed the material, INGR and IC numbers along with its unique traits. Besides, information on 31 DUS descriptors in respect of registered lines, parental lines and released public-bred hybrids (1993 onwards) that were filed for protection under extant category of PPVFRAct, 2001 has also been compiled.

5.3 Image Gallery Component

This component carries representative photographs of the cobs/standing crop of notified cultivars released post 1993, registered inbred lines, parental lines and their hybrids and OPVs listed in component 2.

6. Maize AGRIdaksh

In 2009, a three year collaborative project between ICAR-IIMR (then DMR) and ICAR-Indian Agricultural Statistical Research Institute (ICAR-IASRI) was implemented under which an expert system on maize called AGRIdaksh was developed (www.agridaksh.iasri.res.in/maize). The project was further extended for a period of four years (2012-2016) for strengthening and refining maize AGRIdaksh.

AGRIdaksh is an efficient and effective tool for building online expert system that has the capability to transfer location specific technology and advice to the users (Yadav et al., 2012). Apart from this, it is an online tool to researchers who are interested in maize breeding, agronomy, pathology, entomology, seed production, plant

variety protection, etc. The variety information system of maize AGRIdaksh presents the information on notified cultivars stored in maize database (Figures 2, 3, and 4).

7. Current Status of IMCDB

Table 1 summarizes the records contained within maize database from 1961 to 2017. The varietal component currently contains information about 348 notified cultivars including 226 hybrids and 122 OPVs that were released for cultivation in different parts of the country. Of these, 239 cultivars (117 hybrids and 122 OPVs) emanated from public sector. Likewise, 109 notified hybrids were proprietary that were developed by private breeding programmes but released after AICRP testing. Less than quarter of the cultivars (54) were state releases from public sector. Further on, the database highlights the development of 81 and 41 SCHs by public and private sector, respectively. The database records also display information on 10 QPM hybrids and one OPV besides three each of *opaque 2* and fodder varieties, respectively. In case of sweet corn, information on nine cultivars that included five public-bred (two hybrids and three OPVs) and four proprietary hybrids has been given. The database also contains information about four pop corn OPVs, five baby corn cultivars (two hybrids and three OPVs) and one high starch hybrid that emanated from public breeding programmes.

The registered germplasm component features information on 97 lines and six pools/populations that were registered since the inception of the programme. Among the registered lines 64 were of normal maize, 18 QPM, eight sweet corn, three pop corn and four high oil corn, respectively. Further, this part of the database also features information on 31 DUS descriptors in respect of 97 registered lines and 110 public-bred cultivars including 67 hybrids (and their parental lines), respectively.

Table 1. Records contained within maize database at a glance (1961-2017)

Maize Database		Public Sector	Private Sector	Total
Notified cultivars		239	109	348
	OPVs	122	-	122
	SCHs	81	41	122
	MPCs	36	61	97
	Unspecified	-	7	7
State releases		54	-	54
	QPM	11	-	11
	OPVs	1	-	1
	SCHs	9	-	9
	MPCs	1	-	1
opaque-2	OPVs	3	-	3
Sweet corn		5	4	9
	OPVs	3	-	3
	SCHs	2	4	6
Pop corn	OPVs	4	-	4
High starch	MPCs	1	-	1
Baby corn		5	-	5
	OPVs	3	-	3
	SCHs	2	-	2
Fodder maize	OPVs	3	-	3
Production ecology (season)				
	Rainy	218	95	313
	Post-rainy	10	11	21
	Summer	1	-	1
	Rainy and post-rainy	10	3	13
Registered germplasm		103	-	103
	Pools/populations	6	-	6
	Inbred lines	97	-	97
Normal maize		64		64
QPM		18	-	18
Sweet corn		8	-	8
Pop corn		3	-	3
High oil corn		4	-	4

Note. OPV: Open Pollinated Variety; SCH: Single Cross Hybrid; MPC: Multi-Parent Cross; QPM: Quality Protein Maize.

Figure 1. A screenshot of web page (www.iimr.res.in/publications/) showing information on hybrids and composites of maize and registered germplasm

Figure 2. A screenshot of home page (www.agridaksh.iasri.res.in.jsp/) showing the link to maize hybrids and composites and varieties

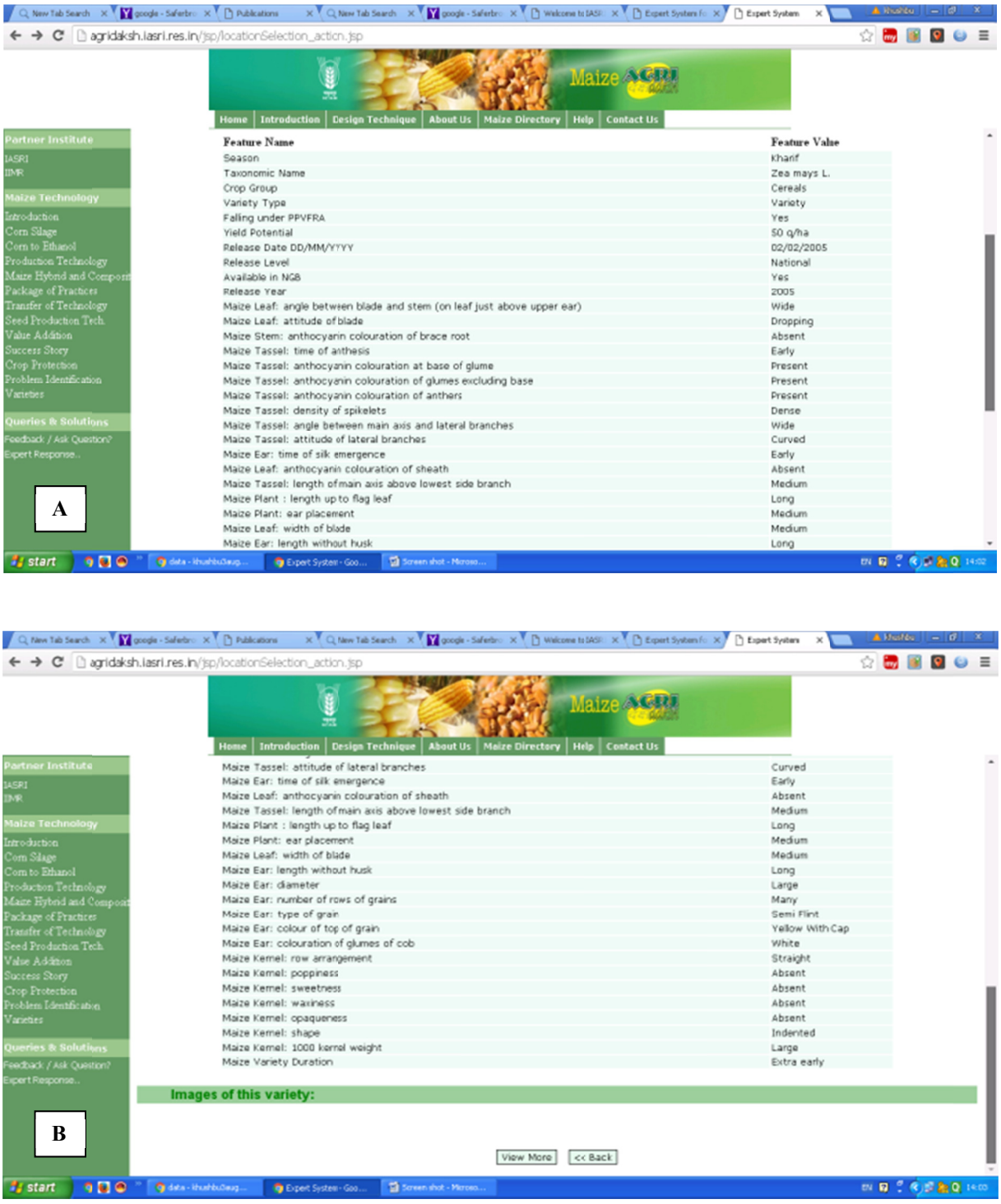

Figure 3. A screen shot showing description of a maize variety

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