Introduction of Maize Germplasm in India: Utilization and Opportunities

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Maize (*Zea mays* L.) is an important cereal crop having significance as food, feed and industrial raw material. India harbours quite rich diversity in maize particularly in the North-eastern Himalayan region. Impressed by this diversity some workers have proposed Asiatic origin of maize. But indigenous diversity is very limited in comparison to that available in Mexico and South America, and it widely agreed that maize originated in Mexico about 9,000 years ago.

In mid-1940s, many varieties were introduced in to India and evaluated along with indigenous material. Among them Malan and Amarillo-de-Cuba deserve mention. In early 1950s, a number of commercial hybrids were introduced from the USA, Australia and other countries. Some hybrids from the US Cornbelt like US 13, Dixie 18, Texas 26, NC 27 and Illinois 1656 showed marked superiority over local varieties. These hybrids, however, could not create an impact due to their unattractive grain type, late maturity and problems associated with their seed production.

The Indian Council of Agricultural Research established All-India Coordinated Maize Improvement Project in 1957 to organize and integrate maize research at the national level. This project introduced a large number of germplasm from many countries particularly the USA, Mexico, Colombia, Peru, Venezuela and Caribbean islands. Inbreeding was undertaken in the promising introduced and indigenous germplasm which led to the development of many hybrids, the first set of which was released in 1961. The emphasis then shifted to open-pollinated varieties, and six composites were released in 1967. In late 1980s maize breeding programme was again reoriented with a focus on single cross and other simple hybrids and first single cross, Paras, was released in 1995.

Germplasm introduction got great importance with the establishment of CIMMYT, Mexico, in 1966. In addition to germplasm bank accessions, CIMMYT has been providing improved germplasm (pools, populations, inbred lines and experimental varieties and hybrids). Earlier CIMMYT worked on the development of open-pollinated varieties and the programme was reoriented towards hybrid breeding in 1980s; and this affected the type of material supplied by CIMMYT. The CIMMYT maize germplasm has significantly enhanced genetic diversity of maize in India and has contributed to the development and release of several new maize cultivars.

Since 1961, 50 open-pedigree hybrids and 97 composites have been released for general cultivation. The cultivars that played a role in increasing the maize productivity in the country include hybrids Ganga Safed 2, Hi-starch, Ganga 5, Sartaj, Ganga 11, Deccan 103, Deccan 105, Paras and Parkash; and composites Vijay, Kisan, Ageti 76, Tarun, Parbhat, Navjot, Arun, Shweta, Navin, Pusa Composite 1, Parvati, Mahi Kanchan, Megha, Mahi Dhawal and Devaki. Almost all these have been developed by using exotic germplasm, the contribution of indigenous germplasm being only a little. There have been some outstanding introductions. Suwan 1, Pop 44 and [VC 80 x (ETO x Tuxpeno *br*2)] were directly released for commercial cultivation. In addition, Tuxpeno PB, Pop 35, Antigua Gr 1 and CM202 are other examples of extensive use in the breeding programme. During the initial years (1961-64), nine hybrids were released, the parents of which included CM202, which later on was used as a parent of other commercial hybrids; and CM104 and CM105, which showed durable resistance against leaf blights. These elite lines and germplasm like Suwan 1 and Antigua Gr1 could not be utilized much in inbred line development.

With an emphasis the reorientation towards the breeding of single-cross hybrids, constitution and improvement of heteortic pools got emphasis. Indian maize programme has developed eight pairs of heterotic pools. Three of them have been developed by Punjab Agricultural University (PAU), Ludhiana. Of these, Makki Safed & Tuxpeno and Indigenous & Semi-exotic, adapted to rainy season, have full-season and early maturity, respectively. Exotic germplasm have largely contributed in the constitution of Makki Safed and Semi-exotic pools, and Tuxpeno is entirely based on introduced germplasm. The third pair, which is adapted to winter season, has almost all germplasm of exotic origin mainly US Cornbelt. The important germplasm which have been used to develop and improve various pools are: Arun, Ageti 76, Navjot, Partap, Tarun, Vijay, CM111, CM123,

CM202, CM205, CM206, A670, B57, B73, B79, B84, BS13, FR13A, FR619, FR632, FR670, FRVa26, H96, H98, H99, H100, H101, Mo17, MSP1, Tuxpeno, Suwan 1 and Populations 24, 26, 31 and 36. Commercial hybrids like Paras, Parkash, JH3459, Sheetal and Buland have been developed using the inbred lines derived from these heterotic pools.

The efforts on introduction of maize germplasm have been focused on CIMMYT. Other sources need to be tapped, such as heterotic pools developed in other parts of the world; physiologically efficient, input responsive, high plant density and inbreeding stress tolerant germplasm in the US Cornbelt and Europe; high oil and protein germplasm in the USA; high protein and cold tolerant germplasm in Germany; cold tolerant germplasm in Canada, northern Europe and New Zealand; downy mildew resistant germplasm in South-east Asia besides known genetic stocks having genes for nutritional, stress resistance/tolerance and other traits. Trait specific germplasm developed by CIMMYT, such as resistance/ tolerance to downy mildews, maize streak virus, drought, acid-soils and other abiotic stresses needs more rigorous efforts on introduction and utilization. Further, germplasm adapted to Indian agro-climatic conditions have been obtained in abundance from CIMMYT, which should not be expected in case of germplasm introduced from other sources. Many times exotic germplasm would be required to be subjected to adaptive mass selection, and early generation recycling would need to be incorporated in inbreeding. The utilization of exotic germplasm has to be a stepwise approach.

The germplasm from different geographical areas have different useful traits. For example, the tropical germplasm are tall, late and large biomass producers. Therefore, these are good for fodder maize. The US Corn Belt germplasm have high harvest index, standability, responsiveness to inputs and tolerance to high plant density (relatively light canopy and erect leaves). Highland germplasm have cold tolerance, rapid seedling emergence, long roots, purple pigmentation on stem and leaf, and pubescent leaf. In India major germplasm introduction has been of tropical and sub-tropical germplasm whereas temperate germplasm did not get required focus. The genetic base of specialty maize (quality protein, high oil, special starch types, sweet corn, pop corn etc.) and fodder maize germplasm available with Indian maize breeders is very narrow which needs to be urgently widened. Introduction of germplasm of teosinte and *Tripsacum*, particularly that of the former, is also required. The importance of maize as feed and industrial crop is bound to increase. Maize cultivation during winter may expand with expected climate change. To meet these challenges, an increased need for expanding genetic base of maize in India is foreseen, for which highly diverse germplasm would have to be introduced, evaluated, adapted and utilized.

Sorghum and Millets Introduction: Achievements and Opportunities in India

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The origin and domestication of *Sorghum bicolor* (L.) Moench has taken place in Africa about 5000–8000 years ago. Indian subcontinent is the secondary centre of origin of Sorghum. The evidence for its cultivation was discovered at Saurastra dating back to about 4500 years. Sorghum was probably brought to India from eastern Africa during the first millennium BC. It is reported to have existed there around 1000 BC. The sorghums of India are related to those of northeastern Africa and the coast between Cape Guardafui and Mozambique. *Pennisetum glaucum* (L.) R. Br. is important millet in India, second to sorghum. It is considered to have been introduced to India from Africa. A large number of related species are found wild in Africa. The small millets indigenous to India are little millet (*Panicum sumentranse* Roth), kodo millet (*Paspalum scrobiculatum* L.) and Indian barnyard millet (*Echinochloa frumentacea* Link). On the contrary, three other small