THE ROLE OF CIMMYT TO THE PROGRESS OF MAIZE IN INDONESIA

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Maize in Indonesia is the second important food crops with the annual harvested areas of 4.0 M ha with the total production 16.32 M ton (CBS, 2008). However, the country still imports maize to meet its increasing domestic demand, which mainly used for feed industry. The increase of maize production in the future will depend on the areas expansion particularly to outer islands of Java. Much of the potential areas for maize expansions in eastern parts of the country are characterized by dry land ecology which often facing drought problems. Therefore, generating a variety that tolerant to drought, early duration and high yield to support maize environment is one of the major activities at ICERI. Several maize that have been released had a genetic background from CIMMYT line, i.e. the OPV Lamuru (20% genetic background from CIMMYT lines), Sukmaraga and Anoman (the major genetic contribution were derived from CIMMYT line), and Srikandi Kuning and Putih (CIMMYT population), while ICERI was carried out in producing the population, and recombination and selection through multiple location trials in many site prior to be released). Similar works were done in two of our maize hybrids (Bima-2 and Bima 3), the male parents were also genetically derived from CIMMYT line in Mexico and CIMMYT Thailand.

CIMMYT has tremendous impact on maize development in Indonesia, through the collaboration of research activities and capacity buildings, i.e.

I. NETWORK

The project in connection to CIMMYT collaboration consisted of: (1) TAMNET (Tropical Asian Maize Network); (2) AMNET (Asian Maize Network); (3) QPM seed exchange and (4) AMBIONET (Asian Maize Biotechnology Network). These project has enable Indonesia to establish network on maize research and development. AMNET facilitated Indonesia to interact with other Asian countries maize producers. The establishment of maize producer network which let Indonesia to exchange the genetic material, experience, transfer knowledge and technology in order to accelerate the development of drought and acid tolerant varieties.

II. GENETIC MATERIAL

The demand of maize for food, feed and fuel in the world has been increasing within the last 2 years due to the high demand of maize as biofuel, and as the impact of global climate change. These changes resulted in rapid increase on price and decrease on supply of worldwide maize. Indonesia with the annual harvested areas of 4.0 M ha and production of 16.32 M ton, is still import maize to meet its increasing domestic demand. Many programs have been carried out to improve and increase maize productivity to fulfill domestic's need. Intensification is one way to solve the problem through developing of high

yielding varieties, which tolerance to abiotic and biotic stresses. Developing high yielding hybrids and OPVs has been a challenging effort, because of little germplasm genetic diversity. High germplasm diversity has an important role on developing prime varieties, because large size genetic diversity will accelerate the breeding progress, and increase the possibility of obtaining prime variety. CIMMYT as the International Institution mandatory in Maize and wheat research and development has been facilitating, supporting and donating germplasm, especially in enriching ICERI's germplasm collection. This collection would enhance the development of new inbreed lines and populations which finally generate new variety, either OPV or hybrid.

Table 1. CIMMYT's contribution on genetic material transfer

Name of project	Number of accessions	Type of accessions	
		Inbreed lines	Populations
TAMNET	20 accessions	20 hybrids	-
AMNET	147 accessions	114	35 Synthetics
QPM seed exchange	60 accessions	20 lines	40 populations
AMBIONET	30 accessions	30 lines	-

Several projects that CIMMYT developed has help ICERI enrich the germplasm collection, and accelerate breeding programs. Many of ICERI's elite inbreed lines and populations were introduced from CIMMYT, i.e., drought tolerance lines, QPM lines and provit A. Several maize varieties had been released in Indonesia i.e., OPV: Lamuru, Sukmaraga, Srikandi Kuning-1, Srikandi Putih-1, Anoman, and some hybrids: Bima-2 and Bima-3. Lamuru is an OPV variety developed in 2000, and 20% of its genetic background derived from CIMMYT. It has excellent adaptation on drought stress area, with the yielding capacity up to 7,6 t/ha. To anticipate the extension of growing maize on acid soil, ICERI (Indonesian Cereal Research Institute) had released a new improved OPV tolerance to acid soil in 2003 called Sukmaraga. Which is the second released of acid soil tolerance after Antasena in 1993. Sukmaraga was derived from AMATL (Asian Mildew Acid Tolerance Late), which has better adaptation on acid soil and high aluminum saturated soil, and resistant to downy mildew. It has potential yield up to 8.5 t/ha, with average yield of 6.0 t/ha. The effort to developed acid soil tolerant OPV was because no private company ever focus on acid soil tolerant OPV, which could help poor farmer to have access to commercial-high yielding varieties.

Most of the improved varieties released by IAARD (Indonesian Agency for Agriculture Research and Development) are yellow kernel maize, while white kernel maize is usually utilize as alternate food beside rice. One potential white kernel maize is Maros Synthetic-2 (MS-2), which is synthetic variety derived from CIMMYT population Tuxpeno sequia-C6 in 1999. The population was released in 2006 with new name called Anoman, named after a wise and

powerful monkey hero from the story of "Ramayana". Quality Protein Maize is special type of maize, which requires vigilant work to keep the proteins present. All of the QPM accessions introduced from CIMMYT. These lines would then be evaluated in numerous trials and multi-locations, in order to obtain the best entries to be released as prime variety. One example of the wide-spread QPM variety is Srikandi Kuning-1, which is QPM synthetic variety made of 8 inbreed lines introduced from CIMMYT was released in 2004. The variety has yield potential up to 8.0 t/ha, although there is still no significant value added in QPM variety compared to field corn. The demand of the variety is still high and lead to high demand in commercial seed for the poor farmer.

Many of CIMMYT projects were aimed to develop and increase genetic materials of its collaborator, and utilize the genetic materials for breeding programs. One of the projects is AMNET (Asian Maize Network), which started in 2005 is a CIMMYT-ADB project (ADB RETA No. 6208): "*Improving farmer's income through enhanced maize productivities in drought prone environments in East and South East Asia*". The project was executed by the Indonesian Cereal Research Institute (ICERI) located in Maros, S. Sulawesi. The coordination of project is carried out by the Indonesian Center for Food Crops Research and Development (ICFORD), Bogor which signed the agreement with CIMMYT. The activities related to germplasm are, (1) Evaluation of germplasm for drought tolerance, (2) Development and improvement of germplasm for drought tolerance.

III. INFRASTRUCTURE

The Indonesian Agency for Agricultural Research and Development (IAARD) has been conducting research on drought tolerant maize for several years ago under limited facilities. The AMNET project under CIMMYT has bring a great improvement for drought research in Indonesia. AMNET has helped us in establishing drought infrastructures; therefore we have been able to conduct proper evaluation for DT of 2000 genotypes per year since 2005. The infrastructure is also shared with other research groups. Trials of national breeding program related to DT have been conducted in this DT station. These are among the infrastructures:

Development of Drought Tolerant Screening Nursery

Development of stress managed screening nursery for drought tolerance was at Bajeng Experimental Station, South Sulawesi (Fig.1 and 2). The station is a major experimental farm located about 70 km south of the ICERI headquarters. The station covers 40 ha and the stress site is about 0.90 to 1.50 ha, consisting of three plots (0.30-0.50 ha each). Physical works were done in September, 2005. The stress site was developed by leveling the land to allow application of precise amounts of irrigation water.

Installation of Water Pipe

The water pipe is used for drought screening during dry season (June – October). Physical works of the installation were done in April, 2006 and covers 2 x 75 meter.

Figure 1. Soil levelling for drought nursery at Bajeng

Figure 2. Dr David Berginson is checking the land that being prepare for DT nursery at Bajeng

Under drought stress, there were susceptible entries (left), while photo on the right showed border of well watered plots on the left and drought stress one on the right (Fig. 3 and 4).

Figure 3. Perfotmance of suscentible entries

Figure 4. Irrigated (left) vs non irrigated

Supporting the infrastructure which has been donated by CIMMYT, the Indonesian government (IAARD) has been allocated adequate budget to

develop irrigation channels since 2006. Until the recent time, the installation is still being used for screening and evaluation of Indonesian breeding material during the year (including DT screening at dry season), and will be continued for future.

Figure 5. Participatory breeding program carried out in Naibonat East Nusa Tenggara 2007.

IV. CAPACITY BUILDING:

A. IMPROVING KNOWLEDGE & SKILL

CIMMYT has significant contribution in building the capacity of Indonesian researcher through training, scientific meeting, exchanges visit, and student training. These opportunities have let the share of knowledge in maize research and lead to a better quality researcher for Indonesian researcher. We have improved the knowledge and skills such as laying out and handling research, data analysis, report writing and another important thing is introduced us to molecular breeding and help us on developed it in here. Here is the list of scientific meeting which has been attended by Indonesian researcher:

The workshop was carried in October 20 to 23, 2008 in Makassar Indonesia, attended by eleven countries. The dominant participant beside Indonesia was China. The significant achievement for IAARD is generating a new research collaboration so called General Challenges Program (GCP) which mainly concerned on drought tolerant.

Table 2. Scientific Meeting and workshop

Year	Activities	Place	support
1995	The Sixth Asian Regional Maize Worksop (ARMW)	New DelhiIndia	ICAR-CIMMYT
1998	Ambionet First Training Workshop On Molecular Marker Application On Plant Breeding	Malaysia	CIMMYT
1999	Seed Production Technology	Indonesia	NARS-CIMMYT
2000	CRAWFORD Fund Master Class in Molecular Plant Breeding, University of Adelaide and La Trobe University	Australia	CIMMYT
	ISAR Management course 2000-managing biotechnology in transition	Malaysia	CIMMYT
2001	Asian Maize Biotechnology Network and QTL Mapping Workshop	IRRI, Los Banos, Philippines	ADB (AMBIONET)
2002	1. 8th Asian Maize Regional Maize Workshop 2. Workshop on Genetic Diversity study 3. Training course on genetic diversity study	Thailand, Bangkok Thailand, Bangkok New Delhi, India	ADB (AMBIONET) ADB (AMBIONET) ADB (AMBIONET)
2003	Training Genomic and Crop Improvement	New Delhi, India	ADB (AMBIONET)
	Training on Proposal development	Chiang may, Thailand	CIMMYT AMbionet-ADB
2004	Training of Trainer on the Basic of Moleclar Breeding at IABIOGRRAD	Bogor, Indonesia	NARS & ADB (AMBIONET)
2005	Scientific Writing Workshop	IRRI, Philippines	ADB (AMBIONET)
	On-job training the AMBIONET Service Lab of CIMMYT	IRRI, Los Banos, Philippines	AMBIONET-CIMMYT
	Workshops of a Grader impact through participatory approaches to variety development and slivery and the 9th ARMW	Beijing, RRC	CIMMYT
2006	International Plant Breeding Symposium	Mexico Elbatan	CIMMYT
2007	Workshop on low cost gene based for MAS Application in Rice and Maize	Jalna, India	GCP
	ADB-CIMMYT Asian Maize Network Drought Project Second Annual Meeting, 5 – 8 March	Ho Chi Minh City, Vietnam	AMNET-CIMMYT
2007	Training of Trainer on Data Collection an analysis, Site Selection, and Farmers Participation in *On-farm* Experimentation	Maros, ICERI Indonesia	AMNET-CIMMYT-Private Sectors
2008	ADB-CIMMYT Asian Maize Network Drought Project Annual Meeting and Regional Training, 5 – 8 March 2008	Kunming City, China	AMNET-CIMMYT
2008	The 10thAsian Regional Maize Workshop, October 20-23	Makassar Indonesia	NARS-CIMMYT

Table 3. Exchange Visit

Exchange visit	Person	Country	Year	Support
Exchange visited at IRRI on genetic diversity study	M.B. Pabendon	Philippines	March 2002	ADB (AMBIONET, CIMMYT)
Exchange visited at IARI on genetic diversity study, mapping and MAS	Muh. Azrai M.B. Pabendon	New Delhi, India	Sept. 2002	ADB (AMBIONET, CIMMYT)
Drought Tolerant Exchange Visite	N.Iriany Syafruddin	Hyderabad	Feb.2005	CIMMYT
Exchange visited at Yunan Agricultural University (YAU)	Muh. Azrai	Kunminng City, China	March 2008	Air ticket supported by AMNET, lumpsum and accommodation supported by YAU
Exchange visit at Nakhon Sawan Field Crops Research center, Takfa	Sigit Budi S.	Thailand	October 2007	NARS, AMNET (CIMMYT) & Thailand

CIMMYT has helped and support ICERI maize breeder in university study. Several breeders have received CIMMYT support on their research for theses and dissertation. Among them are:

- A. Takdir Makkulawu, PhD degree at Bogor Agriculture University. Dissertation: Development of Drought Tolerant QPM and Waxy Corn.
- Rafidah Neny Iriany, PhD degree at at Bogor Agriculture University. Dissertation: Development of Sweet Corn resistance to downy mildew basic on Molecular Marker.
- Nuning Argo Subekti, PhD degree at Gadjah Mada University. Disertion: Development of Acid Tolerant Maize Hybrid.
- Musdalifah Isnaeni, Master degree at IPB. Thesis: Diallel analysis for drought tolerant Maize hybrids. AMNET
- Roy Effendy, Master degree at Bogor Agriculture University. Thesis: Selection of Maize lines and population for drought tolerant using PEG
- Amin Nur, Master degree at Bogor Agriculture University. Thesis: Development of QPM drought tolerant maize.

A. IMPACT OF CIMMYT ON CAPACITY BUILDING TO INDONESIAN RESEARCHER

Over years, CIMMYT has been building and improving partnership and capacity, as well as in sharing the knowledge of maize production and technology with Indonesian researcher. Researchers have received CIMMYT support and many of them occupied positions of influence on research and policy making in Indonesia.

Muhammad Azrai has completed his MSc in Plant Breeding at Padjajaran University in Indonesia in 2002. He was study on Maize QTL Mapping for Downy mildew under the AMBIONET Project (CIMMYT) for his thesis. He has attended several rigorous trainings conducted by CIMMYT from 2001 until 2008 on various subjects, i.e. maize biotechnology, maize drought project, variety and technology of maize development and adoption. He has completed his PhD in Plant Breeding at Bogor Agricultural Institute in Indonesia in 2007. He was study on Downy mildew resistant QPM Hybrid for his dissertation and using the genetic materials from CIMMYT and the laboratory equipments and materials supported by AMBIONET. He is now holding an important role in Indonesian agriculture as Programe Coordinator for Plant Breeding and germplasm of Indonesian Cereal Research Institute (ICERI), Member of National Evaluator Team of Food Crops Variety Riliese (Representative for Maize Breeder), Evaluator of Indonesian Plant Variety Protection especially for Maize Crops DUSS Testing.

Marcia Bunga Pabendon received support and guidance through several trainings and research exchanges on maize biotechnology from 2001 until 2007. These trainings have build and improved her skill on molecular breeding for maize such as genotyping. The AMBIONET project was supported her research on genetic diversity study for thesis at Padjajaran University in Indonesia in 2002. She completed her PhD at Bogor Agricultural Institute in Indonesia in 2008 using CIMMYT'S genetic material on correlation analysis of heterotic pattern of inbreeds based on SSRs marker to the phenotypic performance of test cross and diallel cross of maize hybrid. She has been able to set up a satellite molecular laboratory at ICERI in 2006 supported by NARS and AMBIONET project which donated laboratory equipments and chemical materials.

There are still some peoples who has important role in Indonesian maize program who has not been mentioned above.

V. MAIZE PROGRESS IN INDONESIA

There are 5 major provinces out of 30 provinces in Indonesia that contributed almost 50% of maize production (Table 4).

Table 4. Maize harvested area, production and yield rate in 2008.

Province	Harvested area (ha)	Production (t/ha)	Yield rate (t/ha)
East Java	1.235.933	5.053.107	4.09
Central Java	639.354	2.679.914	4.19
Lampung	387.259	1.808.720	4.67
South Sulawesi	287.181	1.205.750	4.20
North Sumatera	240.413	1.098.969	4.57
Remaining Provinces	2.150.235	4.516.423	3.19
Indonesia	**4.003.313**	**16.323.922**	**4.08**

Source : CBS-Statistic Indonesia (2008)

IAARD recently consider the need of a proper variety that can be accepted by farmer especially in rural areas, concerning that food consumption from maize is increased from 17.34 kg/capita/year in 2002 to 21.35 kg/capita/year in 2006 (Table 6). Srikandi Kuning-1, Srikandi Kuning Putih-1 and Anoman have been released to fulfill the need of people especially in rural areas, concerning that the people in rural areas consumed more maize than that of living in the city (Table 7).

Table 6. Demand estimation of maize for direct consumption and food industries

Year	Food consumption (kg/cap/year)	Total food consumption (000 ton)
2002	17.34	3,791.2
2003	18.26	4,078.3
2004	19.24	4,386.3
2005	20.27	4,718.1
2006	21.35	5,074.8
Growth rate (%/year)	5.4%	5.4%

Source: Ariani and Pasandaran, 2007

The demand of maize for direct consumption was generally decreased as the increased of the expenditures. Under expenditure of < Rp 40,000 per capita/month, people tend to consume more maize (24.15 kg/capita/year) as direct consumption, and decreased to 0.68 kg/capita/year under the expenditures of > Rp 500,000/capita/year as presented in Table 7. This data indicated that improving of maize quality in term of nutritive value would improve the diet of the poor people, especially in rural areas, to help the rural people to improve their nutrition diet (Table 7).

Table 7. Rate of maize consumption based on expenditures, 1999 (kg/capita/year)

Group of Expenditures (Rp./month)	Kg/capita/year	
	City	Village
< 40.000	16.90	24.15
40.000 – 59.999	16.2	7.56
60.000 – 79.999	1.23	7.45
80.000 – 99.999	0.84	3.93
100.000 – 149.999	0.41	2.10
150.000 – 199.999	0.23	1.35
200.000 – 299.999	0.37	1.59
300.000 – 499.999	0.45	1.18
> 500.000	0.42	0.68

Source: Susenas, BPS *cit.* Ariani and Pasandaran (2002)

Dr Marsum Dahlan (has passed away) played a significant role in initiating and generating most of maize varieties developed in Indonesia both Open Pollinated and hybrid varieties, started from developing based population until generating elite lines and varieties. Moreover he has been succeeded in improving the capacity knowledge and skill most of ICERI researchers in generating a new variety of maize.

Table 8. Open pollinated and hybrid maize varieties released in Indonesia by IAARD, 1996-2008

Variety	Year released	Maturity (days)	Grain yield (t/ha)		Disease resistance [a]		
			Average	Potential	DM	LR	LS
OPV's							
Laga Ligo	1996	90	5.1	7.5	r	r	r
Gumarang	2000	82	5.0	8.0	mr	r	r
Kresna	2000	90	5.2	7.0	mr	mr	mr
Lamuru	2000	95	5.6	7.6	mr	mr	mr
Palakka	2002	95	6.0	8.0	r	r	r
Sukmaraga	2003	105	6.0	8.5	r	r	r
Srikandi K-1	2004	105	5.4	7.92	s	r	r
Srikandi P-1	2004	105	5.89	8.09	s	r	r
MS-2 (promi-sing pop.	*	95	4.60	6.6	r	mr	mr
Hybrid							
Semar-10	2001	97	7.2	9.0	mt	r	r
Bima-1	2001	97	7.3	9.0	mt	r	r
Bima-2	2007	100		11.0	r		
Bima-3	2007	100		10.0	r		
Bima-4	2008	100		12.0	t		
Bima-5	2008	100		13.0	t		
Bima-6	2008	100		13.5	t		

[a] DM = downy mildew; LR = leaf rust; LS = leaf spot; r = resistant; mr = moderately resistant; mt=moderately tolerant

Satellite molecular laboratory which supported by AMBIONet (CIMMYT) has delivered important impact on maize development in Indonesia, e.g:

1. Genetic diversity study of inbred lines collection. Several data set of inbred lines have characterized (1 Indonesian & Introduced Inbred, 2 Indonesian & CYMMIT Asia Inbred, 3 Indonesian & Tamnet Inbred, 4 QPM & non QPM, 5 AMNET & Indonesian Inbred, 6 waxy, 7 drought, 8 low N, 9 Sweet Corn). The first three data sets were conducted by ICERI researcher (Marcia B.P et. al) at the laboratory of molecular biology of IABIOGRRAD (Indonesian Agricultural Biotechnology and Genetic Resources Research and Development) under AMBIONET project in 1998 until 2005. The rest of 6 data sets were conducted at ICERI satellite molecular laboratory from 2006 until present time.
2. Fingerprinting of Indonesian hybrid parental i.e. Semar 8,Semar 9, Semar 10, Bima 1, Bima 2, Bima 3, Bima 4, Bima 5 and Bima 6, using 10 polymorphic SSR primers. All of the parental hybrids have fingerprinting.
3. Introgression gen o2 using Marker Assisted Backcrossing (Azrai et al., 2006). Donor of QPM lines from CIMMYT. Recurrent parent using lines from CIMMYT Asia (Thailand) that generated in Indonesia (ICERI). Marker selection is phi057. A number of QPM hybrids candidate using MAB (three tolerant to Downy mildew).
4. Purification of Indonesian hybrids parental & tester using SSR marker. Each parent was tested using 100 individual. Conducted at ICERI molecular laboratory from 2006 until present time.
5. Development of hybrid maize SSR marker based (genetic distance). The selected lines were clustered in different heterotic group. From these selected lines we have six promising hybrids (ready for multiple-location) which genetic distance was higher than 0.7.

VI. FUTURE MAIZE AND TROPICAL WHEAT PROGRAM IN INDONESIA

1. Germplasm Collection, Characterization, Utilization such as (bioethanol) and Conservation of Genetic Resources of Cereals.
2. Varietal Improvement, Improvement of Crop Management, and (techno-socio-economy) of maize for marginal land (including development of early and extra early maturing lines of maize and development of tropical wheat to be adapted in the tropical regions). Donating of early and extra early maturing germ plams of maize and has a good eating quality is still expecting from CIMMYT as well as the germplams of tropical wheat).
3. Increase the Competitive Advantage of Cereals for market oriented *(demand driving)* and *(demand driven).*
4. Development of Research Collaboration, Information System, Communication, Dissemination, and Feedback for Innovation Technology of Cereals.
5. Development of Seed Systems and Production of Cereals Seed Sources.
6. Capacity Building
7. Human Resources Development of ICERI Staffs (post graduate training for molecular breeding of maize and wheat).