

# International Maize Improvement Consortium (IMIC) in Asia: Partnership with Seed Partners for Client-Oriented Product Development and Delivery

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## Maize in Asia

Maize is an important field crop in Asia with a cultivated area of 58.3 million hectares (m/ha) (in 2013). Area under maize has been increasing consistently in Asia (except in Central and West Asia). Asia requires more than a million tons of maize seed per year and the demand increases annually (Table 1). Even though the maize seed industry is vibrant in Asia, farmers in some countries in South and South East Asia, still use open-pollinated varieties (OPV) as there is a lack of a formal seed system for hybrid seed delivery. Even in countries like India, which has a very active and dynamic seed system, OPVs are still predominantly cultivated in some States (Table 2).

Seed systems across Asian countries vary considerably both in nature and magnitude (Table 3).

Countries like China, Thailand and India, have strong research and development (R&D) programs supporting seed systems both at the public- and private-levels. Most other countries of Asia have local capacity for R&D, mainly in the public sector. However, they lack a strong supporting seed system for production, processing and marketing. In such countries, seed is imported by traders, from both small and large multinational seed companies (MNCs) operating in Thailand, India and Indonesia and then marketed internationally. Also, there is variation in the regulatory system for commercialization of maize hybrids (Table 3), not only between countries, but also within countries like India, where the regulatory system for commercialization of a new hybrid varies from one state to another.

**Table 1.** Requirement of maize seed in Asia

Year	Area (Million ha)	Seed Requirement in 1000 tons					Average Increase (%)
		Central & West Asia	South Asia	SE Asia	East Asia	Across Asia	
2011	54.7	32.0	221.0	170.9	670.8	1094.7	
2012	56.3	28.2	224.3	172.5	700.6	1125.7	2.8
2013	58.3	28.6	236.9	178.1	722.0	1165.6	3.5

**Table 2.** Major OPV markets featured in Seed Rolling Plan of Maize for 2013-17 of GOI.

State	% OPV
Uttar Pradesh	63
Madhya Pradesh	30
Bihar	20
Chattisgarh	34
Jammu & Kashmir	75
Arunachal Pradesh	100
Assam	100
Sikkim	11
Tripura	42
Meghalaya	17

Source: Extracted from [Seednet.gov.in/seedplan/seedplan.html](http://Seednet.gov.in/seedplan/seedplan.html).

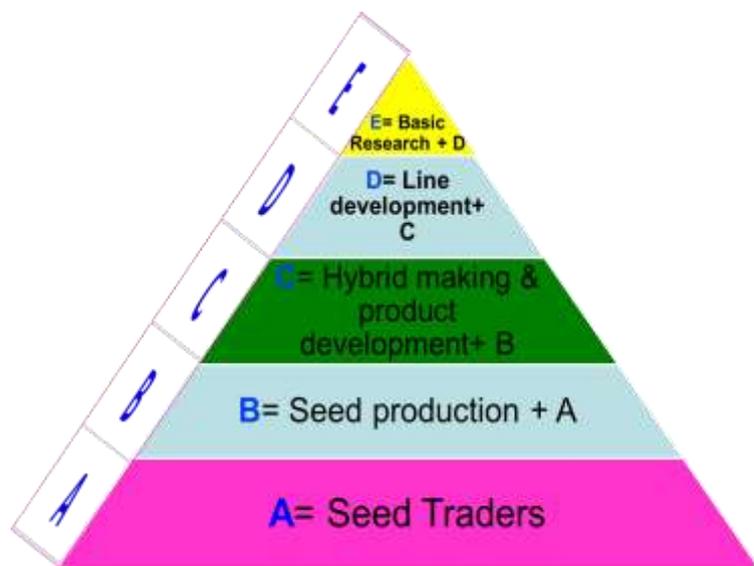
**Table 3.** Seed systems in different Asian countries

Characteristics	India	Pakistan	Bangladesh	Nepal	Indonesia	Vietnam	Thailand
Seed Business	Mostly by Local & MNC companies; Seed corporations to smaller extent; Seed exporter	Predominantly MNCs	Predominantly MNCs	MNCs	Predominantly MNCs	Mostly by Local & MNC companies; Seed corporations to smaller extent	Mostly by Local & MNC companies; Major exporter of maize seed
Hybrid coverage	60%	40%	90%	30%	60%	98%	98%
Hybrid market (K tons)	110	8.5	4.5	3	40	10	23
Seed supply	Local production	Imports	Imports	Imports	Local production	Mostly Imports	Local production
Seed production Infrastructure	Strong	Nil	Poor	Nil	Moderate	Moderate	Strong
Registration requirement	Not Mandatory	Mandatory	Not required	Mandatory	Mandatory	Mandatory	Mandatory
Source of hybrids	Predominantly local	Predominantly Imports	Predominantly local				
Hybrid Development	Indian & MNC companies; NARS	NARS	NARS	NARS	NARS	MNCs & NARS	Thai & MNC companies; NARS
Private R&D	Strong	Nascent	Nascent	Nil	Nascent	Medium	Strong

### Structure of the seed industry

The seed industry, in Asia, is not a monolithic block: the role and capabilities of seed companies vary. The seed industry in Asia as a whole, may be represented by a pyramid with five layers, each with distinct capabilities (Figure 1). Seed traders form the largest proportion of the seed industry and they are represented at the bottom of the pyramid. Companies, comprised largely of MNCs, are represented at the top of the pyramid as they are few in number. MNCs have a long history of R&D and they have adequate resources. The growth of the seed enterprise may be measured by the proportionate movement of seed companies from the bottom to top of the pyramid. Even though countries like China, Thailand and India are considered to have strong systems; seed companies in these countries have varying capabilities and may be grouped into different layers of the pyramid. Only India, Thailand and China have seed enterprises in all of the five layers, while in other countries that have a weak seed system, the top layers of the pyramid may not be represented. In general, most of the seed companies that deal with self-

pollinated crops like wheat and rice are predominantly represented in layer B (seed production and marketing), while most seed companies dealing with hybrid crops like corn are represented in layer A (seed traders). The general requirements for germplasm, hybrid testing, training and advanced technical services, which CGIAR funded- international R&D institutions and local national agricultural research system, can effectively provide different services as per the level of the seed company (Table 4). Public-sector institutions have good research capabilities, but do not necessarily possess adequate capabilities in the area of deployment logistics. Therefore, in order to strengthen the seed system for effectively deployment of improved germplasm -technologies, public sector institutions, including CGIAR centers and NARS, may need to design and implement different types of strategies which are aligned with different layers of the pyramid, including well-supported growth of local seed enterprises for providing efficient services in the marginal markets that are not always served by the large seed companies.



**Figure 1.** Classification of seed enterprises based on the role and capabilities.

**Table 4.** Areas of partnerships between R&D institutions and seed enterprises

Level	Areas of Partnership						
	Hybrids	Inbreds	Donor	Parent seed production	Testing	Training	Technical & advanced Services
E			√		√	√	√
D		√	√		√	√	√
C	√	√		√	√	√	√
B	√		√	√	√	√	
A					√	√	

### International Maize Improvement Consortium-Asia (IMIC-Asia)

Drawing upon strong science and effective partnerships, CIMMYT creates, shares, and uses knowledge and technologies to enhance the productivity and profitability of the maize- and wheat-based farming systems, thereby improving food security and the livelihoods of the smallholders. CIMMYT is a non-profit research and training international agricultural research center with direct links to about 100 developing countries through offices in Asia, Africa, and Latin America. CIMMYT's crop improvement research outputs remain in the domain of international public goods (IPGs). These goods are accessible equally to public research institutions, private- and public-sector seed enterprises. CIMMYT's development and deployment of such IPGs has had a tremendous global impact on humankind.

New seed policies have been enacted by different Asian countries at different times. This has encouraged private sector participation in improved seed production and R&D. In China, India, and

Thailand, which were among the first to enact this policy, the private sector has dominated agricultural research and seed production and marketed a large number of hybrids in several crops, including maize. In countries which have enacted new seed policies more recently, the private sector has shown keen interest in developing its capacities in R&D and seed production, in addition to their core competency in marketing.

CIMMYT, since its inception, has been playing a catalytic role in strengthening maize R&D activities of NARS in various Asian countries and facilitated development and deployment of improved varieties. CIMMYT has also made substantial contributions to enhance genetic diversity, productivity, yield stability in maize, thus improving the livelihoods of resource-poor farmers (Prasanna, 2011). CIMMYT, during the past two decades, played a nurturing role to the fledgling private seed industry and provided breeding material, often through informal networks. As private sector seed companies grew in the tropics, they started developing significant R&D capabilities of their own and became a major conduit for large-scale, farm-

level adoption of maize hybrids derived from CIMMYT-derived inbred parents and/or their derivatives. Thus, CIMMYT-private sector partnership has significantly contributed to the development and delivery of improved maize hybrids and varieties in several Asian countries. The private sector, being close to the farming communities, has a strong understanding of farmers' needs, choices and preferences, and thus, plays an effective role in completing the seed supply chain from breeder-to-farmer.

Based on these considerations, many CGIAR centers recognized private seed companies as valuable research partners for hybrid seed production and deployment. ICRISAT was among the first CGIAR centers to establish the Joint Hybrid Parents Research Consortia in 2000, with several private companies as members (Gowda et al. 2001). IRRI, on similar considerations, established the Hybrid Rice Development Consortium in 2008 (Arlegui, 2014).

CIMMYT, as an established global leader in maize research, similarly initiated the "International Maize Improvement Consortium-Asia" (IMIC-Asia) in 2010, offering an opportunity for institutions actively involved in the maize seed business to be a part of a regional initiative. IMIC uses complementary expertise from the private sector in producing and marketing improved maize hybrids, without compromising on CIMMYT's global agenda for developing and delivering new technologies as IPGs. A significant aspect of this arrangement is that the products developed through this consortium continue to be freely available to public sector R&D institutions at all stages of germplasm development.

IMIC-Asia is structured to further strengthen the partnerships between CIMMYT and NARS, private & public sector seed companies for the advancement of training, development, and testing of improved inbred and hybrid maize. Under this model, which operates in a renewable five-year framework, each partner institution Consortium member signs a Memorandum of Agreement (MoA) thereby making a commitment to abide by the guidelines of the Consortium. The Consortium guidelines were agreed upon following several rounds of consultation among potential partners. Additionally, each seed company pays an annual consortium fee to become a member. NARS leads the Consortium, the public-sector partners and is an honorary member. A consortium advisory committee (comprised of representatives from private sector members of the Consortium, a NARS representative, and CIMMYT's Global Maize Program representatives) provides guidance and advice on research and development activities of the Consortium.

IMIC-Asia works on the following guidelines:

- As a member of the CGIAR, CIMMYT adheres to policies concerning the transfer of germplasm in line with the 1993 Convention on Biological Diversity (CBD) and the agreement between the CGIAR Centers and FAO by which designated germplasm held in-trust for the world community is made freely available, to all R&D institutions, through the Standard Material Transfer Agreement (SMTA) under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).
- Improved breeding lines, populations, and potential hybrid parents will be available to the private sector members of the Consortium, under the SMTA, while the improved breeding material, at all stages of development, will be available to the NARS institutions under SMTA.
- Private sector institutions, as well as profit-making public sector seed companies, can join the Consortium by paying an annual Consortium fee, in two different tiers (gold and silver).
- Field Days and other Consortium-specific meetings serve to elicit feedback on the usefulness of breeding materials, and also to set priorities (such as farmer or trade or industry preferences) for further research and product development.

### **IMIC-Asia sub-projects**

This Consortium has three specific sub-projects at present, with the possibility of adding on others, as needs evolve.

#### ***Sub-project 1: Development and distribution of inbred lines and identification of marketable CIMMYT hybrids***

This sub-project involves prioritization of target environments and traits as agreed upon by a majority of the participant members. CIMMYT identifies the elite donor and recipient lines for each of the target environments and makes pedigree populations ( $F_1$ -derived  $F_2$ s or breeding synthetics using sets of lines) for inbred line development. Products are made available through Field Days conducted once every two years. The selected materials are provided to the member, pursuant to the terms of the MoA on a non-exclusive basis. IMIC-Asia members may continue the selection process and extract lines from these, if the selection is from early-generation progenies, and can also use advanced inbred lines directly in combination with their own lines to generate proprietary hybrids.

Identifying marketable CIMMYT hybrids for registration and commercialization by IMIC-Asia members has also been flagged of as a potentially important area, especially by the SME seed company members.

**Sub-project 2: Training / capacity building**

CIMMYT develops and provides need-based training on precision phenotyping, genotyping tools and techniques and data management. CIMMYT offers hands-on training to IMIC-Asia members, on the use of the Fieldbook-IMIS system, an in-house, publicly available, free-software which is an efficient data management tool. Group training on maize breeding is planned in accordance with other CIMMYT priorities and fund availability.

**Sub-project 3: Hybrid testing**

CIMMYT coordinates evaluation of maize hybrids, submitted by IMIC members, in common trials covering India and the South and South-East Asian region. The number of sites and the names of sites is determined based on the priorities expressed by the IMIC-Asia members in consultation with CIMMYT. Trial coordination is performed by CIMMYT. Currently, this activity is restricted to India only, due to regulatory issues involved in export of germplasm. The objective of the hybrid testing under IMIC-Asia is to obtain information on hybrid performance in advance, for identifying best-bet hybrids that can be further evaluated in the national level testing conducted through respective notified agencies of

South and South East Asia, like the All India Coordinated Maize Improvement Project (AICMIP), for possible release and notification of varieties. Thus, the IMIC-Asia hybrid evaluation/testing is merely used as a potential precursor for the national performance trials.

Consortium members submit a limited number of proprietary hybrids to CIMMYT. CIMMYT forms the trials and dispatches to pre-identified collaborator locations. Data collected by collaborators through this testing network, is analyzed by CIMMYT, using advanced and appropriate data management tools and the summarized data is provided to the members. The trials are monitored by a team selected by the IMIC-Asia Steering Committee.

**IMIC-Asia: present status and activities**

**Membership**

IMIC-Asia membership is steadily increasing over the years and currently there are 43 members, including both the public and the private sectors (Figure 2). Of these, two members are from Indonesia. As mentioned above, regulatory hurdles in germplasm export, due to CBD, temporarily restricted membership to India-based-seed enterprises only. However, efforts to resolve this issue are bearing results and there is promise of expanding the membership to seed enterprises in other countries of Asia from 2015.



Figure 2. IMIC-Asia membership over the years.

### **Germplasm development: priority traits**

- Medium (90-110 days) to late (>110 days) maturity at 60:40 proportion;
- Good agronomic performance, including per se yield (at least 2.5 t/ha);
- High density tolerance (80,000 plants per hectare)
- Bright orange/yellow;
- PFSR, rust, *turcicum* and *maydis* blights resistance;
- Heat stress tolerance without yield penalty under optimal conditions;
- Drought tolerance without yield penalty under optimal conditions.

### **IMIC-Asia Field Days**

The first IMIC-Asia Field Day was held in March 2012 and the second Field Day was held in March 2014. During the 2012 Field Day, about 1,060 inbred lines were offered to members, while 798 inbred lines were offered during the 2014 Field Day. Eighteen members participated in the 2012 Field Day, while 32 seed companies and 22 Indian NARS-partners

participated in the 2014 Field Day. The value and usefulness of the germplasm developed by IMIC-Asia to the members, can be judged by a significant increase in the number of lines selected by the members (Table 5). In 2014, 87 percent of the germplasm offered were selected by the members compared to 58.5 percent in 2012. The 2014 Field Day had a display of improved germplasm for high per se yield, disease resistance (BLSB and downy mildew), heat and drought tolerance and temperate introgressions. A high-level of selection (above 84 percent) was exercised by members on the germplasm for all specific traits (Table 6). The pattern of selection not only varied between the two field days, but also between the private sector and the NARS. The diversity of selection was more noticed among private companies, as indicated by the choice of fewer common selections and high frequency of single member selected lines, 116 versus 47 selected by NARS partners (Table 7).

**Table 5.** Germplasm selected by members in 2012 and 2014 Field Days

Germplasm	2012			2014		
	Total	Selected	%	Total	Selected	%
Advanced	426	299	70.2	394	354	90
Early	634	321	50.6	404	338	84
Total lines	1060	620	58.5	798	692	87

**Table 6.** Types of germplasm selected by partners in 2014

Germplasm	Total	Selected	%
Disease Resistant	79	66	84
Productive inbreds	178	154	87
Heat tolerant	13	12	92
Drought tolerant	522	454	87
Temperate Introgressions	6	6	100
<b>Total</b>	<b>798</b>	<b>692</b>	<b>87</b>

**Table 7.** Pattern of germplasm selection over years and between companies and NARS in Field Days

Selection	2012	2014		
		Total	Private	NARS
Total partners	18	55	32	23
Lines Selected by >50% partners	16	9	11	51
Lines Selected by 1/3 of partners	65	81	52	136
1 partner selected lines	221	48	116	47

### ***Testing the potential of CIMMYT-derived pre-commercial hybrids***

Fifty-three trials, including 317 CIMMYT-bred hybrids, have been distributed to IMIC-Asia members for evaluation during the wet season of 2014, for the members to evaluate in-house and to shortlist the best five hybrids. Efforts are also underway to link the NARS partners with seed companies to facilitate deployment of the hybrids once registered.

### ***Training / Capacity building***

Based on the demand from the Consortium members, IMIC-Asia conducted the following training courses:

1. Managing drought stress trials (19 December, 2011);
2. Precision phenotyping for abiotic stresses (29 August - 1 September, 2012);
3. Maize phenotypic data management (1-4 May, 2013);
4. Statistical & genomic analysis (12-17 May, 2014).

### ***IMIC partners' hybrid testing***

Two IMIC trials, namely medium- and late-maturity groups, are being distributed three times a year (for testing in the wet, spring and winter seasons) for the fourth year in a row. A network of 15 testing sites is now operational under IMIC-Asia in India for hybrid testing.

### ***Possible activities for consideration in IMIC-Asia Phase 2***

IMIC-Asia Phase II will begin from July 2015. The areas under consideration are: (a) Doubled haploid (DH) production service; (b) Germplasm Enhancement of Maize (GEM); and (c) Molecular-marker-assisted breeding service, as additional activities/services.

## **CIMMYT's Improved Maize Product Allocation Principles and Criteria**

### ***Principles***

The principal purpose of CIMMYT's improved maize germplasm development work is to:

1. Provide stress-resilient and adapted pre-commercial products for the particular benefit of resource-poor farmers in the targeted geographies;
2. Enhance the access and uptake of improved maize products through public and private seed companies;
3. Enhance seed production, distribution and impact among the stakeholders.

### ***Criteria***

1. Ensure equity and fairness in the access to products by interested partner institutions.
2. Ensure uninterrupted access to the improved seed to the farmers who need such products in the target geographies.
3. Enable post-allocation follow-up and support, to the extent possible, to enhance understanding and impact of CIMMYT products.

CIMMYT has established a transparent system for announcement and allocation of pre-commercial hybrids. Any institute or organization interested in CIMMYT's improved products may contact Dr. B.M. Prasanna, Director, Global Maize Program, CIMMYT ([b.m.prasanna@cgiar.org](mailto:b.m.prasanna@cgiar.org)).

### **References**

- Gowda CLL, Reddy BVS and Rai KN (2003) ICRISAT strengthens ties with private seed companies. *Asian Seed and Planting Material* 10(4): 16-17
- Arlegui CGP (2014) HRDC General Report. 7thHRDC Annual Meeting, 19March 2014
- Prasanna BM (2011) Maize in Asia: Trends, Challenges and Opportunities. 11<sup>th</sup> Asian Maize conference, Nanning, China, 07-11 November 2011
- Seed Rolling Plan 2013-17; [Seednet.gov.in/seedplan/seedplan.html](http://Seednet.gov.in/seedplan/seedplan.html).
- United States Department of Agriculture (2014) Corn Statistics; <http://www.indexmundi.com/agriculture/?commodity=corn>