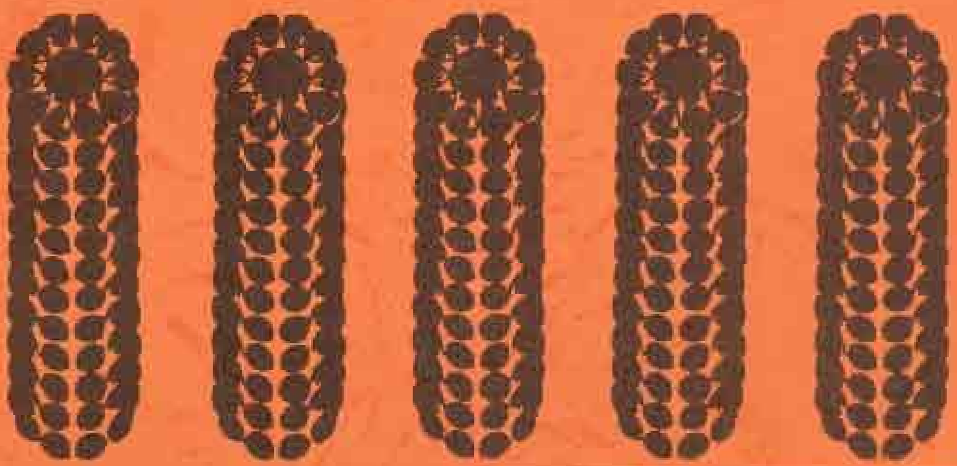
Proceedings of the Sixth Asian Regional Maize Workshop

Punjab Agricultural University, Ludhiana and
Indian Agricultural Research Institute, New Delhi, India
October 30 to November 3, 1995



Sponsored by the Indian Council for Agricultural Research (ICAR), Directorate of Maize Research and the International Maize and Wheat Improvement Center (CIMMYT)

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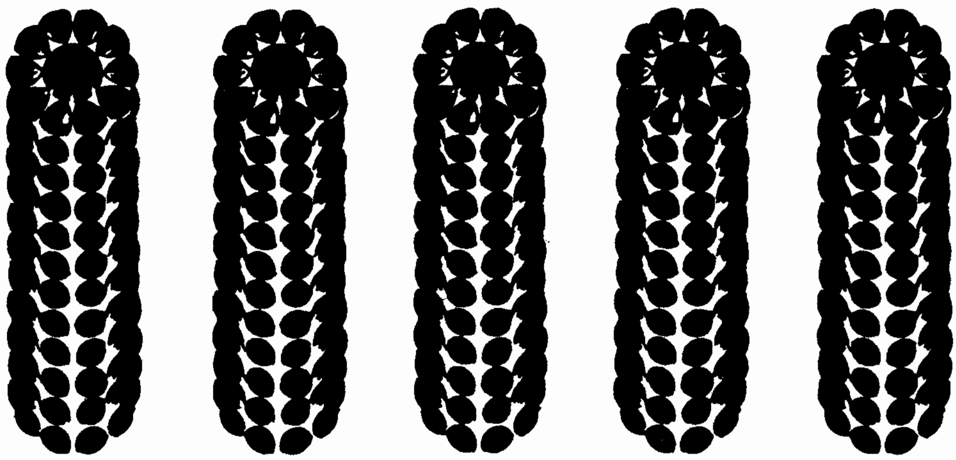

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CIMMYT is an internationally funded, nonprofit scientific research and training organization. Headquartered in Mexico, the Center works with agricultural research institutions worldwide to improve the productivity and sustainability of maize and wheat systems for poor farmers in developing countries. It is one of 16 similar centers supported by the Consultative Group on International Agricultural Research (CGIAR). The CGIAR comprises over 50 partner countries, international and regional organizations, and private foundations. It is co-sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the International Bank for Reconstruction and Development (World Bank), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP).

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FOREWORD

The Asian Regional Maize Workshop has been an important activity in the region to bring together scientists from the public and private sectors to interact and exchange results of their work through various presentations. Also, in having a field demonstration of the important and new germplasm available from each country, scientists were able to examine the performance of these materials at the time of the workshop. The previous workshops were held in Thailand, Indonesia, Pakistan, Vietnam, and China. This particular workshop was unique in a way as the Indian Council for Agricultural Research (ICAR), the Maize Directorate and the Punjab Agricultural University (PAU) took the initiative in organizing the workshop providing not only the facilities but also accommodation, food and travel to some of the participants. The first part of the workshop was held in Punjab Agricultural University, Ludhiana October 30-31, and the second part in the Indian Agricultural Research Institute (IARI) in New Delhi from November 1-3, 1995.

The workshop was indeed a success as participants from all the maize growing countries in the region attended. Of particular importance was the presence of the private sector and their very active participation and interaction during the discussion sessions were most welcome. A workshop of this nature is extremely important as it brings awareness to the rapidly changing scenario of maize demand and supply in the region. Some of the senior officials of ICAR, in particular, Dr Mangala Rai made an excellent presentation to bring to the scientists attention the changing scenario of maize needs for food, feed and industrial uses in the region so the scientists, while presenting their country reports can highlight these points in their presentation. The need for maize as feed is increasing dramatically in the region over the past decade or so. Some of the countries have shifted from the position of being exporter to a net importer of maize grain in recent years.

The regional workshop has been very useful in defining new research activities to cope with new emerging problems and challenges that have been observed in recent years. This region has been particularly effective in developing proposals for collaborative research projects, designing problem solving strategies, and providing useful germplasm for such constraints. An exceedingly important effort was made in strengthening of collaborative research projects that are difficult, resource consuming and involve problems of biotic and abiotic nature. This workshop provided the forum for exchange of results and progress made in various collaborative research activities that are underway in the region.

Country reports have been a very important feature of the workshop as each scientist brings the latest information from his country and presents it to collegeaues in this region. Country reports are also very useful in presenting the changing situation of maize production and use of germplasm products. The interesting highlight of the workshop was a very timely theme, "Maize seed production and seed situation in Asia" which was thoroughly discussed by maize scientists from each country. The organizing committee of the workshop also requested special lectures by inviting the Director of Maize Program, CIMMYT to talk on the "Current Status of Maize Research at CIMMYT". In addition, a special lecture on " Concepts and Use of Testers in Maize Breeding Research" provided information on hybrid technology so that scientists from different countries were made aware of the new research initiatives that they may have to take in the future.

Highlighted in the workshop was the increasing importance of strengthening private-public interactions and developing partnership in areas where one can benefit from the other and working in the spirit of togetherness. Commitments and offers were made from private and public sectors to identify and even financially supporting areas of common interest.

The shifting trend in the use of germplasm products in each country and in the region as a whole was underscored. It was important to point out the rapid change in thinking and exploitation of the various hybrid options that are available to the maize scientist. A few examples from some countries which have rapidly shifted to two parent single cross hybrid maize should encourage thinking to shift breeding methodologies to adopt the best hybrid options to increase maize productivity in each country. We are going to witness dramatic growth in hybrid maize in several countries in the region. It is imperative that we strengthen the available maize networks like TAMNET and more testing activities are done on hybrid maize technology. Apart from the presentations and country reports, the workshop gave the scientists the opportunity to look at various germplasm products that have been developed and are in use in each country. A lot can be learned by examining the field demonstrations and by studying the behavior of the materials where they have not been tested before. In this particular workshop the field demonstration trials were planted both in PAU, Ludhiana and at IARI, New Delhi. At Ludhiana the materials were harvested at the time of demonstration and the scientists were able to examine and take notes on the yield and plant types and some reactions to leaf diseases. Unfortunately, in New Delhi only the harvested piles could be observed as the materials could not be left in the field any longer.

The regional workshop got a very positive support from the private sector. They contributed to provide meals and at times directly supported the travel of key speakers. We take this opportunity to thank ICAR, PAU, the private sector; Pioneer Hi-Bred, Cargill, Mahyco, Kanchana (India), G & K, ProAgro, ITC-Zeneca, Messina, Mahindra and Ciba Geigy for their generous support for the workshop. To end this foreword it is our pleasant duty to thank ICAR, IARI and PAU scientists for providing excellent facilities and in arranging the workshop so well that most of the participants were extremely happy with the arrangements during their stay.

Dr Surinder K. Vasal
Maize Breeder and Team Leader
CIMMYT-Asian Regional
Maize Program, Bangkok

INTRODUCTORY REMARKS

E. A. Siddiq [1]

It is a great privilege for me to extend a hearty welcome to all of you on behalf of the Indian Council of Agricultural Research and on my own. Also, let me convey the best wishes of my Director General, who could not be present due to his prior commitments abroad, for the success of the Sixth Asian Regional Maize Workshop. We are indeed happy that CIMMYT has chosen India as the venue for holding this years' Workshop.

It is a coincidence that this workshop is being held when FAO is celebrating its 50th Anniversary- the time target set by the World body to ensure food for all. In spite of major advances made in food grain production during the last three decades, all over the world in general and tropical Asia in particular, the fact that over 800 million people still remain under-nourished is quite disturbing. Sadly, 90 percent of them are in the developing world and India alone accounts for about 150 million. Economic inaccessibility may be among the reasons for this situation. Yet, the fact that we are still far from ensuring sustained food security can not be underrated. With shrinking land resources, we are left with no option but to strive continuously for progressive yield growth in all major food crops. This realization, no doubt, has accelerated research efforts towards this end, but the excessive emphasis on the same two crops, rice and wheat, as was the case in the past, with hardly any serious attention to the coarse cereals, the staple of the poor, is certainly unfortunate.

Among cereals, Maize is the second most important crop after wheat in terms of production and is top ranking in productivity, and is still having sizeable untapped yield reservoir. To cite our own example, progress achieved in maize production from less than 6 million tons to more than 10 million tons during the past one decade with no increase in area is solely due to steady yield increase from 0.6 to 1.7 t/ha. The yield increases range from 2-times in less productive region comprising Rajasthan, Uttar Pradesh, Madhya Pradesh and Gujarat, to 3-5 times in high productive regions, which includes the states of Punjab, Himachal Pradesh, Bihar, Andhra Pradesh and Karnataka. Nevertheless, the average yield is far less than not only the world average, but also that of some of the countries in the region, like China and Korea, which harvest on an average 5 t/ha. Yields as high as 5 t/ha being obtained in *rabi* under irrigated conditions suggest existence of sizeable untapped yield potential which is unlike the other major cereal crops. Exploitation of such potential is one of the reliable strategies to sustain the production growth of food grains in the coming decade.

The following are some of the underexploited productive niches that offer opportunities to increase and stabilize maize production:

i. Scope for maximizing yield levels in less productive states of Rajasthan, Gujarat, UP and MP that account for 60 percent of the maize area,
ii. Good prospects for *rabi* maize in as many as ten states,
iii. As much as 50 percent of the area is still remaining uncovered by high yielding strains, and
iv. Least exploited potential of single cross hybrids for both *kharif* and *rabi* seasons.

Crop improvement research strategies contemplated for increasing maize production are: a) development of more productive and stable early maturing composites for resource poor less productive states, and heterotic hybrids for high productive states, b) development of hybrids for risk-free high productive *rabi* season with emphasis on single cross hybrids, c) insulation of all future hybrids and composites with desired level of resistance to emerging diseases, such as leaf and sheath blight and post flowering stalk rot, and insect pests like cutworm and thrips; and d) evolution of varieties/hybrids with added value for alternate uses - edible oil, starch and raw material for pharmaceutical and several other industrial products.

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[1] Deputy Director General (Crop Sciences), Indian Council of Agric. Res., Krishi Bhawan, Rajendra Prasad Road, New Delhi 110001, India.

Among the major constraints for the spread of high yielding strains, non- availability of quality seed in adequate quantity is important. The vertical seed replacement rate in maize is 13 percent, of which 60 percent is for hybrids. To increase the area under high yielding strains to 80 percent, from the present level of 50 percent, concerted efforts for augmenting seed production and supply are needed. Increased participation of private sector and establishment of seed villages are the means to meet the growing seed requirement. I am happy that this workshop has chosen 'seed' as the focal theme for deliberation.

If many countries in the region including India could have today a strong research base for maize improvement, it is to a great extent due to the unlimited flow of germplasm in the form of finished and semi-finished breeding lines, gene pools and genetic stocks, and knowledge from CIMMYT during the last three decades. The Asian Regional Maize Program is again an initiative by CIMMYT to add further strength to the national programs by way of promoting collaborative research on problems of regional importance, facilitating exchange of research knowledge and materials among the countries in the region, and helping in human resource development through training and workshops on topics/subjects relevant to the region. We are confident that efforts of this kind would bring us in the region together to achieve our production goals and help in alleviating poverty and hunger from the face of the region.

The pace with which we are directing our research and development for maize improvement makes us feel confident that it would be the turn of maize in the coming two decades to sustain the 'food grain revolution' triggered by wheat and rice three decades back.

FUTURE OF MAIZE IN ASIA.

Carlos De Leon [1]

Abstract

For the last 10 years, maize production in Asia has shown a continuous increase, with a high annual growth rate of 3.3% as compared to lower values in other regions in the World. During this period, P.R. China became the second largest maize producer and exporter after USA, with an increased competition for Asian markets. With the population increase, plus an increase in demand for animal products due to higher per capita income, an increase in demand for maize for both human food and animal feed has developed. According to projections for the next 10 years, the present rate of increase in maize production will not be enough to cope with the expected demand. Several alternatives to increase maize production in countries in the Asian region are discussed, including alternatives in crop improvement and management.

1. PRODUCTION.

At world level, maize continues to be the cereal with a continuous increase in production, reaching 500 million tons in 1992. Industrialized countries reached a record production in the early 1990's (Fig. 1), while the developing countries passed the 200 million tons level, producing 40% of the total world's maize.

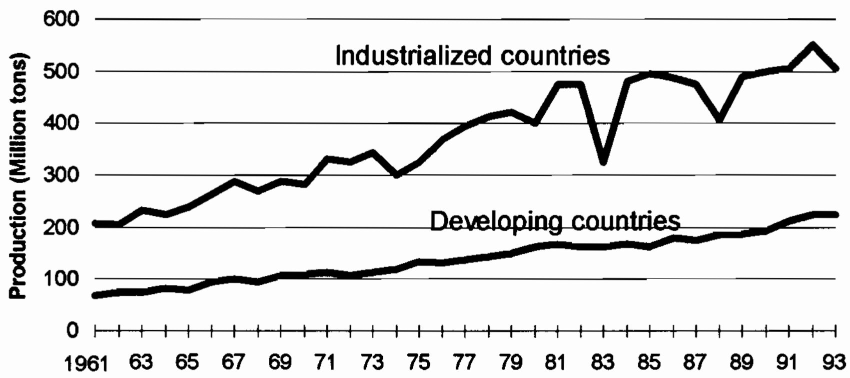

Fig. 1. World maize production, 1961-93.

In many instances, countries reported increases in production, in spite of reductions in maize area. During the period 1983-93, the countries in the Asian region maintained a high 3.3% annual rate of growth in maize production. An artificial 4% increase in maize production is reported for countries in the W. Asia N. Africa region, where only 2 countries obtained abundant production in the last few years (Table 1). The Asian region contributed over 28% of the total world production of this cereal (Table 2). This was in spite of the fact that maize produced in Asia was only 15% of the total cereal output (Table 3).

2. DEMAND.

In Asia, the demand for maize to be used as food and feed has been continuously increasing with the increased economic incomes growing at 3.2% increase per year in most of the countries in the region. Byerlee and Saad (1993) assume that the increase in demand is expected to be at the level of 4.1% annually. However, more recently, it is considered that this was an underestimated value for demand of maize in Asia, probably because demand for feed uses is increasing 7% annually.

[1] Maize Specialist, CIMMYT-ARMP, P. O. Box 9-188, Bangkok 10900, Thailand.

As the demand increases, yields have to have a parallel increase. Faced with the increases in human and animal population and the associated demand, maize yields in most countries in the region have not increased at the required levels (**Tables 4, 5, 6**).

Table 1. Growth of maize area, yield and production in developing countries by region, 1983-92.

Region	Mean annual percent growth in production due to:		Total mean annual percent growth in production.
	Area	Yield	
South, East and Southeast Asia	1.2	2.0	3.3
Latin America	0.8	1.1	1.9
West Asia, North Africa	0.1	3.2	4.0
Sub-Sahara Africa	2.1	1.7	2.5

Source: Calculated from 1994 CIMMYT 1993/94 - World Maize Facts and Trends.

Table 2. Production and area of maize and cereals in the Asia-Pacific region and the World, 1993.

Geographic entity	Production (million tons)		Area (million ha)	
	Maize	Cereals	Maize	Cereals
Asia-Pacific	133.4	882.9	37.5	291.0
Rest of World	337.1	1011.4	89.8	394.2
World	470.5	1894.3	127.4	691.2

Source: 1994. FAO/RAPA, - Selected indicators 1983-1993.

Table 3. Share of maize in total cereal production in the Asia-Pacific region.

Crop	Production (million tons)
Cereals	882.9
Rice Paddy	482.7
Wheat	210.5
Maize	133.4

Source: 1994. FAO/RAPA, - Selected indicators 1983-1993.

During the past 10 years, land planted to maize has slightly increased in some countries viz. China, Indonesia, Myanmar, Nepal, Pakistan and Vietnam, while in others it has decreased (**Table 7**). During this same period of time, yields and production have been maintained at 2.9 and 4.0% annual growth rates, respectively (**Tables 8, 9**). The above data indicates the need to transport massive amounts of maize, especially to satisfy an increasing demand for animal feed (**Table 10**). The suppliers might be one of the nearby countries (**Figs. 2, 3**) but larger volumes will have to come from distant countries, thereby increasing costs of the grain.

3. **THE CHALLENGES.**

a. Increased demand. - A general consensus is that the growing gap between supply and demand will increase, if the current trends continue. FAO projects an increase in demand for all food at 3.1% per year in Asia, and a 2.5% increase for cereals. This is considered to be very low considering the present trends. The demand will also increase with increases in both human and animal population growth.

b. Improved crop management. - This technology needs to be supported and increased to fully exploit the yield potential of the improved germplasm.

c. Plant breeding and higher yielding germplasm. - The development and expansion of hybrid technology needs to be promoted in areas with potential for hybrid production.

Table 4. Estimated population (1993) and growth rate (1991-2000) in Asian Countries.

	Population (million)	Growth rate (%/year)
Bhutan	-	-
Cambodia	9.0	-
P. R. China	1205.6	1.3
India	896.6	1.8
Indonesia	194.6	1.4
Laos	-	-
Malaysia	19.2	2.2
Myanmar	44.6	-
Nepal	21.0	2.5
Pakistan	128.0	2.8
Philippines	66.5	1.9
Sri Lanka	-	-
Thailand	56.9	1.4
Vietnam	70.9	-

Source: 1994. CIMMYT 1993/94 - World Maize Facts and Trends.

d. Winter maize. - After rice, planting with maize offers a good option for increasing production in several countries in the region.

e. Quality seed availability. - Quality seed of improved germplasm has been one of the bottlenecks in most programs limiting the use of high yielding improved varieties/hybrids.

f. Use of modern biotechnology. - To be used in the future development of improved maize germplasm.

g. Development of stress tolerant varieties. - New resistant/tolerant varieties to various biotic and abiotic stresses limiting production have to be developed.

h. Higher investments in agricultural research. - Is necessary when higher productivity and total production are needed. National programs have been suffering due to lack of financial resources limiting research activities to a minimum.

i. Support to private sector. - This important aspect has been overlooked by many national programs. Private sector would bring an increased business perspective to seed production, open new job opportunities and increase competitiveness among institutions, resulting in increased quality of germplasm.

j. Increased relation with international centers and other international agencies. - These are to contribute with new germplasm, improved technologies, training possibilities and probably some financial benefits to national programs. These will bring improvements in germplasm and crop management technologies, which will bring higher productivity and production,

Table 5. Maize consumption (per capita), growth rate of maize consumption (per capita), and use of maize for human food and animal feed, 1990-92.

	Consumption (kg/yr)	% Growth rate consumption	% Use human food	% Use animal feed
Bangladesh	-	-	-	-
Bhutan	-	-	-	-
Cambodia	6	-2.2	0	94
P. R. China	83	2.5	57	33
India	11	0.8	2	7.8
Indonesia	37	2.8	26	67
Laos				
Malaysia	88	3.5	95	3
Myanmar	4	-8.1	41	52
Nepal	61	3.3	9	74
Pakistan	10	-0.8	20	58
Philippines	75	0.4	58	29
Sri Lanka				
Taiwan	143	6.9	76	3
Thailand	53	15.1	95	1
Vietnam	9	1.5	20	74

Source: CIMMYT 1993/94, World maize Facts and Trends.

Table 6. Average annual growth rates (%) of livestock population in Asia, 1983-93.

Species	Livestock % Av. annual growth	Meat % Av. annual growth
Beef	5.1	6.3
Pig	2.5	6.5
Goat	3.3	6.9
Chicken	7.5	8.3
Duck	6.1	8.3

Source: 1994. FAO/RAPA, - Selected indicators 1983-1993.

Table 7. Maize area and growth rates in Asian countries, 1983-93.

Country	Year		Av. annual growth (%)
	1983	1993	
Bangladesh	1	3	7.3
Bhutan	59	45	-3.3
Cambodia	49	48	-0.8
P. R. China	18868	20625	1.6
India	5860	5900	0.2
Indonesia	3002	29827	1.2
Laos	30	27	-0.9
Malaysia	14	22	5.1
Myanmar	181	22	2.7
Nepal	504	76	4.0
Pakistan	798	899	1.0
Philippines	3270	3324	0.4
Sri Lanka	26	30	1
Thailand	1587	1400	-2.4
Vietnam	378	501	2.8
Asia-Pacific region	33455	37550	1.1

Source: 1994. FAO/RAPA, - Selected indicators 1983-1993.

Table 8. Maize yield (t/ha) and annual growth rates in Asian countries, 1983-93.

Country	Year		Av. annual growth (%)
	1983	1993	
Bangladesh	0.8	0.9	1.8
Bhutan	1.4	0.9	- 5.6
Cambodia	0.8	1.2	3.9
P. R. China	3.6	5	3
India	1.3	1.6	2.7
Indonesia	1.7	2.2	2.9
Laos	1.1	1.7	5.9
Malaysia	1.4	1.7	1.3
Myanmar	1.7	1	- 6.7
Nepal	1.51	1.58	1.6
Pakistan	1.37	1.3	0.8
Philippines	1.02	1.43	3.1
Sri Lanka	1.1	1	-0.5
Thailand	2.26	2.03	0.4
Vietnam	1.2	1.6	2
Asia-Pacific region	2.651	3.554	2.9

Source: 1994. FAO/RAPA, - Selected indicators. 1983-1993.

Table 9. Maize production and growth rates in Asian countries, 1983-93.

(Unit - ' 000 t)

Country	Year		Av. Annual growth (%)
	1983	1993	
Bangladesh	1	3	9.2
Bhutan	83	40	-8.7
Cambodia	43	60	4.7
P. R. China	68353	103380	4.7
India	7922	9700	2.9
Indonesia	5087	6513	4.1
Laos	32	48	6.8
Malaysia	20	37	6.5
Myanmar	310	220	-4.2
Nepal	761	1200	5.6
Pakistan	1014	1180	1.8
Philippines	3346	4751	3.5
Sri Lanka	29	30	1.1
Thailand	3552	2850	-2.1
Vietnam	467	800	4.8
Asia-Pacific region	93974	133446	4

Source: 1994. FAO/RAPA, - Selected indicators. 1983-1993.

Table 10. Trade of cereals (except rice, wheat) in Asian countries, 1992.

Country	Exports		Imports	
	1982	1992	1982	1992
Bangladesh	-	-	1848	1339
Bhutan	-	-	10	37
Cambodia	-	4	150	81
P.R. China	891	12127	20187	18186
India	561	592	1688	3044
Indonesia	1	193	1908	3178
Japan	-	-	-	-
Korea Rep.	11	5	5538	10488
Korea DPR	210	5	585	986
Laos			31	44
Malaysia	167	118		
Myanmar	721	240	1922	3198
Nepal	52	1	7	21
Pakistan	997	1512	71	15
Philippines	16	35	361	2044
Sri Lanka	1	11	619	1055
Thailand	6893	5345	154	992
Vietnam	36	2051	519	283
Deficit for Asia				14250

Source: 1994. FAO/RAPA, - Selected indicators.

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FUTURE OF MAIZE IN CHINA.

S. H. Zhang [1]

The versatile nature and tremendous genetic variability in maize enables it to grow successfully throughout Asia and the world, covering the tropical, subtropical and temperate conditions. It is noticed that maize hectarage has expanded rapidly, and the total output and productivity has increased dramatically in Asia. This trend will continue in the next 15 years. But small farmers dominate maize production in Asia. The challenge is thus still severe for dissemination of hybrid maize in Asia, although maize was the first major cereal crop to undergo rapid and widespread technological transformation in the world. Hybridization methodology and hybrid seed production will be the keys to increase maize production in the future. Some important issues concerning maize production in China are more or less the same for Asia as a whole. These are as follows:

1. Demand for maize grain will increase tremendously as the animal feed industry develops in Asia. Maize imports will rise in some countries. For example, China was the second largest maize producer and exporter in the world, but now she is becoming a big maize importer to meet the demand for feed maize.
2. Hybridization methodology will continue to be popularized rapidly and to be widespread in Asia. Considering that small farmers dominate maize production in most Asian countries, and the complex of mega-environments, this technological transformation will take place gradually, and types of hybrids should be multiform, including modified single crosses, three way crosses, top crosses and improved OPV's and populations as well as single crosses. In China, most of the maize acreage is planted to single crosses, but modified single crosses, three way crosses, top crosses and modified OPV's still occupy more than half of the acreage in Guangxi, Yunnan and Guizhou provinces.
3. Drought is a very important constraint affecting maize production in many provinces in China. Most of the spring maize is planted under rainfed conditions in China, and the effect of date of sowing and amount of precipitation is critical on maize production. Although rainfall is usually enough to grow a crop of maize, drought often occurs in spring and in summer, and causes severe damage to the maize crop. This is a major reason for yield fluctuations observed in maize. Summer drought may reduce yield by 30-40%. Thus, it is very important to develop hybrids with drought tolerance for China's maize belt.
4. Low soil fertility is another constraint affecting maize production in some provinces. Many institutions have released a number of hybrids with high yield potential, but most of these hybrids usually require fairly good conditions of fertilizer and irrigation water. It is difficult to expand such hybrids in many marginal areas, where the soils are shallow, deficient in organic matter, nitrogen and phosphorus, and have low water holding capacity. In many mountain areas, fertilizers, especially compost, are not supplied in sufficient quantities, and farmers do not have enough purchasing power to buy chemical fertilizers. Maize breeders should thus improve germplasm and develop hybrids which can be cultivated in poor soils with low fertility.
5. Multiple disease resistance is a pre-requisite for a successful hybrid cultivar to be released in China's maize belt. Elite hybrids, as well as good inbred lines, have to be resistant to stalk rots, ear rots, viruses, head smut, *turcicum* and other diseases, etc.
6. Introduction and utilization of exotic germplasm. An important bottleneck for the maize breeding program in China is lack of appropriate germplasm. Most of the maize breeders have selected inbred lines from developed hybrids by a recycling methodology. Accordingly, it was difficult to develop elite lines and hybrids with multiple disease resistance and good adaptation. More and more breeders have now realized the need for introduction and utilization of exotic germplasm from the centers of maize diversity. A program in collaboration with CIMMYT has been initiated in this direction. The Chinese Academy of Agricultural Sciences (CAAS) is drawing up a plan to strengthen this co-operation so as to overcome the constraints impeding germplasm exchange. It is expected that more

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exotic germplasm will be introduced in China, and used to broaden the genetic base of hybrid maize breeding programs.

7. Reforms in the overall seed industry of China. The endeavor is to combine breeding research, seed production, and technology dissemination systems into one integrated system. At the same time, it is necessary to protect both breeders' property rights and the profits of seed companies. The seed law should be helpful to promote seed quality control and improvement.

In a nutshell, while China has successfully achieved a great increase in maize production and productivity, maize grain imports have increased comparatively more quickly. This is a challenge and an opportunity. In view of China's success in hybrid maize technology, it is felt now that the country should also direct its efforts to disseminate this technology in many more maize growing Asian countries, and thus help to increase maize production in this part of the world.

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CURRENT STATUS OF MAIZE RESEARCH AT CIMMYT

Delbert C. Hess [1]

Abstract

This presentation covers the mission, organization, activities, and current staffing of the CIMMYT Maize Program. In addition to work at center headquarters in Mexico, research at each of eight regional offices located throughout the developing world is briefly described. The Program's recently drafted strategic plan receives mention, as well as its matrix management approach, resource allocations, and germplasm development and distribution strategies and policies.

Mission

The mission of the CIMMYT Maize Program is to help the poor in developing countries by increasing the productivity of resources committed to maize, while protecting natural resources. This is accomplished through the preservation, improvement, and dissemination of genetic resources; the development of environmentally compatible crop management practices; the provision of research methodologies and information; and through training and consultations.

Organization and Staffing

The above activities take place within the organization shown in (**Fig. 1**). The Program is divided into five subprograms: Lowland Tropical Maize, Subtropical and Midaltitude Maize, and Physiology and Stress Resistant Maize. Leaders of these subprograms, the coordinator of the East Africa activities and the Associate Director, report to the Director of the Program. The across-Program units, the Highland Maize Breeding unit, the Ghana Project, the Central America Project, the CIMMYT-ORSTOM Collaborative Project, and the maize experiment stations report to the Associate Director. The Associate Director is also responsible for budgeting and other general administration of the Program. This organization appears to be working well, with the management workload well distributed. An effort has been made in recent years to decentralize management decisions as far as is practical, including approval of expenditures, which have been delegated to input cost center leaders (see below).

The coordination of outreach breeding activities with those of headquarters takes place mostly on an informal basis. Periodic visits of breeders to other breeding stations are encouraged, particularly to stations within the same or similar ecology.

There are now 38.5 staff members assigned to the Maize Program, including postdoctoral fellows and associate scientists. Twenty-four members are located at headquarters and 14.5 at outreach locations. These numbers remain the same as during the last two years, but there are fewer senior scientists and more post-doctoral fellows and associate scientists.

Research Stations

Researchers at headquarters are engaged mostly in activities related to crop improvement and training, and work primarily at the following CIMMYT research stations in Mexico (**Fig. 2**): Mexico's geographical diversity allows CIMMYT researchers to develop broad based germplasm for most maize ecologies in the developing world. To improve the targeting of its products, address key production constraints in specific regions, and maintain contact with national agricultural research systems, the Program posts staff at seven other locations throughout the developing world (**Fig. 3**):

- *Central America and the Caribbean (Guatemala City, Guatemala)* -- An agronomist provides technical and other assistance to the Regional Maize Program (PRM), a network of maize researchers from nine countries which develops germplasm and crop management techniques for maize farmers

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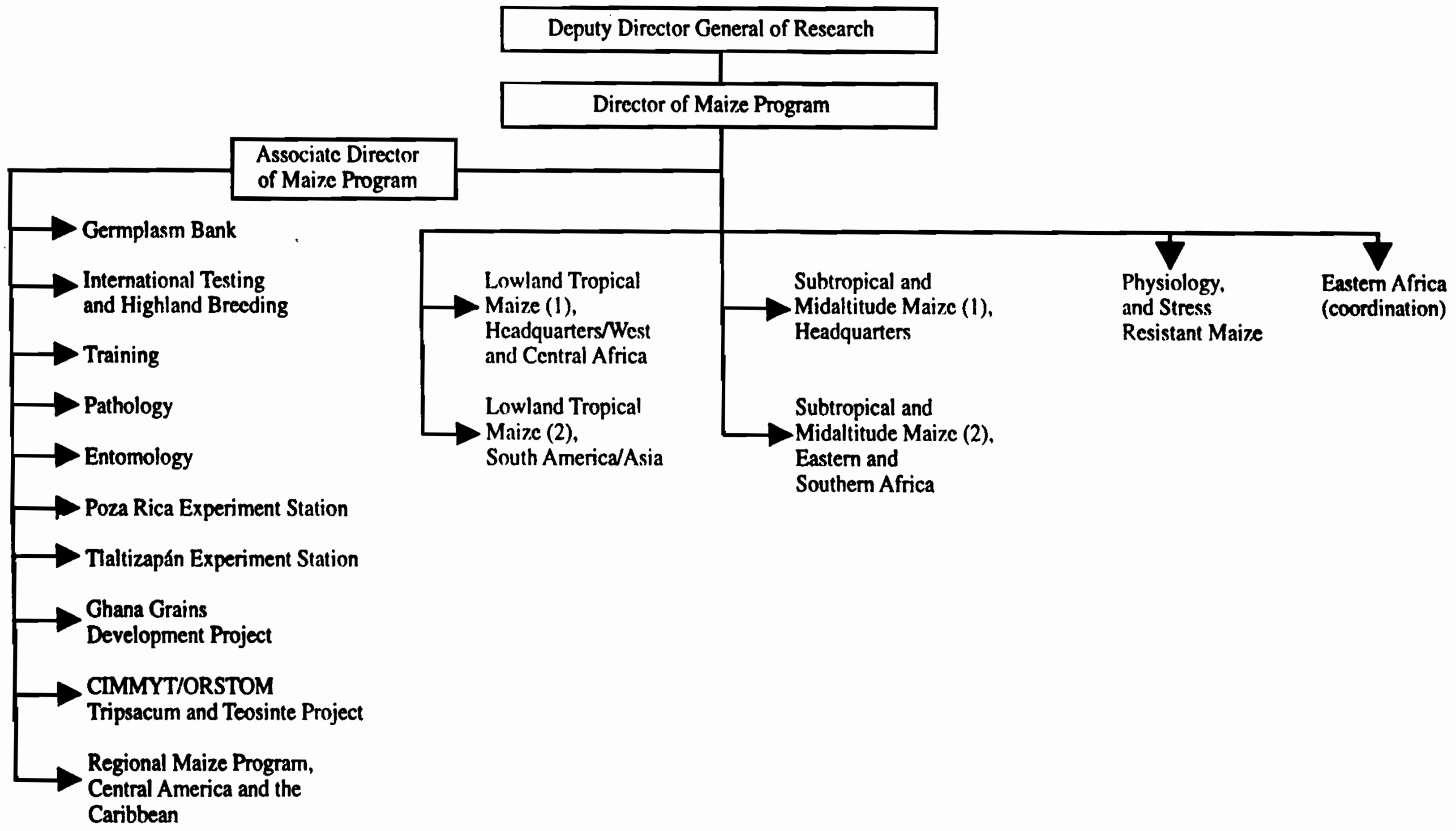

Fig. 1. Organizational structure of the CIMMYT maize program.

in Central America and the Caribbean, with funding from the Swiss Development Cooperation (SDC).

- *South America (Cali, Colombia)* -- Two breeders here work closely with national systems, mainly to develop varieties and hybrids that tolerate the acid soils characteristic of 3 m ha of maize areas in South America (8 m ha worldwide), with significant funding from the Inter-American Development Bank (IDB).

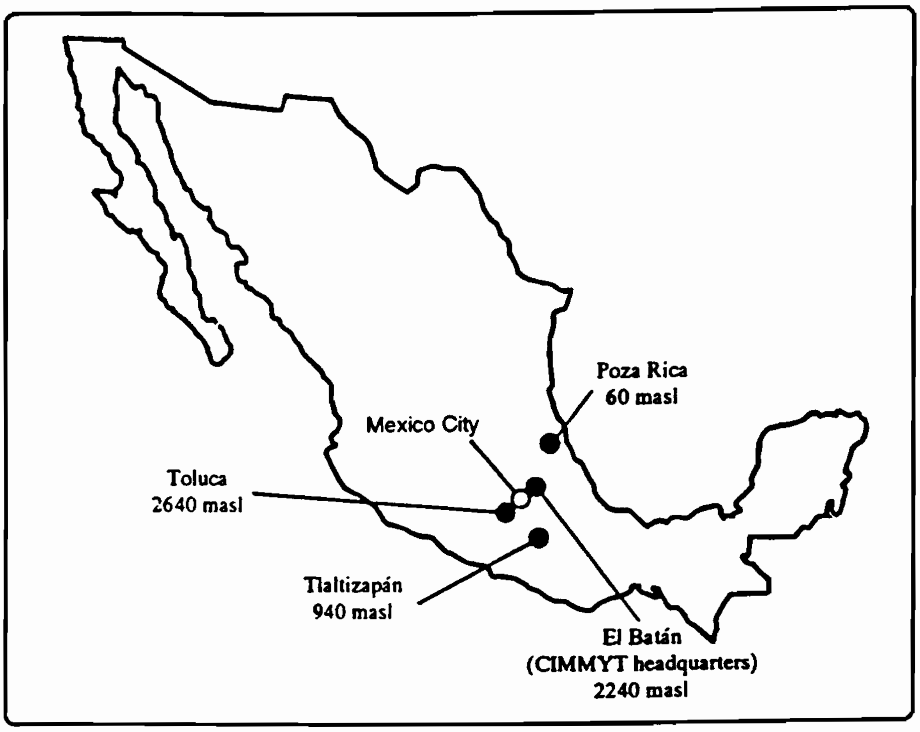

Fig. 2. Experiment stations in Mexico used by the CIMMYT Maize Program.

- El Batán (headquarters), State of Mexico (highland tropical)
- Poza Rica, Veracruz (lowland tropical)
- Tlaltizapán, Morelos (subtropical)

- *Eastern Africa (Nairobi/Njoro, Kenya)* -- One agronomist works with national programs in research funded by the Canadian International Development Agency (CIDA) to generate improved, sustainable management techniques that allow farmers to take full advantage of high-yielding varieties and hybrids; another provides technical and administrative assistance for a regional crop management research training initiative.
- *Southern Africa (Harare, Zimbabwe)* -- Two breeders develop maize varieties and hybrids for some 6.5 m ha of mid-altitude maize area in sub-Saharan Africa, with emphasis on resistance to maize streak virus. Another breeder helps coordinate a network of national system researchers involved in germplasm development and dissemination, under the Southern African Development Community (SADC), with funding from the European Community. An agronomist provides technical and administrative assistance to a network of researchers aimed at providing improved soil fertility

management recommendations for subsistence maize farmers in the region, with funding from the Rockefeller Foundation.

- *West Africa (Bouaké, Côte d'Ivoire)* -- With support from the OPEC Fund for International Development and in close collaboration with IITA, a breeder develops streak resistant maize for poor farmers in the lowland tropical areas of West Africa.

1. El Batán, Mexico (headquarters)
2. Guatemala City, Guatemala
3. Cali, Colombia
4. Bouaké, Côte d'Ivoire
5. Kumasi, Ghana
6. Nairobi/Njoro, Kenya
7. Harare, Zimbabwe
8. Bangkok, Thailand

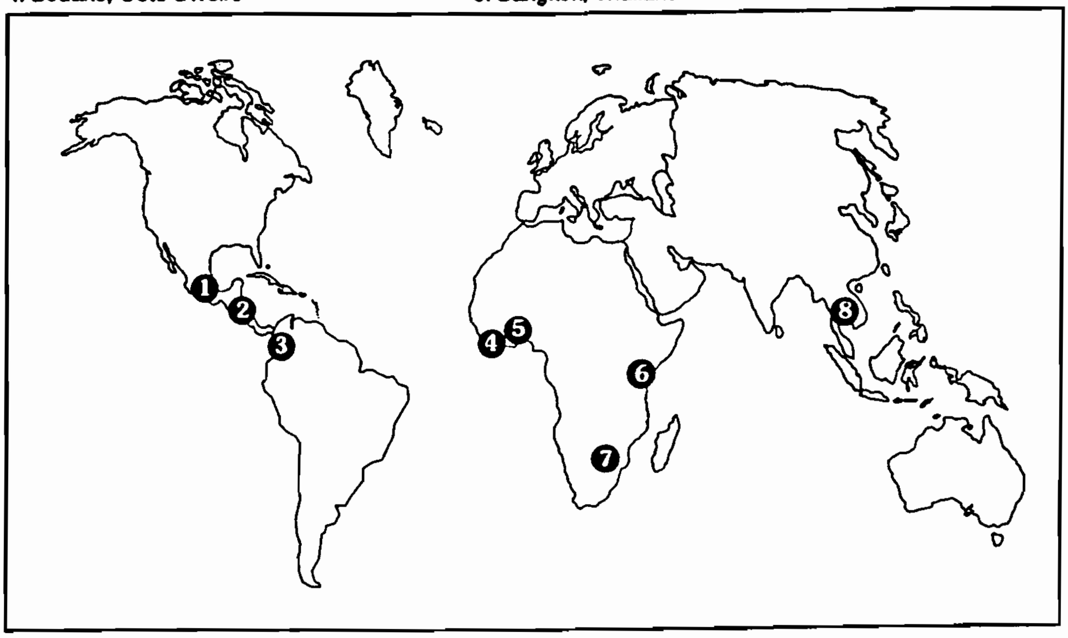

Fig. 3. Locations of the CIMMYT Maize Program.

- *West Africa (Bouaké, Côte d'Ivoire)* -- With support from the OPEC Fund for International Development and in close collaboration with IITA, a breeder develops streak resistant maize for poor farmers in the lowland tropical areas of West Africa.
- *West Africa (Kumasi, Ghana)* -- Under a bilateral project funded by CIDA, an agronomist works to help Ghanaian scientists improve their research and research management capabilities.
- *Asia (Bangkok, Thailand)* -- Maize is sown on more than 38 million hectares in Asia. Under CIMMYT's Asian Regional Maize Program (ARMP), a pathologist and breeder work with national systems in the region to develop and disseminate improved germplasm, with special emphasis on resistance to downy mildew. In addition to adapting germplasm from CIMMYT-Mexico for use in Asia, the ARMP has developed several broad-based, downy-mildew-resistant populations to meet a range of local needs. Recent efforts also include pyramiding other types of stress resistance -- such as to corn borers, acid soils or water logging -- into germplasm that already possesses resistance to downy mildew. In response to significant demand from cooperators, the ARMP increasingly seeks to provide germplasm that national breeders can use to generate high-yielding hybrids. Our researchers in Asia have developed excellent collaborative ties with the FAO, DOA, Kasetsart University, and the Farm Suwan research station, as well as with commercial maize breeders throughout the region. Finally, an ARMP agronomist provides technical and administrative assistance for a regional crop management research training initiative launched during this year with funding from the Asian

Development Bank and the government of Thailand, and additional material support from the Thai Department of Agriculture and Kasetsart University.

In addition to the individual breeding and crop management research activities described above, regional staff of the Maize Program work to strengthen the research capacity of national systems through training, research collaboration, and consultations.

Strategic Plan

After more than a year of discussions and revisions, the Program published a strategic plan in early 1995. The plan describes the Program's mission, partners, and beneficiaries; identifies key external factors that will influence the Program's future research directions; enumerates the Program's major activities; and discusses general strategies for allocation of research resources, participation in research partnerships, distribution of germplasm, and organizing research in the years to come. It provides strategies for the key activities through which the Program accomplishes its mission (see above), as well as general strategies for the following areas:

- Resource allocation priorities
- Collaborative research and networks
- Organization and management
- Fund raising
- Outreach versus headquarters activities
- Biotechnology
- Germplasm distribution
- Impact measurement and documentation

As is probably true for all strategic plans, this one does not address all issues and is not intended to include detailed operational procedures. However, it does provide the reader with the mission and general directions of the Program and seems to represent the current general strategy accurately.

Matrix Management

A matrix form of resource allocation and accounting, driven largely by the CGIAR system and strongly supported by the former Director General, was recently implemented at CIMMYT. The system offers several advantages for CIMMYT managers. It makes the allocation of resources much more transparent to all involved, including the donors, who increasingly demand more input in project development and execution. The Maize Program matrix comprises some 50 input cost centers and 15 output cost centers. The latter define the types of research to which the Program is committed and the former define the source of funding. The matrix itself displays many details of funding sources and uses, and enables an almost unlimited number of comparisons.

Resource Allocations

i) By ecology -- Given the Program's mission, the difficult circumstances of maize in the lowland tropics, and the size of this ecology -- some 35 million hectares in the developing world -- it is not surprising that the CIMMYT Maize Program devotes at least 60% of its resources to work targeted for lowland tropical areas. Two major subprograms focus on developing improved germplasm for such ecologies in sub-Saharan Africa and Asia. Nearly half the Program staff are dedicated largely or exclusively to breeding or other research relating to the lowland tropics. The Program allocates just over 30% of its resources to research targeted for subtropical and midaltitude areas. These account for 16.6 million hectares of developing world maize area, and 25 countries in Africa, Asia, and Latin America grow more than 100,000 hectares of maize in the subtropics or midaltitude zones. Highland maize is sown on a much smaller area -- some 6 million hectares -- in the developing world, but is often a major foodstuff for subsistence farmers, and the Program allots 6% of its resources to research on this type of maize.

ii) By output -- By far the greatest portion of Program resources -- some 59% -- supports germplasm improvement research. Allocations to training account for nearly 11% of the the budget; those to information and analysis, cropping systems research, and consulting, approximately 8% each. Finally, the Program spends some 6% of its funds on the preservation and management of maize genetic resources.

Breeding Strategies: Dual-purpose Populations

Although for many years (prior to 1985), the strategy of the Maize Program was to develop and distribute only open pollinated varieties of maize, recent trends in hybrid use in developing countries have caused a revision of this strategy. The Program cannot afford to ignore hybrids but, at the same time, significant areas of the developing world are still better suited to open pollinated varieties. Breeding strategies and methodologies thus need to serve both objectives. With this in mind a general scheme, entitled "dual purpose populations" was developed (Fig. 4). In this scheme populations are classified into heterotic groups, with improvements being made within each population and progenies ultimately being used against the progeny of another population to form either synthetic varieties or hybrids. The scheme allows a breeder many ways to fulfill specific research objectives. It implies considerable self pollination and selection based on both *per se* and testcross performance of the selfed progenies. Better performing lines can be recycled for population improvement, combined into synthetic varieties, or further selfed to produce uniform inbreds for use in numerous ways, but particularly for developing hybrids.

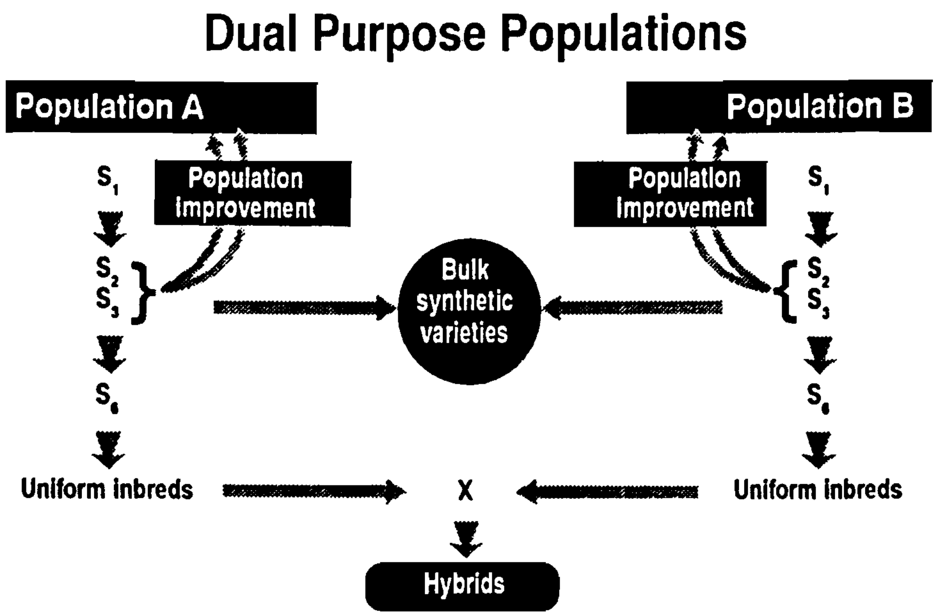

Fig. 4. Dual purpose populations: the breeding scheme through which the CIMMYT Maize Program obtains both open pollinated varieties and hybrid oriented products.

Germplasm Distribution Policies

The CIMMYT Maize Program distributes maize, teosinte, and *Tripsacum* germplasm for the benefit of producers and consumers in developing countries. The policy of the Program regarding the distribution and use of this germplasm is consistent with the CIMMYT policy of making germplasm freely available to all clients so that it reaches as many farmers in the developing world as possible. The Program distributes germplasm through:

- The maize international testing system, for which regular announcements are sent to national programs and other interested parties.
- Responses to requests for seed to CIMMYT scientists and the germplasm bank.
- Direct collection from CIMMYT trials at headquarters and outreach locations.

The following is the policy of the Program on the distribution and use of germplasm:

i) **Maize Program germplasm distributed in collaborative trials** -- Seed of the germplasm distributed as part of international testing is freely available to the cooperators and to anyone requesting such seed, so long as there are adequate supplies. The Maize Program develops and tests experimental hybrids to evaluate its hybrid oriented germplasm products, but does not generally distribute hybrid seed.

ii) **Announced inbred lines and source populations** -- This category includes materials that are publicly announced through direct communications from the Maize Program, in technical journals, in special bulletins, in International Testing reports, or by other means. Upon request and depending upon availability, seed of these materials is distributed on a priority basis with the first priority given to publicly funded national programs, followed by private cooperators within client countries, national seed companies, and multinational private seed companies. When national programs request it, seed will be channeled to private companies through them. The Program offers seed of more than 300 inbred lines of varying ecological adaptation, grain type, maturity, and stress tolerance to cooperators worldwide, and new, improved lines are constantly under development.

iii) **Breeding nursery germplasm** -- The CIMMYT germplasm not referred to above that is in various stages of development and is being grown by Program staff may be made available in small quantities to scientific collaborators requesting the seed. However, seed will be distributed based on availability and at the discretion of the scientist.

iv) **Germplasm Bank accessions** -- Accessions of maize genetic resources maintained in the CIMMYT Maize Germplasm Bank are held in trust for the world community, as stipulated in the FAO-CGIAR agreement. These materials and related information on their origin and attributes have unrestricted availability, and recipients accept them in accordance with an accompanying materials transfer agreement and will take no steps which limit their availability to other interested parties.

v) **Non-CIMMYT germplasm** -- Any germplasm obtained from other institutions or organizations is not distributed by the Maize Program without the written permission of the originator of the seed. However, if such materials are processed and admitted as accessions (with permission of the originator) in the Germplasm Bank, they may be distributed as indicated in the preceding paragraph.

The Program's Role in Maize Improvement for Developing Countries

Various players involved in meeting the maize seed needs of the farmers in developing countries and the primary activities in which they engage are shown in **Fig. 5**.

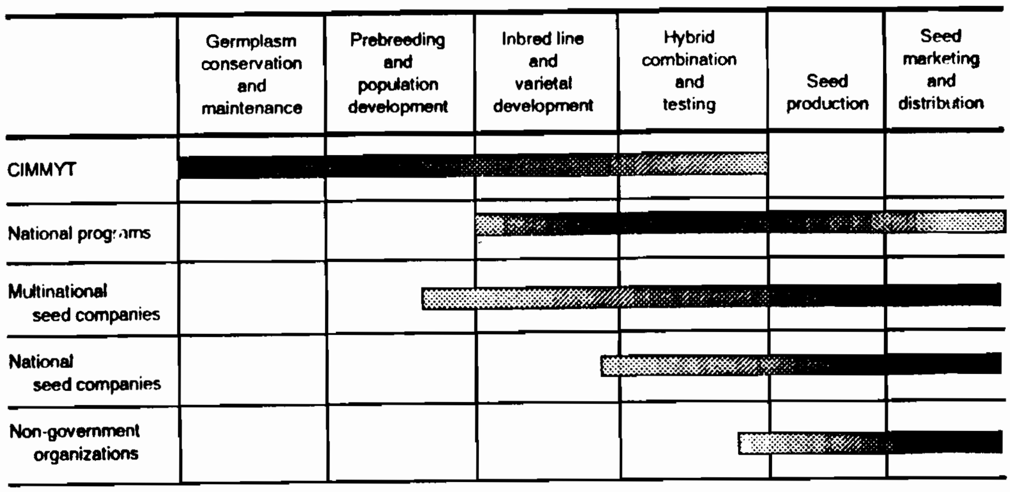

Fig. 5. Key players in maize improvement for developing countries.

HETEROTIC PATTERNS AND THE CHOICE OF TESTERS - AN OVERVIEW

S. K. Vasal, S. McLean, F. San Vicente and S. K. Ramanujam [1]

The CIMMYT Maize Program has developed a wide array of germplasm suited for different environments in lowland tropical, subtropical and highland areas. Much of this germplasm has been improved using intra-population breeding schemes involving non-inbred progenies. Inbreeding phases were added as part of the intra-family improvement in the on-going population improvement program. Little emphasis was placed on combining ability because the major thrust in the Program was to develop open-pollinated maize cultivars (OPV's). A major shift took place in 1984, with the decision to begin research on maize hybrids. Emphasis was relatively moderate in the beginning, but has developed into a full-fledged activity during the past 3-4 years. Every sub-program at headquarters and all regional programs have a hybrid component. The allocation of resources vary in different sub-programs but may be as high as 70% in some cases. Emphasis on hybrid development requires adjustment in other program activities, and hybrid-related activities should be fully integrated with those of population improvement to make the best use of available resources.

Hybrid development procedures, testing phases and complexity depend on whether two-parent or multi-parent hybrids are being formed. Irrespective of hybrid type, though, certain features in cultivar development are relevant to both population improvement and hybrid research. They evolve with time but are intended to improve efficiency, maximize yield performance, reduce testing phases, facilitate precise ranking and thus eliminate poorer genotypes and guide hybrid identification. In addition, to begin with, one would like to capitalize on useful genetic variability and heterotic patterns, particularly for inter-population and hybrid research activities.

Heterotic Patterns

At the outset of our hybrid maize efforts, an attempt was made to characterize potentially important germplasm types in the maize program for their combining ability and heterotic behavior. It was almost impossible to study every material against all others, given the sheer volume of germplasm, so we grouped our collections by adaptation, maturity, and in some instances, grain color. Quality protein maize (QPM) was studied separately in two groups. Genetically similar materials (judged by genetic make-up and our experience) were chosen to strike an appropriate balance within each group. Crosses were developed within each group using either diallel or design-2 matings. In all cases, parents and the F_1 crosses resulting within each group were studied in multilocation trials involving several interested countries.

Although the germplasm was of no direct use to US maize breeders, they were very interested and provided much support for the trials. A diagram of heterotic relationships among CIMMYT materials, along with other potentially important heterotic patterns, is also attached.

Tropical maize - All tropical maize germplasm for study was subdivided into three groups: 1) tropical late white (Diallel 5), 2) tropical late yellow (Diallel 4), and 3) early, intermediate white and yellow (Diallel 6). Amongst the late yellow materials, Populations 24, 28 and 36 exhibited high GCA effects and were also the highest yielding populations per se (**Tables 1, 2**). Populations 24 and Suwan-1 were quite conspicuous for their superior performance in crosses. Among the top seven high yielding crosses, Populations 24 and Suwan-1 were each involved at least in four out of seven crosses. The two highest yielding crosses were Pop. 24 x Pop. 36 and Pop. 24 x Suwan-1, with significant SCA effects. The percent high-parent heterosis, however, was not high, ranging from 12.6 to 13.6 in these two crosses. The cross of Pop. 27 x Suwan-1 was also quite high yielding with positive SCA effects and with positive high-parent heterosis of 17.47%. This particular cross will be of great interest in producing yellow flint hybrids.

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The late white populations were tested separately in Diallel 5. Populations exhibiting positive GCA effects were 21, 22 and 43, but Populations 22 and 43 gave the highest per se performance. Several crosses provided outstanding yields. Quite unexpectedly, the cross of Pop. 21 x Pop. 43 gave superior yields with positive SCA effects and high-parent heterosis of 10.9%. Both Populations 21 and 32 were involved at least four times in the eight highest yielding crosses. Population 22 crossed fairly well with Pop. 43 (7.55 t/ha) and Pop. 32 (7.55 t/ha). Other outstanding crosses were Pop. 21 x Pop. 25, Pop. 29 x Pop. 32, Pop. 32 x Pop. 43, Pop. 21 x Pop. 32 and Pop. 21 x Pool 24. Of the eight best crosses, SCA effects were positive in four, namely Pop. 21 x Pop. 43, Pop. 21 x Pop. 25, Pop. 29 x Pop. 32 and Pop. 22 x Pop. 32. Of the four crosses exhibiting high SCA effects, the first 3 crosses were among those exhibiting high high-parent heterosis.

The results from early and intermediate germplasm were slightly confusing because of the inclusion of white and yellow maize germplasm in the same trial. Several materials exhibited high GCA effects, including Populations 23, 26, 49 and Pools 20, 21 and 22. The four early populations and pools exhibited negative GCA effects, mainly due to the inclusion of intermediate materials. Pool 22 and Pop. 23 gave the highest per se performance. The highest yielding crosses of practical importance were Pop. 23 x Pool 20, Pop. 26 x Pool 21, Pop. 31 x Pool 18 and Pop. 26 x Pool 22.

Subtropical maize - The early subtropical and temperate germplasm was studied as a group in Diallel 1, comprising Pop. 46, 48 and Pools 27, 28, 30, 40 and 42. Pops. 46 and 48 were quite consistent in exhibiting positive GCA effects in both subtropical and temperate environments (**Table 3**). Population 46 and Pool 27 exhibited positive GCA effects, but only in subtropical environments. Pools 40 and 42 were consistent for their negative GCA performance in both temperate and subtropical environments. Population 48 in particular performed well in crosses with Pools 27, 28 and 30 and with Pop. 46. Pool 30 also combined well with Pop. 46. Two crosses of practical importance in this study were Pop. 46 x Pop. 48 and Pop. 46 x Pool 30.

The subtropical intermediate germplasm was studied in a separate trial (Diallel 2) comprising Pops. 33, 34, 42, 45, 47 and Pools 31, 34, 39 and 41. The materials performed differently in Mexican and temperate environments. Pops. 42, 47 and 34 exhibited highly significant positive GCA effects for yield in Mexico whereas only Pool 41 gave significant positive effects for yield in the USA (**Table 3**). In crosses, Pop. 42 x Pop. 47 ranked first in yield in Mexican environments. Among yellow crosses, Pop. 33 x Pop. 45 was the only one with significant positive SCA effects for yield. In the USA, the four highest yielding combinations included Pool 41 with Pops. 42, 47, 34 and 45.

Tropical x subtropical maize - Crosses involved six tropical (Pops. 22, 25, 27, 28, 32 and 43) and five subtropical (Pops. 42, 44, 45, 47 and Pool 34) materials. Population 43, 42, and 44 showed positive GCA effects for yield (**Table 4**). The three top-yielding crosses that also showed high heterosis were Pop. 43 x Pop. 42, Pop. 32 x Pop. 44 and Pop. 22 x Pop. 47. The latter was a high yielding hybrid in transition and mid-altitude environments.

Choice of Testers - Maize testers are required in breeding schemes that emphasize combining ability, inter-population improvement, and hybrid development. The germplasm to be used as tester should evolve as source germplasm is improved and trends in germplasm product development are changed. When breeding activities are quite varied, as at CIMMYT, a whole array of maize testers may be required. The Maize Program defines a tester as a genotype (OPV, synthetic, inbred or hybrid) that 1) facilitates discrimination among progenies for genetic worth and combining ability, 2) reduces testing phases during hybrid development, and 3) helps us to identify outstanding hybrids.

Our first use of testers came as part of a shift from intra-population to inter-population improvement in the tropical populations Tuxpeno and Eto. It would have been easy to use counterpart populations as testers, but instead we used 12-line, inbreeding-tolerant synthetics from populations 21 and 32. In the forthcoming cycles, we may, however, be able to switch to single cross hybrids. In evaluating the combining ability of lines, we first used related populations as testers but later switched to non-related populations or synthetics. Once, during a period of interest in developing top cross types of non-conventional hybrids, we crossed 23 white lines to 4 related and unrelated populations as testers.

Similarly, 13 yellow lines were crossed to 4 related and unrelated populations as testers. The results and discussion here will be limited to white line x tester crosses. The 23 lines included in the study were from Pops. 21 (11 lines), Pop. 22 (1 line), Pop. 29 (1 line), Pop. 43 (2 lines), Pool 24 (1 line), Pop. 73 (2 lines), Pop. 25 (3 lines) and Pop. 32 (2 lines). The tester populations were Pop. 21 (STE)C_1 (T_1), Pop. 22 (STE)C_1 (T_2), Pop. 43 (STE)C_1 (T_3) and Pop. 25 (STE)C_1 (T_4). The 92 testcrosses and the checks were evaluated at six locations in Mexico, Venezuela and Colombia. Considering mean performance of 23 lines over four testers and of single testers individually, it appeared that tester 2 (Pop. 22) was superior to other testers as judged by its mean performance over 23 lines (5.9 t/ha), variance of the testcross progenies, and a correlation coefficient of 0.77 with the mean test-cross value of each line across four testers. Tester I had a lower correlation coefficient, partly because half the lines in the study came from the same source as the tester. However, when testcrosses of 12 lines from sources other than Pop. 21 were examined, the T_1 was slightly better than T_2. In testcrosses of 11 lines from Pop. 21, the unrelated tester T_2 was best followed closely by T_3. The results of this study demonstrated clearly that one tester was enough and that it should be an unrelated tester. The top-performing hybrid comprised lines and testers from different populations.

The program has long sought inbred testers for the Lowland Tropical Maize and other sub-programs to evaluate combining ability and sort out heterotic patterns in newly developed lines. During 1986, we studied good performing per se early generation lines in hybrid combinations using a diallel crossing system. Twenty eight such lines representing different tropical (**Table 5**) and subtropical populations appeared promising and were tentatively classified as testers. Some were advanced through inbreeding and announced as CMLs in 1991, and some were used extensively as testers both by breeders in the Lowland Tropical Maize and Subtropical Maize sub-programs to sort out heterotic patterns of the lines, and based on the results, to help from new heterotic populations and identify new hybrid combinations. Tester lines from Pops. 21, 32 and 25 have been used by the wide-cross and stress breeding sub-programs, and the stress and insect resistant breeding program has used several other lines particularly from the yellow populations as testers.

Research has continued to find new and better lines that are more highly inbred. A series of single cross and 3-way hybrid trials conducted in Mexico and other locations in 1993 helped identify a new group of white and yellow lines for use as testers. The two white lines were CMLs 247 and 254. The first was recycled from Pool 24 and the second is a derivative from Tuxpeno Sequia, a population improved for drought tolerance. The hybrid CMS 933133 (CML247 x CML254) performed exceedingly well at 30 locations in the CIMMYT tropical white hybrid trial (CHTTW), out yielding the best local check across locations by approximately 12%, and the lines themselves perform well per se and are fairly resistant to most common foliar diseases. The line CML 247 is quite heteoritic to CML 274. The hybrid CMS 933137 (CML247 x CML274) was the second highest in yield performance in CHTTW-1994. The line CML274 was recycled from two lines of Pop. 43. Three additional lines -- CML264, CML258 and CML273 -- may serve as testers. The crosses CML264 x CML273 (CMS 930015) and CML264 x CML258 (CMS 33011) yielded 6.87 and 6.74 t/ha across locations. Lines CML258 and CML264 were derived from Pop. 21; CML273 was recycled from Pop. 43 and is genetically similar to CML274.

Yellow lines identified as potential testers from 1993 trial data were CML287 and CL00331; the first a recycled line from Pops. 24 and 27, and the latter from Sintetico Amarillo TSR, characterized by good resistance to tar spot. The cross CML287 x CL00331 (CMS 933080) did fairly well in the international yellow tropical hybrid trial (CHTTY-1995), and was quite stable across locations, though its superiority over the best check across locations was only 3%.

The white and yellow lines indicated above have been used extensively by the Lowland Tropical Maize, Physiology and Stress Breeding sub-programs. Some white materials, particularly the single cross testers (CML247 x CML254, CML264 x CML273 and P29 (STE) C_1 F17-4-1-1-2-1-BB-## x P_{21} C5 F218-2-3-B-##4-B-1-BBB-##) have been used by the Subtropical and Mid-altitude Maize sub-program in developing three-way cross hybrids. The cross CML264 x CML273 (CMS 933015) yielded more overall and showed high GCA effects, compared with the other two testers.

The Lowland Tropical Maize sub-program is currently investigating some 20 white lines and 15 yellow lines (CMLs and others) in hybrid combinations with other lines, and preliminary results appear encouraging. Three flint testers from Pops. 23, 25 and 32 provided a good spread of line x tester crosses.

Similarly, 13 yellow lines were crossed to 4 related and unrelated populations as testers. The results and discussion here will be limited to white line x tester crosses. The 23 lines included in the study were from Pops. 21 (11 lines), Pop. 22 (1 line), Pop. 29 (1 line), Pop. 43 (2 lines), Pool 24 (1 line), Pop. 73 (2 lines), Pop. 25 (3 lines) and Pop. 32 (2 lines). The tester populations were Pop. 21 (STE)C_1 (T_1), Pop. 22 (STE)C_1 (T_2), Pop. 43 (STE)C_1 (T_3) and Pop. 25 (STE)C_1 (T_4). The 92 testcrosses and the checks were evaluated at six locations in Mexico, Venezuela and Colombia. Considering mean performance of 23 lines over four testers and of single testers individually, it appeared that tester 2 (Pop. 22) was superior to other testers as judged by its mean performance over 23 lines (5.9 t/ha), variance of the testcross progenies, and a correlation coefficient of 0.77 with the mean test-cross value of each line across four testers. Tester I had a lower correlation coefficient, partly because half the lines in the study came from the same source as the tester. However, when testcrosses of 12 lines from sources other than Pop. 21 were examined, the T_1 was slightly better than T_2. In testcrosses of 11 lines from Pop. 21, the unrelated tester T_2 was best followed closely by T_3. The results of this study demonstrated clearly that one tester was enough and that it should be an unrelated tester. The top-performing hybrid comprised lines and testers from different populations.

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Tester 3 from Pop. 23, though, appears most compatible with a practical hybrid development program, it not only provided good separation among lines but also identified the three highest yielding hybrids from 54 line x tester crosses. Twenty-two lines from Pop. 21 were evaluated in crosses with testers from Pop. 43 (T_1), Pool 24 (T_2) and Pop. 73 (T_3). Tester 1 appears superior to the others, providing good separation among lines but also identifying the highest yielding hybrids from 66 line x tester crosses. These results are from limited data and should be interpreted with caution. We are accumulating more information to identify outstanding testers.

As soon as we identified the first group of testers (early generation lines), we became interested in sorting out heterotic patterns of lines available in the Program to form new inbred-based heterotic populations. We conducted two parallel studies, one involving tropical lines and the other subtropical lines. In the tropical study, 92 lines in various stages of inbreeding were crossed with 4 inbred testers from Pop. 21 (CML 9)-T_1, Pop. 32 (CML 38)-T_2, Pop. 25 (CML 24)-T_3, and Pool 24 (CML 56)-T_4. The 368 line x tester crosses were evaluated in multiple environments. Only performance data of lines from Pop. 21 with four testers is given in **Table 6**.

Testers 1 and 4, which are genetically similar and belong to the same source population as the lines, did not perform as well as testers 2 and 3. Even similar testers, though, were able to discriminate between top-performing and poorer lines fairly well. Among the dissimilar testers, tester 3 was definitely superior across 33 Tuxpeno lines, in variance among test-cross progenies, and in its high correlation with the line performance across 4 testers. Of course, the best yielding hybrids involved lines from different populations, preferably from genetically different backgrounds (**Table 7**). The inter-population inter-line hybrids were superior to the intra-population inter-line hybrids, with one exception (hybrids involving lines from Pool 24). From the results, we can conclude that a non-related tester discriminates more effectively among lines and is more helpful in identifying superior hybrids. If carefully chosen, a single inbred tester can do a fairly good job.

In a similar study, 88 subtropical lines from different source populations were crossed to 4 inbred testers from 4 sources viz. Pool 32 (CML80) - Tester 1; Pop. 44 (CML101) - Tester 2; Pop. 42 (CML 93) - Tester 3; and Pop. 34 (CML 86) - Tester 4. **Tables 8** and **9** provide results for lines from Pops. 34 and 44. The trends are very similar to those observed in tropical lines. The four testers discriminated effectively between superior and inferior performing lines. Individual line rankings by each tester corresponded well with rankings across four testers, in most cases. Hybrids from unrelated lines generally performed well, except for some line x tester hybrids from Pop. 34. Tester 2 was the best for yield performance, followed by Tester 3; but Tester 2 also produced some good intra-population inter-line hybrids. Without exception, the inter-population hybrids were superior to intra-population ones (**Table 10**).

In 1990, the Lowland Tropical Maize sub-program evaluated several modified single crosses involving a highly inbred line and an early generation line developed using the forward and reverse inbreeding procedure (FRIP). Six single crosses (three white and three yellow) selected from this experiment were used as testers in 1993 to evaluate the performance of 45 white yellow lines each. Since the trends in most trials were identical, only results from one white and one yellow trial are presented. Top-combining lines were picked up by each tester; however, there may be slight variation in the way the lines are ranked (**Tables 11** and **12**). Tester 2 from the white group and Tester 4 from the yellow group appear to be good. The data suggest that one single cross, unrelated tester is enough to discriminate among lines for their relative merits.

Considering the Maize Program's array of activities, the following guidelines are proposed for choosing testers.

Germplasm development - This refers to research to improve gene pools, currently conducted through a combined S_2 and modified half-sib system. Intra-population improvement is used, with emphasis though on attributes important for hybrid breeding, and populations themselves can be used as testers. When half-sib families are planted, a bulk of families constituting the male rows serve as a tester. Similarly, when selected S_2 families are recombined in a half-sib isolation, a bulk of selected S_2 families forming the male rows serve as a tester. Combining ability is inherently emphasized in the modified half-sib system.

Population improvement - Currently conducted through both intra- and inter-population schemes, population improvement is shifting rapidly to various forms of inter-population schemes. When more than two populations manifest heterotic relationships, most likely the third population will be handled through recurrent selection for specific combining ability. In inter-population improvement, we are using either modified reciprocal recurrent selection (MRRS-HS), or modified reciprocal FS recurrent selection (MRRS-FS). In the first, non-parental populations or non-parental synthetic varieties are used as testers, but this will likely change in the near future to single-cross testers composed of two lines from the same population for use against the other.

In reciprocal recurrent FS selection, no testers are required as such. Selfed progenies from one population are used in crosses with selfed progenies from the other to generate inter-population FS progenies.

Evaluating Combining Ability and Hybrid Identification - Quite often, the use of tester will be dictated by the kind of hybrid that is to be produced. If a non-conventional hybrid such as a top cross is the aim, then one would need a narrow-genetic-base synthetic from the opposite heterotic group. Similarly, for the double top cross, one should use a non-parental synthetic variety as a tester. As for conventional hybrids, one may achieve this goal through one or more testing phases, but a single-phase strategy would be most efficient. Non-parental single crosses and non-parental inbred lines can greatly facilitate development of three-way crosses and single crosses, respectively, using a single-phase testing strategy.

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Table 1. Mean grain yield of lowland tropical maize germplasm *per se* and in crosses, along with GCA values from across location data.

Populations	Diallel tested	Mean grain yield *Per se*	Mean grain yield Crosses	GCA (t/ha)
Pop. 21	5	6.66	7.32	0.24 **
Pop. 22	5	7.12	7.25	0.15
Pop. 25	5	6.31	6.94	-0.21 **
Pop. 29	5	6.51	7.02	-0.11
Pop. 32	5	5.96	7.11	-0.01
Pop. 43	5	7.05	7.31	0.23 **
Pool 24	5	6.36	6.87	-0.30 **
LSD (0.05)		0.39		
Pop. 24	4	6.04	6.43	0.35 *
Pop. 27	4	5.29	6.04	-0.40 *
Pop. 28	4	5.99	6.05	0.30 *
Pop. 36	4	5.89	6.00	0.20 *
Pool 25	4	5.18	5.86	-0.50 *
Pool 26	4	5.64	5.93	-0.05
Suwan-1	4	5.78	6.42	0.09
LSD (0.05)		0.49		
Pop. 23	6	5.86	4.90	0.27 **
Pop. 26	6	5.60	5.84	0.20 **
Pop. 30	6	5.15	5.42	-0.26 **
Pop. 31	6	4.73	5.40	-0.28 **
Pop. 49	6	5.40	5.80	0.17 **
Pool 16	6	4.63	5.33	-0.36 **
Pool 18	6	4.44	4.77	-0.41 **
Pool 20	6	5.76	5.78	0.14 *
Pool 21	6	5.63	5.80	0.17 **
Pool 22	6	6.13	5.98	0.37 **
LSD (0.05)		0.37		

Table 2. Mean grain yield of superior crosses, SCA values and heterosis (%) in different diallels from across location data.

Trial No.	Cross	Grain yield (t/ha)	SCA (t/ha)	High parent heterosis (%)
Diallel-4	Pop. 24 x Pop. 26	6.78	0.42 **	13.58
	Pop. 24 x Suwan-1	6.67	0.21 **	12.58
	Pop. 27 x Suwan-1	6.55	0.13	17.47
	Pop. 24 x Pop. 28	6.50	0.07	7.95
	Pop. 28 x Suwan-1	6.41	-0.02	8.7
	Pop. 36 x Suwan-1	6.37	0.01	9.17
	Pop. 24 x Pop. 27	6.27	-0.14	10.1
Diallel-5	Pop. 21 x Pop. 43	7.83	0.23	10.9
	Pop. 21 x Pop. 25	7.40	0.25	11.1
	Pop. 29 x Pop. 32	7.34	0.34	12.7
	Pop. 22 x Pop. 43	7.55	0.05	6.0
	Pop. 21 x Pop. 32	7.15	-0.20	7.4
	Pop. 21 x Pool 24	7.22	0.15	8.4
	Pop. 22 x Pop. 32	7.55	0.28	6.0
	Pop. 32 x Pop. 43	7.40	0.05	5.0
Diallel-6	Pop. 23 x Pool 20	6.28	-	6.7
	Pop. 26 x Pool 21	6.05	-	7.3
	Pop. 31 x Pool 18	5.05	-	6.7
	Pop. 26 x Pool 22	6.23	-	1.6

Table 3. Mean grain yield of subtropical and temperate maize germplasm per se and in crosses, along with GCA values from across location data.

Material	Diallel	Subtropical environments Mean grain yield (t/ha)			Temperate environments Mean grain yield (t/ha)		
	tested	*Per se*	Crosses	GCA	*Per se*	Crosses	GCA
Pop. 46	1	4.50	4.75	0.10	3.70	4.33	-0.11
Pop. 48	1	4.69	4.89	0.27	4.93	4.79	0.43 **
Pool 27	1	4.88	4.83	0.19	3.80	4.39	-0.04
Pool 28	1	4.99	4.81	0.17	4.30	4.49	0.07
Pool 30	1	4.41	4.88	0.25	4.95	4.70	0.33 **
Pool 40	1	3.73	4.24	-0.51 *	3.80	4.22	-0.25 **
Pool 42	1	3.26	4.28	-0.47 **	3.45	4.08	-0.42 **
LSD (.05)		0.42			0.34		
Pop. 33	2	5.77	6.40	-0.11	3.34	3.50	-0.04
Pop. 34	2	6.60	6.83	0.39 **	2.66	3.31	-0.27 **
Pop. 42	2	7.21	7.09	0.68 **	3.01	3.64	0.12
Pop. 45	2	6.36	6.58	0.10	3.72	3.66	0.13
Pop. 47	2	7.01	6.97	0.54 **	3.04	3.49	-0.06
Pool 31	2	6.11	6.42	-0.09	2.99	3.23	-0.36 **
Pool 34	2	6.19	6.46	-0.04	3.33	3.52	-0.02
Pool 39	2	5.16	5.87	-0.71 **	3.72	3.58	0.04
Pool 41	2	4.61	5.82	-0.77 **	3.73	3.94	0.45 **
LSD (.05)		0.67			0.47		

Table 4. Means and estimates of general combining ability effects for grain yield for six tropical and five subtropical maize populations evaluated in three mega-environments.

Germplasm	Tropical Yield Per se	Tropical GCA	Subtropical Yield Per se	Subtropical GCA	Transition & Midaltitude Yield Per se	Transition & Midaltitude GCA
	-------------------	-------------------	-------------------	tons/ha	-------------------	
	Tropical					
Pop. 22	6.65	-0.008	7.56	0.198	6.83	0.088
Pop. 25	6.27	-0.095	6.77	-0.229	6.46	-0.219
Pop. 27	6.17	-0.010	6.92	-0.051	6.53	-0.139
Pop. 28	6.50	-0.061	7.35	-0.169	6.66	0.110
Pop. 32	6.13	-0.280	6.00	-0.487 *	6.73	0.015
Pop. 43	7.25	0.454 *	6.73	0.256	6.71	0.144
Mean	6.50		6.89		6.65	
	Subtropical					
Pool 34	3.84	-0.497 *	4.85	-0.631 **	5.33	-0.392
Pop. 42	5.44	0.169	7.14	0.373	6.89	0.094
Pop. 44	5.92	0.455 *	7.32	0.608 **	5.85	0.185
Pop. 45	4.97	0.023	5.67	-0.181	5.10	-0.236
Pop. 47	5.25	-0.150	6.83	-0.169	6.43	0.348
Mean	5.08		6.36		5.96	
Mean (parents)	5.85		6.65		6.34	
LSD (.05)	0.72		0.76		1.18	

Table 5. White and yellow maize tester lines identified in 1987.

Material	Grain color	Line pedigree	Heterotic partner(s)
Pop. 21	White	P21C5HC199-1-1-B-# # # # #	Lines Pops. 25. 32, Pool 23
Pop. 21	White	P21C5HC219-3-1-B-f	Lines Pops. 25, 32, Pool 23
Pop. 21	White	P21C5HC218-2-3-B-f	Lines Pops. 25, 32, Pool 23
Pop. 21	White	P21C5HC241-1-1-B-f	Lines Pops. 25, 32, Pool 23
Pop. 25	White	P25C0HC128-2-1-B-f	Lines Pop. 21, Pool 24
Pop. 32	White	P32C4HC142-1-1-B-# # #	Lines Pop. 21, Pool 24
Pop. 32	White	P32C4HC128-1-1-B-f	Lines Pop. 21, Pool 24
Pop. 32	White	P32C4HC242-3-1-B-f	Lines Pop. 21, Pool 24
Pool 23	White	G23TSR-31-B-# # # #	Lines Pop. 21, Pool 24
Pool 24	White	G24TSR-19-B-# # # #	Lines Pops. 25, 32, Pool 23
Pool 24	White	G24TSR-29-B-# # # #	Lines Pops. 25, 32, Pool 23
Pop. 24	Yellow	P24C5HC34-2-3-B-# # # #	Lines Pops. 36, 27
Pop. 24	Yellow	P24C5HC219-1-1-B-# # #	Lines Pops. 36, 27
Pop. 36	Yellow	P36C5HC144-2-2-B-# # #	Lines Pops. 24, 27
Pop. 36	Yellow	P36C5HC279-1-1-B-# # #	Lines Pops. 24, 27
Pop. 27	Yellow	P27C5HC71-3-1-B-# # #	Lines Pops. 24, 36
Pop. 27	Yellow	P27C5HC117-1-4-B-# # #	Lines Pops. 24, 36
Pop. 27	Yellow	P27C5HC1-1-3-B-# # #	Lines Pops. 24, 36
Pool 26	Yellow	G26TSR-16-B-# # #	Lines Pops. 27

Table 6. Performance data Population 21 line x tester crosses evaluated in multiple environments.

Lines	Pedigree	Yield kg/ha	% grand mean	GCA	Tester 1 % mean	Tester 2 % mean	Tester 3 % mean	Tester 4 % mean
1	Pop.21 C5 FS218-S6-1 (CML 8)	6861.0	111.5	527.6	109.5	108.1	120.3	107.8
2	Pop.21 C5 FS84-S4-1 (CML 3)	6675.0	108.5	341.5	95.7	106.3	123.8	107.8
3	Pop.21 C5 FS191-S5	6603.0	107.3	269.6	107.8	117.1	109.9	94.2
4	Pop.21 C5 FS117-S6	6557.1	106.5	223.7	106.2	101.9	105.3	112.9
5	Pop.21 C5 FS218-S4-2 (CML 8)	6415.9	104.3	286.5	95.1	109.0	106.5	106.3
6	Pop.21 C5 FS109-S6-1 (CML 4)	6407.7	104.1	74.3	104.6	101.0	105.3	105.6
7	Pop.21 C5 FS84-S4-2	6399.9	104.0	66.4	86.9	97.2	114.7	117.0
8	Pop.21 C5 FS57-S5-1	6335.6	102.9	2.1	97.8	104.1	112.7	97.0
9	Pop.21 C5 FS21-S5	6331.6	102.9	-1.8	99.7	95.9	106.5	109.4
10	Pop.21 TSR (S2) S4	6271.4	101.9	-62.1	103.4	101.7	97.8	104.8
11	Pop.21 C5 FS128-S6	6262.2	101.8	-71.2	103.7	99.3	103.8	100.3
12	Pop.21 C5 FS219-S6 (CML 10)	6210.4	100.9	-123.1	110.0	95.5	102.4	95.7
13	Pop.21 C5 FS133-S4-1	6169.0	100.2	-164.5	104.4	97.6	101.4	97.6
14	Pop.21 C5 FS195-S6	5936.7	96.5	325.0	89.9	97.4	95.5	103.1
15	Pop.21 C5 FS133-S3-2 (CML 5)	5924.5	96.3	312.8	88.5	100.1	97.3	99.1
16	Pop.21 C5 FS38-S4	5894.3	95.8	282.7	93.0	104.9	93.0	92.2
17	ACR 7421-S4	5711.1	92.8	99.4	88.2	99.6	93.3	90.0
18	Pop.21 C5 FS44-S4	5698.5	92.6	86.9	88.6	99.5	94.2	88.1
19	Pop.21 C5 FS57-S4-3 (CML 1)	5679.6	92.3	67.9	87.2	100.7	94.6	86.5
20	Pop.21 C5 FS78-S4 (CML 2)	5665.2	92.1	53.5	79.5	104.9	94.1	89.6
21	Pop.21 C5 FS129-S4	5477.6	89.0	-134.1	84.5	96.5	87.1	87.9
22	Pop.21 C5 FS25-S4	5399.0	87.7	-212.7	80.3	95.1	82.8	92.8
23	Pop.21 C5 FS109-S6-2	5178.0	84.1	-433.6	86.2	84.4	85.8	80.1
	Mean	6089.7			5840.8	6198.1	6332.4	5987.7
	Variance	188801.5			327936.8	144344.3	419950.5	317376.6

Tester 1 = Pop.21 C5 FS219-S4 (CML 9)
Tester 2 = Pop.32 C4 FS142-S4 (CML 38)
Tester 3 = Pop.25 C0 FS128-S4 (CML 24)
Tester 4 = P.24 TSR-29-S3 (CML 56)

Table 7. Comparative performance of inter & intra population interline tropical maize hybrids.

Source population of lines	Tester population	Yield (t/ha) Means over crosses	Yield (t/ha) Highest cross
Pop. 21	Tester 1 = Pop. 21	5.9	6.7
	Tester 2 = Pop. 32	6.2	7.8
	Tester 3 = Pop. 25	6.3	7.7
	Tester 4 = Pool 24	6.0	7.1
Pop. 25	Tester 1 = Pop. 21	6.2	6.8
	Tester 2 = Pop. 32	5.4	5.7
	Tester 3 = Pop. 25	5.9	6.4
	Tester 4 = Pool 24	6.0	6.6
Pop. 32	Tester 1 = Pop. 21	6.3	7.2
	Tester 2 = Pop. 32	5.7	6.3
	Tester 3 = Pop. 25	6.2	6.7
	Tester 4 = Pool 24	6.3	7.2
Pool 24	Tester 1 = Pop. 21	6.2	7.1
	Tester 2 = Pop. 32	5.8	7.0
	Tester 3 = Pop. 25	6.3	7.1
	Tester 4 = Pool 24	6.2	7.0

Table 8. Inbred performance against 4 inbred testers (set 1-4).

					Tester 1			Tester 2			Tester 3			Tester 4		
Line	Pedigree	Av. yield	Av. rank	Yield (%) *	Yield (t/ha)	Rank	Yield (%) *	Yield (t/ha)	Rank	Yield (%) *	Yield (t/ha)	Rank	Yield (%) *	Yield (t/ha)	Rank	Yield (%) *
1	Pop. 34 HC34-S5	9.5	1	112	8.9	1	111.7	10.0	2	109.7	9.9	1	114.1	9.3	1	113.8
2	Pop. 34 HC21-S5	9.0	2	106	8.8	2	110.4	9.0	11	98.7	9.0	6	103.7	9.0	2	110.2
3	Pop. 34 HC21-S3-xxx	8.9	3	104	8.3	4	104.1	9.5	5	104.2	9.4	3	108.3	8.4	7	102.8
4	Pop. 34 HC250-S3-xxx	8.8	4	103	8.1	9	101.6	10.1	1	110.8	9.1	4	104.8	7.9	15	96.7
5	Pop. 34 HC21-S5-xxx	8.8	5	103	8.2	6	102.9	9.1	8	99.8	9.6	2	110.6	8.3	9	101.6
6	Pop. 34 HC188-S5	8.7	6	102	8.4	3	105.4	9.1	9	99.8	8.3	14	95.6	9.0	3	110.2
7	Pop. 34 HC250-S3-xxx	8.7	7	102	8.1	10	101.6	9.5	4	104.2	9.0	5	103.7	8.3	8	101.6
8	Pop. 34 HC21-S3-xxx	8.7	8	102	8.2	8	102.9	9.0	13	98.7	8.7	10	100.2	8.7	4	106.5
9	Pop. 34 HC250-S3-xxx	8.6	9	101	8.2	5	102.9	9.7	3	106.4	8.9	8	102.5	7.7	17	94.2
10	Pop. 34 HC21-S2-xxxx	8.6	10	101	8.2	7	102.9	9.0	12	98.7	8.7	12	100.2	8.6	5	105.3
11	Pop. 34 HC250-S5	8.5	11	100	7.5	17	94.1	9.4	6	103.1	8.9	7	102.5	8.0	12	97.9
12	Pop. 34 HC21-S3-xxx	8.5	12	100	8.0	11	100.4	8.9	15	97.6	8.8	9	101.4	8.3	10	101.6
13	Pop. 34 HC21-S3-xxx	8.4	13	99.0	8.0	12	100.4	9.2	7	100.9	8.7	11	100.2	7.9	14	96.7
14	Pop. 34 HC21-S5	8.2	14	96.6	7.7	16	96.6	8.9	14	97.6	8.3	13	95.6	8.1	11	99.1
15	Pop. 34 HC186-S4	8.1	15	95.5	7.7	14	96.6	8.4	19	92.2	7.9	19	91.0	8.5	6	104.0
16	Pop. 34 HC140-S4	8.1	16	95.5	7.8	13	97.9	8.6	18	94.3	8.2	16	94.5	7.8	16	95.5
17	Pop. 34 HC250-S3-xxx	8.0	17	94.3	7.5	18	94.1	8.3	20	91.1	8.2	15	94.5	7.9	13	96.7
18	Pop. 34 HC250-S3-xxx	7.9	18	93.1	7.7	15	96.6	9.1	10	99.8	7.7	20	88.7	7.2	19	88.1
19	Pop. 34 HC250-S5	7.8	19	91.9	6.7	20	84.1	8.9	16	97.6	8.2	17	94.5	7.4	18	90.6
20	Pop. 34 HC57-S5	7.8	20	91.9	7.4	19	92.8	8.6	17	94.3	8.1	18	93.3	7.1	20	86.9
	Mean	8.5			8.0			9.1			8.7			8.2		

Tester: T1 Pool 32 C19 MH233-S4
T2 Pop. 44 C4 HC65-S4
T3 Pop. 42 C4 HC128-S4
T4 Pop. 34 C5 HC34-S4

* Percentage over mean.

Table 9. Inbred performance against 4 inbred testers (set 1-4).

					Tester 1			Tester 2			Tester 3			Tester 4		
Line	Pedigree	Av. yield	Av. rank	Yield (%) *	Yield (t/ha)	Rank	Yield (%) *	Yield (t/ha)	Rank	Yield (%) *	Yield (t/ha)	Rank	Yield (%) *	Yield (t/ha)	Rank	Yield (%) *
1	Pop. 44 HC65-S5	10.4	1	113.2	9.5	5	106.1	11.0	1	118.0	10.4	1	112.9	10.5	1	113.9
2	Pop. 44 HC65-S3-xxx	9.9	2	107.8	9.4	6	105.0	10.6	2	113.7	9.9	4	107.4	9.8	3	106.3
3	Pop. 44 HC101-S2-xxxx	9.9	3	107.8	9.9	1	110.6	10.0	7	107.3	9.8	5	106.3	9.7	4	105.3
4	Pop. 44 HC65-S3-xxx	9.8	4	106.7	9.6	4	107.2	10.4	5	111.6	9.3	11	100.9	9.8	2	106.3
5	Pop. 44 HC130-S1-xxxx	9.7	5	105.6	9.3	7	103.9	10.4	4	111.6	9.5	9	103.1	9.6	5	104.2
6	Pop. 44 HC39-S5	9.6	6	104.5	9.9	2	110.6	8.8	14	94.4	10.2	3	110.7	9.5	6	103.1
7	Pop. 44 HC101-S3-xxx	9.5	7	103.4	9.0	12	100.5	10.3	6	110.5	9.5	8	103.1	9.2	9	99.8
8	Pop. 44 HC182-S5	9.5	8	103.4	9.0	11	100.5	10.5	3	112.7	9.8	6	106.3	8.9	15	96.6
9	Pop. 44 HC182-S5	9.4	9	102.3	9.0	10	100.5	9.9	8	106.2	9.3	12	100.9	9.2	11	99.8
10	Pop. 44 HC130-S1-xxxx	9.4	10	102.3	9.2	8	102.7	8.7	15	93.3	10.3	2	111.8	9.2	10	99.8
11	Pop. 44 HC101-S3-xxx	9.3	11	101.3	9.6	3	107.2	8.9	11	95.5	9.4	10	102.0	9.1	12	98.8
12	Pop. 44 HC195-S2-xxxx	9.0	12	98.0	9.0	9	100.5	8.9	12	95.5	8.8	16	95.5	9.4	8	102.0
13	Pop. 44 HC182-S5	9.0	13	98.0	8.8	15	98.3	8.9	13	95.5	9.0	14	97.7	9.5	7	103.1
14	Pop. 44 HC33-S5	9.0	14	98.0	8.9	14	99.4	8.4	17	90.1	9.7	7	105.3	9.0	14	97.7
15	Pop. 44 HC101-S5	8.7	15	94.7	8.6	16	96.0	8.5	16	91.2	8.8	15	95.5	8.9	16	96.6
16	Pop. 44 HC195-S2-xxxx	8.7	16	94.7	8.9	13	99.4	9.0	10	96.6	8.0	18	86.8	9.0	13	97.7
17	Pop. 44 HC 101-S5	8.7	17	94.7	8.4	17	93.8	9.0	9	96.6	9.1	13	98.8	8.3	20	90.1
18	Pop. 44 HC195-S5-xx	8.1	18	88.2	7.6	19	84.9	8.3	18	89.1	7.9	19	85.7	8.5	19	92.2
19	Pop. 44 HC231-S4	P.1	19	88.2	7.6	20	84.9	8.0	19	85.8	8.1	17	87.9	8.6	17	93.3
20	Pop. 44 HC195-S5-xx	8.0	20	87.1	7.9	18	88.2	7.9	20	84.8	7.5	20	81.4	8.6	18	93.3
	Mean	9.2			9.0			9.3			9.2			9.2		

Tester: T1 Pool 32 C19 MH233-S4
T2 Pop. 44 C4 HC65-S4
T3 Pop. 42 C4 HC128-S4
T4 Pop. 34 C5 HC34-S4

* Percentage over mean.

Table 10. Comparative performance of inter & inter population interline subtropical maize hybrids.

Source population of lines	Tester population	Yield (t/ha) Means over crosses	Highest cross
Population 34	Tester 1 = Pool 32	8.0	8.9
	Tester 2 = Pop. 44	9.1	10.1
	Tester 3 = Pop. 42	8.7	9.9
	Tester 4 = Pop. 34	8.2	9.3
Population 42	Tester 1 = Pool 32	8.5	10.0
	Tester 2 = Pop. 44	9.5	11.1
	Tester 3 = Pop. 42	8.7	10.4
	Tester 4 = Pop. 34	9.0	10.6
Population 44	Tester 1 = Pool 32	8.9	9.9
	Tester 2 = Pop. 44	9.3	11.0
	Tester 3 = Pop. 42	9.2	10.4
	Tester 4 = Pop. 34	9.2	10.5
Pool 32	Tester 1 = Pool 32	7.8	9.3
	Tester 2 = Pop. 44	9.5	10.7
	Tester 3 = Pop. 42	8.8	10.0
	Tester 4 = Pop. 34	9.0	10.4

TABLE 11. PERFORMANCE OF WHITE TROPICAL LINES AGAINST 3 TESTERS IN TRIAL TWCW-9305 (ACROSS DATA 1993-94).

	ACROSS TESTERS			TESTER 1			TESTER 2			TESTER 3		
	YIELD (%)*			YIELD (%)*			YIELD (%)*			YIELD (%)*		
LINE	KG/HA	MEAN	GCA	KG/HA	MEAN	SCA	KG/HA	MEAN	SCA	KG/HA	MEAN	SCA
5	7205.3	104.9	337.0	7433.1	109.0	276.6	7177.4	100.1	-329.4	7005.3	105.9	52.8
14	7177.9	104.5	309.7	7155.9	104.9	26.8	7470.1	104.2	-9.3	6907.6	104.4	-17.5
6	7095.7	103.3	227.5	6972.1	102.2	-74.8	7488.4	104.4	91.2	6826.6	103.2	-16.4
11	7092.2	103.3	224.4	7392.9	108.4	349.1	7395.7	103.2	1.6	6489.2	98.1	-350.7
1	7088.4	103.2	220.2	6566.5	96.3	-473.1	7352.0	102.5	-37.9	7346.6	111.1	511.0
15	7080.4	103.1	212.2	7164.6	105.1	132.9	7425.9	103.6	44.0	6650.7	100.5	-176.9
12	7047.0	102.6	178.8	6683.7	98.0	-314.6	7496.4	104.6	147.9	6960.9	105.2	166.7
2	7044.7	102.6	176.5	6641.0	97.4	-354.9	7489.9	104.5	138.7	7008.2	105.9	216.2
3	6976.0	101.6	107.8	6361.7	93.3	-565.5	7492.0	104.5	214.5	7074.2	106.9	351
4	6728.8	98.0	-139.5	7076.4	103.8	396.4	7036.7	98.1	6.4	6073.2	91.8	-402.8
7	6704.4	97.6	-160.8	6521.9	95.6	-136.8	7131.2	99.5	122.3	6469.1	97.8	14.5
13	3376.6	97.2	-191.6	6987.0	102.5	359.2	6798.3	94.8	-179.7	6244.4	94.4	-179.5
8	6483.6	94.4	-384.6	6368.0	93.4	-66.8	6914.8	96.4	129.8	6167.9	93.2	-63
10	6353.4	92.5	-514.8	6501.9	95.3	197.3	6697.7	93.4	42.8	5860.5	88.6	-240.1
9	6265.6	91.2	-602.8	6465.0	94.8	248.2	6184.2	86.3	-382.9	6147.5	92.9	134.7
				GCA		-48.7	GCA		301.5	GCA		-252.8
MEAN	6868.2			6819.4			7169.7			6615.5		
		CORRELATION		0.576			0.897			0.835		
		VARIANCE		135553.1			147930.8			197148.57		

LOCATIONS	LINES		TESTERS
LOC 1 = POZARICA, MEXICO	L1 = POB.21C6S1MH125-3-B-1-1-1-BB-4#	L9 = POB.21C6S1MH254-2-B-1-4-4-BB-4#	TESTER 1
LOC 2 = TLALTZAPAN, MEXICO	L2 = POB.21C6S1MH125-3-B-1-1-2-BB-4#	L10 = POB.21C6S1MH254-2-B-1-4-5-BB-4#	(POB.21CHC229 x PORRILLO.8073-11)
LOC 3 = CUYUTA, GUATEMALA	L2 = POB.21C6S1MH125-3-B-1-1-3-BB-4#	L11 = POB.21C5HC218-2-3-B-f-6#-BBB-4#	TESTER 2
LOC 5 = ASGROW, MEXICO	L4 = POB.21C6S1MH154-5-B-1-1-1-BB-4#	L12 = POB.21C5HC218-2-3-B-3#-B-1-BBB-4#	(POB.21CHC219 x AC7843-15)
LOC 6 = ASPROS, MEXICO	L5 = POB.21C6S1MH177-2-B-4-2-1-BB-4#	L13 = POB.49STEC1HC10-2-1-1-2-2-BB-4#	TESTER 3
LOC 7 = COTAXILA, MEXICO	L6 = POB.21C6S1MH177-2-B-4-3-1-BB-4#	L14 = TUX.SEQ.-149-2-BBB-##-1-BB-4#	(POB.21CHC219 x AC7843-16-S5-F3-#)
LOC 9 = COLOMBIA	L7 = POB.21C6S1MH247-4-B-1-1-1-BB-4#	L15 = TUX.SEQ.-149-2-BBB-##-2-BB-4#	
	L8 = POB.21C6S1MH254-2-B-1-4-2-BB-4#		

TABLE 12. PERFORMANCE OF YELLOW TROPICAL LINES AGAINT 3 TESTERS IN TRIAL TWCY-9309 (ACROSS DATA 1993-94).

	ACROSS TESTERS			TESTER 2			TESTER 3			TESTER 4		
	YIELD (%)*			YIELD (%)*			YIELD (%)*			YIELD (%)*		
LINE	KG/HA	MEAN	GCA	KG/HA	MEAN	SCA	KG/HA	MEAN	SCA	KG/HA	MEAN	SCA
11	6418.1	112.5	714.0	6477.6	112.6	10.0	6258.6	115.1	108.2	6518.0	110.1	-118.2
4	6227.8	109.2	523.8	6175.8	107.3	-101.6	6034.2	111.0	74.0	6473.6	109.3	27.6
15	6195	108.6	490.8	6473.7	112.5	229.0	5706.6	105.0	-220.6	6404.7	108.1	-8.4
14	6020.8	105.6	316.7	6142.5	106.8	72.2	5761.0	106.0	7.9	6158.8	104.0	-80.1
5	5850.8	102.6	146.7	5586.2	97.1	-314.1	5679.2	104.5	96.1	6286.9	106.2	218.0
10	5829.2	102.2	125.1	5847.2	101.6	-31.5	5483.2	100.9	-78.3	6157.2	104.0	109.8
6	5740.3	100.6	36.2	5835.3	101.4	45.5	5559.5	102.3	87	5825.9	98.4	-132.5
7	5636.3	98.8	-67.7	5766.8	100.2	81.0	5351.0	98.4	-17.6	5791.1	97.8	-63.4
8	5494.8	96.3	-209.2	5465.2	95.0	-79.3	5312.3	97.7	85.2	5707.1	96.4	-5.9
3	5494.2	96.3	-209.8	5762.6	100.2	218.8	5221.5	96.0	-5.1	5498.7	92.8	-213.7
9	5430.1	95.2	-274.0	5414.3	94.1	-65.3	5156.7	94.9	-5.6	5719.2	96.6	70.9
13	5427.0	95.1	-277.0	5411.5	94.1	-65.2	5248.3	96.5	89.0	5621.3	94.9	-23.8
12	5424.0	95.1	-280.1	5363.1	93.2	-110.5	5144.6	94.6	-11.7	5764.3	97.3	122.2
2	5268.4	92.4	-435.7	5125.5	89.1	-192.5	4886.8	89.9	-113.9	5793.0	97.8	306.4
1	5104.3	89.5	-599.8	5457.3	94.9	303.5	4742.0	87.2	-94.6	5113.5	86.3	-208.9
				GCA		49.6	GCA		-267.7	GCA		218.1
MEAN	5704.1			5753.6			5436.4			5922.2		
		CORRELATION		0.916			0.973			0.929		
		VARIANCE		169003.92			167138.21			158249.16		

LOCATIONS	LINES		TESTERS
LOC 1 = POZARICA, MEXICO	L1 = POB.28TSR-33-3-5-B-3-1-BB-4#	L9 = SINT.AM.TSR-9-1-2-3-2-BB-4#	TESTER 2
LOC 2 = TLALTZAPAN, MEXICO	L2 = POB.28TSR-33-3-5-B-3-2-BB-4#	L10 = SINT.AM.TSR-23-3-2-1-3-BB-4#	(POB.24CSHC34 x POB.27CSHC1)
LOC 3 = LMAQUINA, GUATEMAL	L3 = SINT.AM.TSR-4-1-1-1-1-BB-4#	L11 = SINT.AM.TSR-23-3-1-1-1-BB-4#	TESTER 3
LOC 4 = RIOHATO, PANAMA	L4 = SINT.AM.TSR-7-3-1-1-1-BB-4#	L12 = SINT.AM.TSR-23-3-1-2-3-BB-4#	(POB.36CSHC49 x POB.36CSHC279)
LOC 5 = PHRAP, THAILAND	L5 = SINT.AM.TSR-7-3-1-3-2-BB-4#	L13 = SINT.AM.TSR-23-3-1-2-4-BB-4#	TESTER 4
	L6 = SINT.AM.TSR-7-4-2-2-1-BB-4#	L14 = SINT.AM.TSR-23-3-2-3-2-BB-4#	(POB.24CSHC219 x POB.36CSHC279)
	L7 = SINT.AM.TSR-7-4-2-5-4-BB-4#	L15 = SINT.AM.TSR-23-3-2-4-3-BB-4#	
	L8 = SINT.AM.TSR-7-1-2-B-1-1-BB-4#		

PUBLIC PRIVATE LINKAGES FOR THE IMPROVEMENT OF MAIZE IN ASIA

M. Rai [1]

Existing and emerging agricultural scenario.

In the Asia-Pacific region, per capita availability of land to agricultural population is 0.26 ha against 1.52 ha in the rest of the world, and 0.60 ha in the world as a whole. Thus, small and fragmented holdings in most of the countries in the region viz. Bhutan, Bangladesh, China, Nepal, Vietnam - each less than 0.17 ha; DPR Korea, India, Indonesia, Pakistan, Philippines, Republic of Korea and Sri Lanka - each less than 0.35 ha; and Cambodia, Myanmar and Thailand - each less than 0.7 ha per agricultural person highlights the operational limitations and likely problems in emerging competition with globalization of markets.

The world population of 5.35 billion in 1991, with life expectancy at birth of 66 years, is believed to bring land resources, particularly in developing countries, under further pressure, as the projections of world population stand at 6.168 and 8.345 billion by 2000 and 2025 A.D. respectively. The estimated growth rate of population up to 2000 A.D. indicates no growth in Eastern Europe and the former Soviet Union, as compared to 0.6% in developed countries, 1.8% in less developed countries and 1.5% per annum in the world as a whole.

Presently, 800 m people i.e. every fifth person in the developing world and 15% of the total world population is insecure on the food front. Even the optimistic projections for 2020 A.D. indicate that about 100 m pre-school children would be protein energy malnourished. Historical data reveal that more than half of the world's protein energy malnutrition problem is in South Asia. With the projected position, 46% of the children are to remain malnourished by 2020 A.D. in South Asia despite increases in production, growth in income and reduction in population growth rate.

Income levels and rates of growth vary considerably across developing countries. In 1982, per capita income in low-income developing countries was 18% of those in middle-income developing countries and 3% of that in developed countries. In 1992, it dropped to 16 and 2% respectively, reflecting an increase in inequality. The widening gap between rich and poor is further illustrated by a dramatic decrease in the share of global income obtained by the poorest 20% of the world's population, from 2.5% in 1960 to 1.3% in 1990.

Population induced growth in food and feed demands in a fixed land constraint system would continue to force agricultural intensification for the realization of enhanced productivity. Concurrent rapid growth in the industrial sector with enhanced urbanizational tendencies and growth in income would further enhance demands, especially of high value food while putting further pressure on scarce land, water and labor resources. Growing competition for resources and striving hard for significant productivity gains would not be without the risk of environmental cost involved. Declining soil fertility, increasing micronutrient deficiencies, toxicities and pest outbreaks, environmental pollution and health hazards are bound to be encountered and resolved.

Poverty is degrading both humans and their environment. On the one hand is the pressure to become a global player, and on the other, to reduce the environmental impacts. The specific concern at this juncture should pin-point critical conditions for success so that development becomes truly a mechanism of providing social justice. The environmental problems and policies need coordinated appraisal as they are inextricably enmeshed in their impacts, value-orientation objectives and attainments irrespective of geo-political boundaries. There has to be, therefore, an honest and sincere international cooperation in the exploitation and conservation of the natural resource base so as to secure and ensure development and at the same time, have a safe environment for posterity.

It is necessary to integrate the human and technical dimensions of development, say, biophysical, socio-economic and political aspects. It is necessary to reinforce all the research and development institutions to be able to confront current and future problems - hunger, poverty, environmental degradation, etc. by enhancing productivity for a harmonized realization close to ecological potential.

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This would call for a critical analysis of actual needs, diagnosis of potential and tuning our research and development efforts to attain the desired goal. The production-processing-marketing-consumption chain will have to be analyzed. Needs and influences of internal and external markets will have to be understood and specific analysis of the resource base will have to be resorted to. Accordingly, need-based policies on land, input, services, credit and market will have to be devised. The diagnosis of the functioning in relation to potential and performance of different regions, situations and systems, keeping key aspects of the evolutionary process on research and development front, should facilitate the decision making process. The regional model leading to simulation of evaluations reflecting extrapolated avenues and opportunities would be important. This should lead to setting up of an appropriate research-development-training-translation framework and a system corresponding to well thought out policies.

In coming years, agricultural development would be guided not only by the compulsions of improving food and nutritional security, but also by the concerns for environmental protection, sustainability of production and supply, as well as profitability of farm enterprises. Following the General Agreement on Tariffs & Trade (GATT), liberalization process and globalization of markets would call for competitiveness and efficiency in agricultural production, and the agriculture sector will have to face a challenging situation on the ecological, climatic, economic, equity, social justice, energy and employment fronts.

In general, government-funded agricultural institutions are quite competent in a technical sense but traditional in their organizational set-up, personnel management and human resource development. By and large, the private commercial sector at present is concentrating on resource-rich regions, having irrigated areas, and resource-rich large farmers. This sector at present has limited interest in investing in resource-poor and climatically handicapped farming. Therefore, social responsibility of Government Organizations (GOs) in the agriculture sector will remain, by and large, unaltered even after implementation of new economic policy that encourages free markets and entry of a highly aggressive, rich and commercially oriented private sector in the field of agriculture. There has to be, therefore, full awareness in academic circles, and in government, that small farmers operating in complex risk-prone diverse conditions will adopt new technology that enhances productivity in a sustainable manner, provided that it is low cost, low risk and less demanding in terms of advanced and new skills. Thus, agricultural administrators and researchers need to be fully sensitized to the problems and constraints in realizing the growth potential of agriculture in these areas.

The success of modern agriculture in a free and competitive national as well as international market depends upon many complex activities, such as continuous problem identification under changing environment, development and marketing of appropriate technology, which is consistent with sustainable agriculture and effective technology transfer activity through various ways and means. At present, in agriculture, GOs in the developing world are dominating the field of technology development through research and are also engaged in dissemination of knowledge and technology through their extension set-up. Over the last decade, private sector, cooperative societies, Non-Government Organizations (NGOs), and Farmers Associations (FAs) are playing an increasingly visible role in agricultural development activities. It appears that to achieve faster agricultural growth and development in agriculture sector, a strong, sustained and mutually beneficial partnership needs to be established among all relevant public and private sector organizations, as well as NGOs and FAs engaged in the commercial growth and development of the agricultural sector.

Maize scenario.

Due to its multifarious usage's, relatively higher productivity potential among cereals, wider adaptability, greater involvement of private seed sector, enhanced hybrid maize culture in agriculture etc., maize continues to be an important food, feed, fodder and industrial crop. Globally, it occupies about 20% of the total area under cereals. In the developed market economies its share is about 25%. During 1983-92, the yield growth rate has been 2.5% and 3.2% per annum respectively. Out of the total maize produced in the world, over 60% has gone as animal feed leaving a little over 20% for direct human consumption. However, in developing economies, almost 50% goes for feed and about 40% is used as human food.

Seed is the most critical input in enhancing maize productivity and production. With an ever increasing share of use of improved seed, about 60% of the area is currently under improved varieties in the developing world as compared to virtually 100% in the developed economies. However, over 70% of the maize area in the world is under improved varieties. Out of this, 99% of the area in developed economies is under hybrids, as compared to 45% in developing economies, with an average of 62% in the world. That is primarily one of the most important reasons that during 1990-92 average realized yield was only 2.5 t/ha in developing countries, as compared to 6.9 t/ha in developed countries, and 3.8 t/ha in the world as a whole.

In the South Asian countries - India, Myanmar, Nepal and Pakistan, only 6% of the area of total cereals is under maize. It has an average yield of 1.5 t/ha, registering a growth rate of 0.2% and 0.6% in area, and 1.2% and 2.1% in yield, per year during 1973-82 and 1983-92 respectively. The trend is quite encouraging and indicative of a bright future for maize in the region. On the consumption pattern, there is likely to be a shift from maize use as food to feed.

In India, 75% of the total maize produced is used as direct human food, and less than 5% goes to the animal feed industry. With the indicators on the ground, share of maize to the animal sector is likely to be enhanced substantially in years to come. It is estimated that poultry industry, with continuing phenomenal growth, is expected to increase from 89 million layers in 1994 to 145 million in 2000 A.D. Similarly, the broiler production is expected to go up from 145 million to 750 million in the year 2000. Obviously, the feed requirements are bound to shoot up from 5.3 to 9.5 million t per year for poultry industry alone, where maize, sorghum and fish meal are bound to be the conventional feed ingredients. As the inland fisheries sector has shown a compound growth rate of over 10% per year during nineties, pressure is bound to continue on maize and sorghum.

Maize seed scenario and institutions involved.

As per the 1993 maize seed industry survey conducted by CIMMYT, 75% of the public funded research institutions engaged in maize improvement are in the developing countries, whereas over 77% of the total number of maize breeders are employed by the public sector (**Table 1**). In the developed economies, the trend is just the reverse, with almost 80% of the breeders being in the private sector. With the added role of hybrids, it is apparent that developing economies would follow the path of developed ones.

The maize seed industry, over the years, has grown from strength to strength. Due to greater use of hybrid seeds, where seed is required afresh each year, private sector involvement is considerable. In developing countries, as many as 81 multinational and 379 private national companies are in seed production and trade (**Table 2**). Over and above, 937 small and big nonpublic organizations with greater involvement of NGOs and FAs are engaged in seed production on a commercial scale. Since open-pollinated varieties continue to play an important role in the developing world, public institutions are also considerably involved in seed production and marketing. In the developing and developed world, private sector companies are almost equal in numbers. But the public sector ones are almost five times in number as compared to those in the developed world.

The share of open-pollinated varieties is maximum in Asia excluding China (47%). However, the hybrid share of total commercial seed sales comes to as much as 94% in the world as a whole (**Table 3**). In the developing countries, the share of multinationals, even in the open-pollinated varieties, is quite high (**Table 4**).

Although, in the industrialized countries, seed sales by the private sector of public-bred hybrids is negligible, yet in the developing countries, it is almost 10% of the total number of varieties in the seed production and marketing chain. However, in absolute percentage terms the percent proprietary hybrids comes to only 20% in developing countries as compared to 53% in the world as a whole (**Table 5**).

The market for hybrid seed, irrespective of the sector, is dominated by non-public seed companies in both the developing and developed countries. The role of public sector seed companies was considerably low during 1992 (**Table 6**).

On average, about six years time is taken for the replacement of seed. The highest being 13.4 years in Asia as a whole. This indicates the very low rate of vertical seed dissemination (**Table 7**). However, with the development programs on, the situation is likely to be substantially changed.

Delineation of activities areas of work among various institutions.

On the research front, it is essential that basic and strategic support be competitive among crops, commodities, regions and systems. This would call for identification of pressing problems, delineation of lead functions, identification/ strengthening/establishing centers of excellence and effective linkages for harnessing

Table 1. Public maize research stations and numbers of public and private sector maize breeders in the world.

Region	Number of public research stations engaged in maize improvement research	Number of maize breeders*		
		Public Sector	Private Sector	Total
Asia including China	106	660 (86.05)	107 (13.95)	767
All developing countries	245	1072 (77.85)	305 (22.15)	1377
Industrialized countries	82	214 (21.10)	800 (78.90)	1014
World	327	1286 (53.79)	1105 (46.21)	2391

- Figures in parentheses indicate percentage of total breeders engaged in maize improvement.
Source: 1993 CIMMYT Maize Seed Industry Survey.

the fruits of research, with culmination into location-specific feasible, adaptable and exploitable technological capsules. This would also call for synergies in reoriented actions of all reasonable players as partners. As maize improvement can not be seen in isolation, a system's approach in a program mode would be essential. In this endeavor, linkages between public sector institutes, between public and private sector establishments, and overall, with NGOs and Fas would be important.

NGOs can be involved for the delivery of a range of inputs, and their agenda should extend, beyond service delivery, into wider issues of developing the recipient system in the rural/agriculture sector, involving the reviewing of the respondent's felt needs and their fulfillment, training policy and program formulation, with the aim of improving the effectiveness of government delivery system that will generate sustainable, efficient and demand-led delivery of the services.

There is a need and scope for substantial farmers' participation through FAs in developing appropriate research programs in order to account for complexities of required knowledge involved and the ecology as well as the social environment in which farmers work. FAs can take up a range of activities and cross finance between them. Such activities can be in the areas of product processing, and bulk handling of inputs and outputs. FAs could be major suppliers of extension services.

To take advantage of economies of scale, the GOs, in collaboration with NGOs and private sector, can establish training centers and field extension programs. The FAs can be involved for extending services to small-scale farmers engaged in commercial maize production. FAs may keep a strict vigil

Table 2. The structure of maize seed industry by type of company in 1992 as per the CIMMYT survey 1993.

Region	Number of countries in each region	Number of seed companies				
		Multinational	Private national	Other non-public	Public	Total
Sub-saharan Africa	20	13	12	164	63	252
West Africa and North Afria	4	8	45	1	6	60
Asia including China	10	20	208	597	65	890
Latin America	18	40	114	175	37	366
All developing countries	51	81	379	937	171	1568
Industrialized countries	11	76	362	94	34	566
World	62	157	741	1031	205	2134

Source: CIMMYT 1993 Maize Seed Industry Survey.

Table 3. Maize seed sales by type of seed in 1992.

Region	Commercial seed sales		
	Open pollinated varieties (%)	Hybrid (%)	Total seed sales (,000 t)
Sub-Saharan Africa	27	73	88
West Asia and North Africa	13	87	15
Asian including China	50	150	768
Latin America	11	89	237
All developing countries	10	90	1109
Industrialized countries	0	100	776
World	6	94	1885

Source: CIMMYT 1993 Maize Seed Industry Survey.

when partnerships are formed between farmers and private companies in the production, processing and marketing of commercial crops. FAs can provide an effective avenue, though not fool-proof one, for maintaining healthy firm-farmer relations.

It is observed that private extension for small contract farmers tends to focus on giving instructions and production guidelines on a limited scale rather than giving a comprehensive education. The information disseminated is typically specialized and is only a part of the total package. The intervention of GOs, NGOs, and FAs at this juncture can provide additional information and education to supplement the information flowing from private extension agencies and make the package complete.

Providing information in technology capsules and their effective utilization/adoption should be an important area of education for the farmers by GOs, NGOs, Private sector and FAs because there is often a tendency for either excessive or under use of inputs, especially chemicals. Pilot projects could be contracted out to NGOs for intensive studies and extension of certain new techniques in areas suffering from excessive use of inputs, especially seeds, pesticides and fertilizers.

Table 4. Sales of commercial maize seed of open pollinated varieties in developing countries by type of company, 1992.

Region	Share of commercial OPV sales by company type				Total commercial OPV seed sales (,000 t)
	Multinational (%)	Private national (%)	Other non-public * (%)	Public (%)	
Asia including China	33	25	24	18	38
All developing countries	11	24	17	48	113
Developing countries, less China	14	30	22	34	89

* Includes NGOs producers' cooperatives and individual seed producers.
Source: CIMMYT 1993 Maize Seed Industry Survey.

Table 5. Sales of hybrid maize seed in developing countries by origin of hybrid, 1992.

Region	All hybrid seed sales (,000 t)	Percent public origin*	Percent proprietary origin *
Asia including China	706	30	70
All developing countries	995	80	20
Industrialized	774	5	95
World	1769	47	53

- Seed text for definition of public and proprietary hybrids.

** Includes 51 developing all 11 industrialized countries.
Source: CIMMYT 1993 Maize Seed Industry Survey.

GOs may identify areas with potential for commercialization in the agriculture sector and may make initial investments in the form of venture capital, especially in training of farm entrepreneurs and developing infrastructure that would promote commercialization of maize production systems in these areas. Private sector should be encouraged in taking up high investment projects that would diversity and commercialize production systems around these projects. Subsequently, private sector can be encouraged to develop technologies which are of visible commercial value and highly rewarding in short to medium run. Cooperation of the researches could be mutually supportive and hence could be taken up on effective partnership basis. Modes and modalities can, however, be devised on case-to-case basis.

Table 6. Hybrid seed market in developing countries, by origin of seed and type of company, 1992.

	Share of hybrid seed sales by company type			
	Multinational (%)	Private national (%)	Other non-public* (%)	Public (%)
Developing countries less China.				
Hybrids developed by the public sector.	11	61	12	16
Proprietary hybrids	63	32	4	1
All hybrid seed	42	43	7	7
Industrialized countries.				
Hybrids developed by the public sector.	43	32	9	16
Proprietary hybrids	57	39	2	3
All hybrid seed	56	39	2	3

• Includes NGOs, producers' cooperatives, and individual seed producers.
Source: CIMMYT 1993 Seed Industry Survey.

Table 7. Average recycling period for seed of improved open-pollinated varieties in developing countries during 1992.

Region	Improved OPV seed used (,000 t)		Recycling period * (years)		
	Total	Commercial	Lowest	Average	Highest
Sub-Saharan Africa	44	11	1.4	5.7	12.0
West Asia and North Africa	4	2	1.0	4.2	7.1
Asia	155	39	1.1	6.4	13.4
Latin America	91	25	1.0	5.7	7.2
All developing countries	294	77	1.0	5.7	13.4

Source: CIMMYT 1993 Maize Seed Industry Survey.

Problems and modalities in partnership.

A creditability gap often exists between GOs and private sector staff. Harmonization of activities and interest in technology generation, assessment, refinement and transfer for all round maize development can be helpful in improving the situation.

Public and private sector collaboration may infringe upon proprietary aspects of private sector. Highly trained staff, and technical and specialized information, are often viewed as proprietary asset by private organizations and are thus guarded against un-targeted and generalized dissemination of information and appropriation of skills. However, with the likely Intellectual Property Regime (IPR) in place, services may be developing fast under GATT provisions. Thus, the partnership may not be a real problem as we go along.

Partnerships must be established on equitable if not always on equal footing. Terms of credit and benefit sharing must be spelt out in the beginning and before the start of a project, through mutual negotiations and settlements, and areas of activity can be allocated to different agencies through mutual agreement(s). Tangible and intangible benefits, if any, should be shared equitably on the basis of investments and contributions made by different agencies.

Private sector can be motivated to invest in joint ventures with public sector organizations, NGOs and FAs in resource-poor marginal areas. This deserves careful consideration and special attention because of either uncertain and low economic returns on investments in this sub-sector.

The Public Research Institution should impart need-based training to scientists/technical staff of private sector or vice versa as the case may be. The G0s should help by providing germplasm/techniques/information to build further private sector research capacities and capabilities. For the manpower development, training of scientific and technical personnel through bilateral arrangements as well as international support by FAO/UNDP and CG Centers would be desirable. As such, each country may like to prepare a perspective plan for the required human resource development.

CIMMYT, in collaboration with RAPA, FAO, Bangkok, different NARS and Asia-Pacific Seed Association; could play a catalytic role in meeting the common goal of maize improvement. Before, devising exact research and development strategies, consultations with the representatives of feed, starch, oil, pop corn industries etc. would be helpful. CIMMYT can play a vital role in development and continued supply of gene pools keeping varying and changing requirements in view.

CIMMYT should accord greater thrust on hybrids in general, and single and three-way cross hybrids in particular. In this endeavor, a regional meeting may be organized to work out national and regional needs and strategies. Added thrust would also be required on tackling diseases like leaf and sheath blight and water related problems crippling maize production in the region. Also, research on winter maize by concerned NARS need to be intensified. This would call for according a high priority to hybrid research programs through adequate manpower and resource deployment.

The seed production, processing, storage, marketing and seed health facilities be strengthened to meet the ever growing hybrid seed requirement. In this endeavor, private sector may also be given the encouragement treatment as the public sector by the respective governments. Further, seed corporations, both public and private, may consider demonstration of hybrids at the farmers fields as a powerful tool in creating much needed awareness about their potential.

Genetic enhancement of germplasm is of paramount significance. Private sector must invest in this endeavor with effective tie-up with public sector institutions. This would be rather in their long term interest.

Socio-economic aspects of hybrid technology need to be assessed in order to ensure proper technology transfer. In this endeavor, concerned CG centers, NARS and private sector may take a lead in getting such studies conducted in the potentially most suited areas.

A long term national pricing and procurement policy commensurate with future requirements would be essential. Appropriate incentives to the private sector seed industry for its effective role in hybrid research and development activities would be desirable. In this endeavor, an appropriate legislation, recognizing the right of return on the investment made on developing hybrids, would be needed. As such, a *sui generis* system of protection of hybrids and parental lines, keeping the need and strength of the national system in view, would be desirable.

HOW TO STRENGTHEN THE RELATIONSHIP AMONG PUBLIC AND PRIVATE INSTITUTIONS.

Walter Trevisan [1]

There is no doubt that in today's world the research institutions, particularly the International Research Centers, are facing difficult times to finance their research activities and to keep their best personnel competitively paid and motivated. From an outsiders point of view, like mine, the International Organizations, which normally finance these types of works around the world, seem to have changed their strategies. Agricultural research, particularly crop improvement through conventional breeding, is no longer the top priority, although very important accomplishments have been obtained in the past 2 or 3 decades of integrated work among International Centers and local institutes around the world.

The picture of one international organization alone trying to solve all the problems in the world by staffing and or financing local institutions is becoming rare. The changing times call for a higher integration of the public institutions (International Research Centers, National Research Institutes and Universities) and private companies.

We will concentrate our discussions on several issues related to maize breeding, which is the main objective of this meeting. But surely some of these arguments or examples could be applied to other crops.

Public institutions devoted to conventional breeding around the world, even in highly developed countries, are also facing decreasing budgets. Very few of the maize breeding programs, which were so important in the past for the fast improvement of hybrids and varieties, can compete with today's very advanced and highly specialized seed companies.

We are seeing in several parts of the third world that hybrid maize is becoming the most important seed supplied to the farmers. In some areas, such as Southeast Asia, progress has been really astonishing. Varieties were substituted by double cross and three-way hybrids, and these were substituted by single crosses, in less than a decade. But only a few years ago, CIMMYT, recognizing this evident tendency, started to work/develop hybrids. We still can hear strong arguments against these decisions in some parts of the world. Questions frequently heard are: Is CIMMYT going to forget the poor areas of the world which need research and new cultivars? Is CIMMYT going to compete with seed companies? We in the private sector see this new tendency of CIMMYT as a very healthy one. The improved varieties that CIMMYT has developed over the years were released with no concern for exploiting the heterosis available in the tropics. Most of the companies worked hard on these varieties to develop some hybrids, but the results were not very encouraging.

CIMMYT's new strategy is to develop varieties that can be directly used by poor farmers, but also could be used as better sources of lines. CIMMYT is also developing lines screened for several biotic and abiotic stresses and combining ability, and some hybrid combinations that will be used to supply small companies. All of these efforts are very important in meeting the real needs of our main customer, the farmer.

The decreasing public research budgets are a stimulus for these institutions to work closely with the private ones. But for CIMMYT, it is now strategically important to work closer with the private seed companies to develop materials that better fit the farmer's needs. Ultimately, the gap of over twenty years for a new variety/hybrid to reach the common farmer shall gradually decrease.

Probably, I was invited for this presentation because I have already worked in an International Center/National Program (Brazilian Corn and Sorghum National Research Center) in the beginning of my professional career and, probably because, in my job as Cargill's World Wide Tropical and Sub-tropical maize breeding coordinator, I have a chance to watch several interesting interactions among public and private institutions around the world.

There are several examples of successful joint cooperation around the world, and some other possible opportunities of collaboration among public and private institutions will be discussed in this paper. A summary of the issues is given below:

[1] Cargill International, World Wide Tropical and Sub-tropical maize breeding coordinator.

- Financing of special projects by the private sector. Results to be used exclusively, or not depending on the issue or the country's policy. Interactions could increase if results could be exclusively used for a given period of time and then become available to everybody. Examples: INTA/seed companies in Argentina; Unimilho/Embrapa in Brazil.

- Services to the seed industry community. Disease evaluations; evaluation for some other biotic or abiotic stresses; introduction of some disease/insect resistant, stress tolerant, or genetic/cytoplasmic male sterility traits; supplying of disease inoculum or egg masses for field inoculations/infestations, etc. Examples: All over the world, CIMMYT normally helps us on this; also some public institutions in Argentina and Brazil. Some reasonable fees could be negotiated.

- Germplasm evaluation. Optimizing the countries/worldwide trials network by better cooperation; "trials exchange" is becoming very important all over the world. This interchange normally optimizes resources and may decrease expenditures.

- Training. Normally, it is already done to an extent, but there are many opportunities to increase "paid" training opportunities, by better studying customer's needs.

- Exchange of germplasm. A seed company has a natural tendency to defend strongly its ownership of a product it has obtained, in order to maintain profitability over a longer period of time. But some cooperation in supplying elite lines is possible and is becoming more frequent nowadays. Examples, are 1) the GEM project in USA; 2) CIMMYT's Thailand work to increase heterosis in lowland tropical hybrids; 3) the cooperation to develop streak tolerant germplasm in Africa by CIMMYT-Harare; etc.

- Lines commercialized by royalty basis or definitive sale. Several examples - Thailand, Philippines, etc. Some countries still have a very strong policy of closed pedigrees (Brazil). Sometimes this attitude keeps some valuable germplasm out of use by most of the farmers in a given area. Companies are not against paying royalties provided that the materials are really competitive.

Several issues in today's world need to be re-addressed/re-discussed as some biotech traits could be available (or not?) to the third world:

- Some private organizations are willing to allow access to public institutions for use of some of the biotech traits. Will this happen? What about patents/UPOV issues, non-profit foundations etc.?

The opportunities for a better interaction among the public and private sectors are numerous. With a bit of imagination, and keeping in mind who is our most important consumer (the farmer), we will find other important possible areas for cooperation.

MAIZE SEED SITUATION IN INDIA - ITC ZENECA'S EXPERIENCE

M. J. Vasudeva Rao and B. R. Arun Kumar [1]

Zeneca is one among the top companies in the world involved in the business of supplying high quality seeds to farmers across the globe, and has a strong presence in the Asia-Pacific region. In the crop portfolio of Zeneca, maize occupies the top position in terms of volumes sold.

In India, Zeneca started its seed operations as a joint venture with ITC in 1994 by amalgamating the seed businesses of ITC and ICI. Both partners already had strong research and development programs in maize aimed at identifying and developing hybrids for the Indian market. Currently, ITC Zeneca has a deeply committed team of young maize breeders in India.

Zeneca seeds has strong internationally operating maize breeding programs based in the corn belt of US at Iowa. We also have a smaller but highly productive tropical corn breeders group which includes India, Thailand, Brazil, Australia and other smaller partners. ITC Zeneca's maize breeding program derives its strength from the efforts of the overall tropical corn group.

In India, maize is a traditional cereal grown mainly for human food purposes, though, of late, the industrial uses are steadily increasing. The area, which is steadily hovering around 6.0 m ha, is likely to remain at that level in the foreseeable future. Two significant maize areas of the country, the *kharif* northern maize belt and the *rabi* winter maize areas in eastern states, have recorded little hybrid coverage, and show a lower level of productivity. These areas offer a very good challenge and an opportunity for the maize breeders to show their mettle. It is generally believed that the national average yields could be raised by at least 1 t/ha if significant improvements are made in the genetic content of the crop in these lower productivity regions.

The recent Asian Seed 95 Conference organized by the Asia-Pacific Seed Association, held in New Delhi, focused attention on the importance of seed as a sector for promoting and sustaining higher agricultural growth. While the 1994 supply of maize seed in India was about 35,000 t (Chopra *et al.*, 1995), its projected demand for domestic consumption for the same year was 60,000 t, and expected to reach 90,000 t in 2002 (Kapoor and Sindhu, 1995).

There have been significant policy initiatives by Government of India in the past decade or so to promote the cause of Indian maize farmer. The new Policy on Seed Development of 1988, upgrading of the AICMIP to Directorate of Maize Research, launching of Technology Mission on Maize, increased activities of the Indian Maize Development Association and its constituent state level maize development associations, the strong working relationship built-up between private and public sectors and the productive patronage and encouragement given to private sector are indicators of the sudden increase in the importance given to stabilize the country's increasing maize productivity at a higher level.

With this as the background, ITC Zeneca has been working in India to contribute its complementary strengths to increase and sustain maize production by supplying high quality seed of superior maize hybrids. We have established a strong maize research and development program based at Bangalore. We have utilized improved genetic material from internal company sources, from the All India Maize improvement project and from CIMMYT to build up this program. Our products are targeted primarily to the Indian markets and possess high stable yield, good grain quality, disease and pest resistance and high quality fodder.

We have regularly entered superior hybrids into the New Seed Policy and other coordinated trials organized by the Directorate of Maize Research, and are pleased to record here that one of our earliest introductions, PAC 9714, has performed well and has been identified by the Indian Council of Agricultural Research (ICAR). This hybrid has also been very well received by the maize farming community. More recently, two more hybrids from ITC Zeneca have been identified by ICAR and are currently awaiting market launch. Several other improved hybrids from ITC Zeneca are performing well in different stages of ICAR's coordinated testing trials.

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[1] ITC Zeneca Limited, 309 Raheja Chambers, Museum Road, Bangalore 560001, India.

We would now like to flag a few issues for consideration to assist in boosting the current levels of maize seed production in India to bridge the present and future gaps between demand and supply.

While on the one hand there is a significant policy initiative to liberalize maize and other seed industries in India, the multiplicity of acts, rules and administrative orders has resulted in over-regulation and slowing down of the operative part of the law. The current policy environment in which maize seed is produced and traded needs a serious review. A single act, Seeds Act 1966, amended to cover all important facets of the seed industry, perhaps, can serve the purpose of monitoring and regulating while encouraging the industry to unlock the immense potential of Indian agriculture (Mullick, 1995). This policy initiative should spur increased investment in technology and infrastructure. We have the following suggestions to offer in this direction:

1. Recognition of the proprietary nature of elite germplasm/parent seed, and removal of the provision of compulsory deposit with the national gene bank.

2. Overhauling of the current plant quarantine organization to set up a well defined, well trained and well equipped system for providing plant quarantine facilities of international standards.

3. Removal of mandatory testing, notification and compulsory certification requirements on companies with technical collaboration and with established quality assurance systems.

4. Establishment of ISTA accredited seed testing labs to enable issuance of orange international certificates for the export of seeds, and encouragement to maize seed export by removing maize seeds from all restrictive/canalized lists of the Import-Export Policy. Also, remove compulsory certification provision for export of seeds. Notification, release and certification has a reference to the Indian agro-climatic environment, but has no relevance to the exported seed.

5. Provide for a national register of seed varieties registered under the Act under a system of registration which follows the internationally acceptable DUS system. This system is to be administered by an independent and autonomous body.

We believe that the Indian maize seed industry has now reached a stage of maturity and competence, and we are in a position to compete at national and international levels. The industry can develop and produce superior high quality seeds of international standards at cost advantages compared to global competition in consonance with the liberalized policy of the Government of India. A progressive policy and an effective legislation will help the maize seed industry to play its rightful role in the continued development of maize agriculture in India, and ensure a rightful place for India in the global market.

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INTEGRATING TRADITIONAL PLANT BREEDING WITH BIOCHEMICAL AND BIOTECHNOLOGICAL TECHNIQUES FOR INCREASING MAIZE PRODUCTION IN ASIA.

K. R. Sarkar [1]

During the last 25 years, remarkable progress has been recorded in the fields of molecular biology and tissue culture, opening up possibilities of transferring useful genes in our breeding material. Some of these recent developments may be taken advantage of in complementing and strengthening our breeding efforts. A lot of scientific information has accumulated during the recent years to make maize a pioneer crop plant for molecular biology research. However, some of the information is not readily translatable in our maize improvement work. Considering the rather expensive nature of these molecular biological ventures, the breeders in the developing countries have to weigh carefully the cost-benefit factors before planning to employ these techniques in their crop improvement programs.

A quick survey of some of these developments will be helpful in formulating the breeding strategies *vis-a-vis* the available resources.

1. **Tissue culture technology applications.**

i. Production of homozygous diploid lines.
   a. anther culture.
   b. increasing efficiency of chromosome doubling.

ii. Selection at the cellular level.
   a. selection of resistance to biotic and abiotic stresses - mutagenesis followed by selection *in vitro*.
   b. somaclonal variations - selection for resistance to *Helminthosporium* T-toxin in maize is already well known.

iii. Moving genes from source organisms.
   a. somatic hybridization (introduction of new genetic variability from distantly related species).
   b. transformation.

For any of these objectives, embryogenic callus (type 2) is required for regeneration. The major factors determining embryogenic cultures in maize are plant genotype, explant and medium.

For establishing cultures, the genotype of the plant is of prime importance. In maize, only few genotypes respond well in culture and regeneration - like A188, B73, CML 216, CML 67, CML 72, Sabour selection, Black Mexican Sweet etc. On the other hand, a genotype like Mo17 is a very poor type 2 callus producing material. Protocols suitable for a wide variety of genotypes are yet to be formulated. So far, indications are there that culture response, i.e. high frequency of type 2 callus, is under genetic control, probably of qualitative nature.

2. **Molecular marker technology applications.**

- Fingerprinting varieties - mostly applicable to homozygous inbred lines.
- Protein profiles.
- Isozyme profiles.
- DNA markers (RFLP, PCR, RAPD, AFLP, etc.).
- QTL mapping - identification of traits of importance in maize improvement.
- Marker assisted selection - too early stage of development, should be restricted to qualitative characters.

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3. **Transformation technology constraints.**
- Defining the gene to be transferred.
- Preparing gene constructs.
- Selecting appropriate gene transfer technology.
- Low frequency of stable transformants.
- Cost factor and infrastructure.
- Biosafety measures.
- Gene silencing.
- Regeneration.

4. **Use of transposable elements.**
- For tagging useful genes.
- For creating additional variability.

5. **Biochemical applications using above techniques.**

Improvement in quantity and quality:

a. Proteins.
- improving the quality of storage proteins by site directed mutagenesis - changing codons for lysine and tryptophan.
- use of amino acid analogues for inhibiting regulatory enzymes like aspartate kinase to increase production of lysine.

b. Carbohydrates - use of mutants like *su*1, *su*2, *sh*1, *sh*2, *ae, wx, fl*, *h*.

c. Oils - quality and quantity.

From the above survey, it is apparent that applied biotechnological work in relation to maize improvement is still in its infancy. The breeders are only interested in some simple and fool-proof protocols which can be gainfully employed in the crop improvement work. Fixation of priority and judicious allocation of available resources will determine the nature and extent of application of biotechnological advances in maize breeding in the developing countries.

BIOTECHNOLOGY IN MAIZE IMPROVEMENT - A COMMENT.

S. P. Pandey [1]

I am a practicing plant breeder who is also closely cooperating with the so-called biotechnologists on a couple of projects, aimed at identifying molecular markers and tagging the genes responsible for tolerance to Al toxicity and P-use efficiency. Plant biotechnology has been called anything from New Science to No Science, and I see it simply as a group of practices and techniques to increase the efficiency of plant breeding programs.

Some techniques of biotechnology are being utilized to finger-print lines and hybrids to facilitate their protection and to detect contaminations. They are also being used in limited cases to determine specific parent combinations to maximize heterosis. However, the long and uniquely promised results of biotechnology i.e., transfer of useful genes for tolerances to insects, diseases and abiotic stresses across genera, single gene substitutions, transformation etc., are yet to be realized. Molecular marker assisted selection continues to be explored but has not yet provided any definite results. In summary, much has been spent at CIMMYT and many other private institutions around the world in implementing biotechnology for improvement of maize, but with little to show for its success.

The value of a few gains, such as European maize-borer resistant Bt maize or herbicide resistant hybrids, is yet to be clearly shown to scientists and farmers.

Because of lack of any definitive results from biotechnology to date and costs involved in implementing these procedures, the logical steps in trying to solve plant breeding problems seem to be:

1. Use traditional plant breeding procedures. The good-old selection and back crossing still works.

2. If progress is slow with traditional means, try harder. Change germplasm and traditional breeding methods to reduce experimental error, and consult other plant breeders, but stay with traditional methods.

3. If you must, consult biotechnologists and collaborate with them, always keeping in mind that you are resolving plant breeding problems, not biotechnology problems. Make sure that the tail does not begin to wag the dog.

4. Do keep yourself open to and informed of the developments in the field of biotechnology, and if something looks useful, adopt it. Use of biotechnology can be looked at as a "friendship" issue. When in problems, go to your long-trusted and traditional friends and allies first. These are the traditional breeding methods. But do develop new friendships, i.e., keep yourself open to joining hands with biotechnology, etc. However, just like with any new friendship, go slow with it and don't ever throw away your valued and trusted friends for new friendships.

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STATUS OF COLLABORATIVE PROJECTS AGREED DURING THE 1994 ASIAN REGIONAL MAIZE RESEARCH PLANNING AND COORDINATION MEETING.

C. De Leon and J. Lothrop [1]

ABSTRACT

In Oct. 1994, the CIMMYT-Asian Regional Maize Program (ARMP) held a Maize Research Planning and Coordination Meeting at Farm Suwan, Thailand. Representatives of seven strong national programs, six seed companies, FAO and CIMMYT, participated in this meeting. One year later, the following has been achieved in six research projects accepted by all participants: 1) Right maturity with drought tolerance: a total of 25 trials in extra early and 22 in late maturities were dispatched from ARMP to various national programs. One additional set of each will be planted in a drought nursery at the Nakorn Sawan Field Crops Res. Center (NSFCRC), Thailand, 2) Excess water: India and Thailand have organized their research in the development of early and late yellow populations, 3) Corn borer resistance: India and Philippines have continued selection under artificial infestations in 2 yellow and one white populations, 4) Disease resistance: a. Selection for resistance to Banded Leaf and Sheath Blight (BLSB) in disease nurseries has continued with P. R. China and India. Several selected lines have been made available to various national programs for evaluation. b. Downy mildew: selection continues in various DMR populations in Thailand and Philippines. c. Stalk rots: Selection continues with India. 5) Problem soils: a. Although selection for low fertility soils was not accepted as a regional project, one project in P. R. China has been initiated to select for tolerance to low N soils. b. Soil acidity: A total of 15 trials received from the CIMMYT-South America Reg. Maize Program (SARMP) were distributed to various countries in the Region. 6) Grain Quality: A total of 18 QPM varieties were received from CIMMYT-HQ for distribution in yield trials in the Region. Trials were not distributed by the appointed leading institution.

Background.

During Oct. 24-28, 1994, the CIMMYT-Asian Regional Maize Program (ARMP) organized a Maize Research Planning and Coordination Meeting at Farm Suwan, Thailand. A total of 17 scientists from 7 strong national programs in the Region, 10 from 6 seed companies operating in the Region, one from FAO and 5 from CIMMYT participated in the Meeting. Results of the Discussion Groups are described in the Proceedings of this Meeting. It is considered that all results and germplasm generated by these activities will have a spill-over effect to smaller national programs. The present paper summarizes the results and accomplishments of activities accepted one year ago in the Plenary Session of the Meeting.

Results.

1. Right maturity with drought tolerance (Drs. C. De Leon and J. Lothrop) - Four genetically broad based DMR populations are available at ARMP, i.e. Extra Early White, Extra Early Yellow, Late White and Late Yellow. These are to be improved by reciprocal recurrent selection. Sn lines in each population were top crossed to two heterotic testers. S1 lines in the extra early populations were top crossed to two heterotic lines received from the Indonesian program at Malang, while Sn lines in the late populations were top crossed to two heterotic lines made available from Kasetsart University. Top crosses were assembled in yield trials and dispatched to various programs to be planted under possible drought conditions (**Table 1**). Lines have continued to be screened and advanced in Downy

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Mildew nurseries. Arrangements have also been made to plant entries in all four populations in replicated trials in a drought nursery routinely established at the NSFCRC, Tak Fa, Thailand.

2. Tolerance to excess water (Dr. T. R. Rathore) - During the 1994 Meeting, it was decided that the Directorate of Maize Research, India would take leadership in this project. Research has been done for several years in waterlogged nurseries at Pantnagar University, U.P., India where 2 base populations, White Water Logging Tolerant (WLT) and Yellow WLT have been developed to be improved for tolerance to water logging (**Table 2**). Selection has also been initiated at the NSFCRC, Tak Fa, Thailand.

Table 1. Countries receiving top crosses of two Extra Early and two Late DMR populations in reciprocal recurrent selection program, Thailand 95E.

Population	Trial design	Countries planting
Extra Early White DMR	16 x 16 Simple lattice	P.R. China (2), India, Indonesia, Pakistan, Philippines, Thailand (3) [1], Vietnam, Mexico, Colombia, Ivory Coast.
Extra Early Yellow DMR		P.R. China, India, Indonesia, Pakistan, Philippines, Thailand (3) [1], Vietnam, Mexico, Colombia, Ivory Coast.
Late White DMR	10 x 10 "	India, Philippines (2), Thailand (4) [1], Mexico, Colombia, Ivory Coast.
Late Yellow DMR	14 x 14 "	India, Indonesia, Philippines (2), Thailand (4) [1], Vietnam, Mexico, Colombia, Ivory Coast.

[1] One additional set of each population to be planted in replicated trials in drought nursery, at NSFCRC-96D.

At the NSFCRC, Thailand, one early and one late yellow population have been developed. These are being selected and improved under water logging conditions in paddy fields. Each population has already been split into heterotic groups 'A' and 'B'. The EY-WLT and LY-WLT populations (**Table 2**) are to be improved by following a reciprocal recurrent selection scheme.

Table 2. Germplasm developed for tolerance to excess water conditions, India and Thailand.

Population	Stage of improvement	Institution
White-WLT	C0 second recomb.	Pantnagar Univ., India.
Yellow-WLT	"	"
EY-WLT (A + B groups)	S1s top crossed x heterotic testers)	DOA, Thailand.
LY-WLT "	" "	"

S_1 lines developed under water logging conditions are crossed to a tester from the opposite heterotic group, and test crosses are evaluated under water logging conditions. In 1995, S_1 lines derived from LY-WLT Pop. have been top crossed to 2 heterotic testers to initiate the development of 2 heterotic sub-populations. Germplasm generated by the two above Centers is to be distributed to other collaborative programs once a level of tolerance to water logging conditions is achieved.

Local germplasm in India has been collected and evaluated under waterlogged conditions. Tolerant germplasm was to be top crossed to heterotic testers to identify their heterotic groups. Remnant seed of entries from various national programs in the Region, now in the Demonstration Nurseries for this Workshop, offers a good opportunity to accomplish this activity.

Corn borer (Dr. V.P.S. Panwar, Directorate Maize Research, ICAR, India) - Activities have continued in selecting and developing borer tolerant maize germplasm with the Directorate of Maize Research-India, and the Inst. Plant Breeding, Philippines. Three maize populations are being improved for tolerance to corn borer, AMBT-DMR EW, AMBT-DMR EY, and AMBT-DMR LY (**Table 3**). A shuttle breeding program has been initiated between India and Philippines. Due to financial and personnel restrictions, no further contacts were established with P.R. China, Pakistan, and Vietnam to join in this project at this stage.

3. Selection for disease resistance -

a. Banded Leaf and Sheath Blight (Dr. R.C. Sharma, Directorate Maize Research, ICAR, India). Germplasm is being evaluated under artificial inoculation conditions both in China and India. Resistant and susceptible entries selected in disease nurseries established at the Maize Research Institute, Guangxi, P.R. China (GxMRI), have been distributed to programs in Indonesia and Vietnam for evaluation (**Table 4**). No data has been received on the performance of this germplasm.

Table 3. Germplasm developed for tolerance to corn stalk borer in Asia. India and Philippines, 95L.

Population	Stage of improvement	Institution
AMBT-DMR, EW	C0-S1 formation	IPB and Directorate Maize Res.
AMBT-DMR, EY	C0-S1 "	"
AMBT-DMR, LY	C0-S1 "	"

Table 4. *Rhizoctonia* resistant and susceptible germplasm selected at the GxMRI and distributed in the Asian region, ARMP, 94L.

Entry	Requested by (programs):
Rhizoct. Resist. 1: Fuwar 9	Indonesia, Thailand, Vietnam
2: Fuwar 11	"
3: Bei 11	"
4: Bei 54-2	"
5: San Zhong 1	"
6: San Zhong 5	"
7: Yellow Mg	"
8: Mg x Gonga 1	"
11: Wax Corn	"
Rhizoct. Susc. 1: Nan 60-1	"

b. Downy mildew (DM) (Dr. C. De Leon, CIMMYT-ARMP) - New germplasm evaluated for resistance (DMR) to this disease includes all lowland tropical CML generated by CIMMYT-HQ program (**Fig. 1**), and acid soil tolerant lines received from CIMMYT-SARMP (**Fig. 2**). Several lines showed high levels of DMR without previous known exposure to DMR genes. Additionally, progenies in populations EEW, EEY, LW and LY continue to be screened in DM disease nurseries established at Suwan Farm, Thailand, and the Univ. of Southern Mindanao, Philippines. These progenies are available to all interested programs.

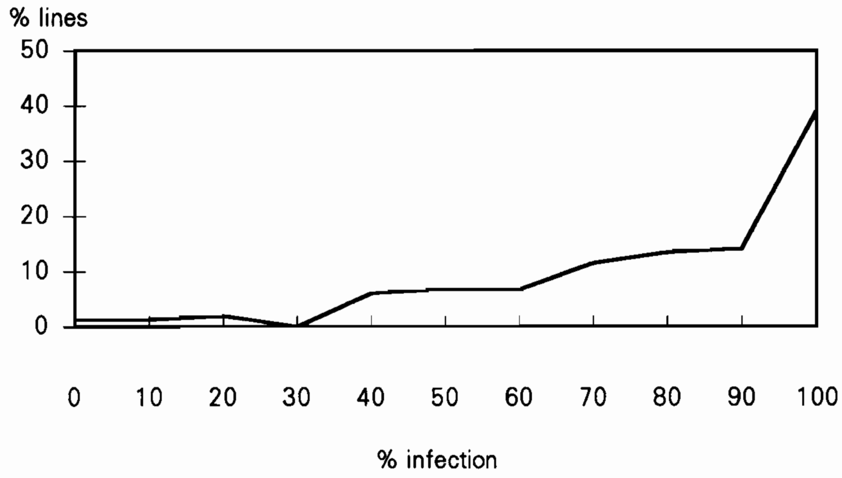

Fig. 1. Frequency distribution of DM infection in 120 CIMMYT's CMLs in DM nursery, SW 95E

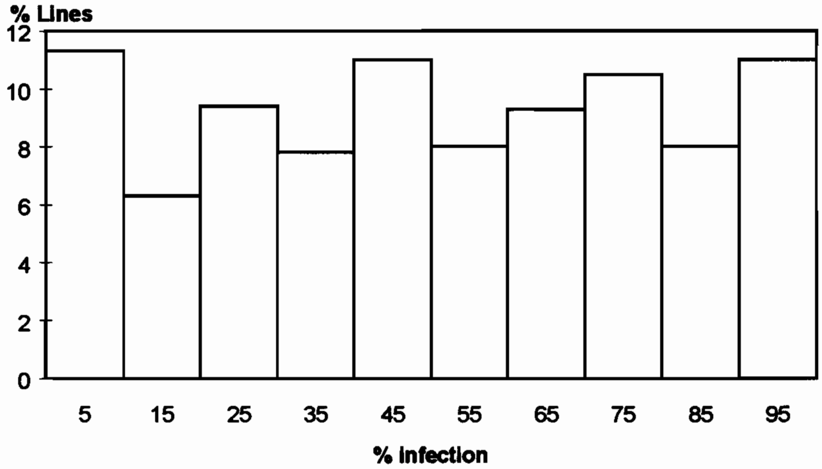

Fig. 2. Frequency distribution of DM infection in 698 CIMMYT-SARMP S6 acid soil-aluminum toleerant inbreds in DM nurery,SW 95E

Experimental synthetic varieties and lines derived from the four above early and late DMR populations will be distributed to national programs in the near future once information on agronomic performance is available from the yield trials, described in (1) above.

c. Other DMR germplasm has been recently identified and is ready for distribution (**Table 5**).
d. Stalk rot (Dr Sangam Lal, Directorate Maize Research ICAR, India) - Two early maturing maize populations, one White and one Yellow, are being improved for stalk rot resistance by the Directorate of Maize Research , India. Several components in these populations had been identified as possessing

resistance to either *Cephalosporium*, *Fusarium* or *Macrophomina* stalk rots. All components were initially crossed to the early DMR White and Yellow populations viz Indimyt 100 and 145, respectively. After two cycles of random mating, progenies have been planted for two seasons in locations with known high stalk rot incidence. In 1996, progenies can be distributed in trials to interested programs after C_2 of improvement for resistance to stalk rots. This character is being carefully monitored in the populations ARMP is handling through reciprocal recurrent selection.

Table 5. Germplasm recently developed with downy mildew resistance. ARMP, 1995.

Available	Derived from
16 Exp. Varieties (1992-95)	Pops. 100 (EW-DMR)
	145 (EY-DMR)
	300 (LW-DMR)
	345 (LY-DMR)
6 Selected S2 x S2 SCs	From Pops. 100, 145, 300, 345
S3 lines (bulks)	Pops. EEW-DMR, EEY-DMR
S4-S6 early lines (Good GCA)	12 W from Pop. 100
	52 Y " Pops. 145, 31 and 49 (Y)

5. Problem soils.

a. Low fertility - Intensification in selection for tolerance to low fertility, especially low N, was requested to the Physiology program, CIMMYT-Headquarters (HQ). Our request was accepted and soon there will be germplasm selected and ready for evaluation by interested programs.

b. Soil acidity - In early 1995, several sets of three trials including germplasm selected for acid soils with high aluminum toxicity, were received from SARMP, Colombia. The trials were distributed as indicated in **Table 6**.

6. Grain quality -

a. Quality protein - A total of 18 selected QPM open pollinated varieties were received from CIMMYT-HQ to be assembled in yield trials and distributed to interested programs. On April 7, 1995, these were passed on to the appointed leading institution. No trials had been prepared by Aug. 15 for distribution to interested programs in the Region.

Table 6. Acid soil-aluminum tolerant germplasm made available from CIMMYT-South America Regional Maize Program to programs in Asia, 1995E.

Trial	Germplasm included:	Planting location:
1. Top crosses	SA3-C4, S2 x Tuxp. Sequia. SA4-C2, S2 x " SA5-C2, S2 x " SA6-C2, S2 x " SA7-C2, S2 x " SA8-C2, S2 x " Inbreds SA3, SA4, SA5, SA6, SA7 x "	Indonesia, Philippines, Vietnam
2. Variety Trials	CIMCALI 93 SA3 " SA4 " SA5 " SA6 " SA7 " SA8 Tuxp. Sequia C8	India, Indonesia, Nepal Philippines (2), Vietnam
3. Cycles of selection	SA3 C0 C1 C2 C3 C5	India, Indonesia, Philippines, Vietnam.

PRODUCTION OF MAIZE UNDER EXCESS SOIL MOISTURE (WATER LOGGING) CONDITIONS

T. R. Rathore [1], M.Z.K. Warsi [2], J. E. Lothrop [3], and N. N. Singh [4]

Maize grown under rainfed conditions in the tropics is frequently damaged by transitory floods as a result of a combination of heavy rainfall and deficient superficial drainage of the soil. In India, about 5.8 m ha of arable soils are in the grip of water logging. Similar situations also exit in other Asian countries, including Bangladesh (0.2-2.0 m ha), Sri Lanka (1.5 m ha), Indonesia, China, Laos, Malaysia, Pakistan, Philippines, Thailand and Vietnam where the problem of poor drainage and surface stagnation of water, especially during the rainy season, is rampant.

The maize growing areas in U.P. and Bihar are the two regions in India most susceptible to floods and water logging during the monsoon season. They receive maximum precipitation in July and August, which saturates the entire soil profile and leads to water logging. The waterlogged areas are mostly located in Tarai belt, and in the canal commands where limited ground water exploitation is presently being done. In eastern region of U.P. state, on average, 15% of the cropped area is damaged by floods and water logging (Rajput, 1995). The extent of damage from water logging, however, depends on a number of factors, including the duration of water logging, soil type, crop growth stage, cloudiness, intensity of sunlight, and tolerance of different maize genotypes to water logging.

EFFECTS OF WATER LOGGING

a) On the soil environment

Water logging initiates a series of physico-chemical and biological changes in soil. It restricts the exchange of oxygen and carbon dioxide in the soil with that in the atmosphere, creates nutrient deficiencies, most notably nitrogen, and accumulates toxic levels of some biochemical products around the root or in the plant (Puris and Williamson, 1972). Apart from reduced oxygen levels, the temperature of ponded water and atmosphere also plays an important role in wilting of plants. Under water logging conditions, temperature of ponded water remained higher by 1.67°C than that of canopy air, and 5.67°C more than that of the submerged soil. In afternoon hours (2 PM) it reached up to 38°C and proved injurious (**Table 1**). Similarly, canopy air temperatures during afternoon hours on hot sunny days reached a critical level (36°C) and caused wilting of plants. In a number of trials conducted at Pantnagar, wilting of plants occurred within three days of water logging under clear and sunny weather. On the other hand, wilting did not occur under cloudy conditions even after 15 days of continuous submergence. At the time of permanent wilting, leaf relative humidity ranged between 47.8 to 50.5%, diffusive resistance 4.86 to 5.33 sec cm^{-1}, temperature 37.8 to 39.9°C and transpiration rate 4.12 to 4.52 μg cm^{-2}, sec^{-1} .

b) On nutrient content

Water logging affected the leaf contents of N, P and K, but not of Ca and Mg, in all the 14 maize varieties tested (**Table 2**). N and K contents were significantly reduced in all the varieties under flooding treatment of 72 hrs, but that of P was found to be significantly increased. In general, water logging increased leaf iron content with increase in duration of water logging, due to transformation of iron from

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ferric to ferrous state. On the other hand, the content of Zn, Mn, Cu and B in leaf tissue was reduced after 3 days of continuous submergence (**Table 3**).

Table 1. Submerged soil, ponded water and canopy air temperature variations during water logged period (*kharif* 1989).

Days after water logging		Temperature (°C)		
		Canopy air	Ponded water	Submerged soil
			Morning (6 AM)	
1		28.50	27.00	28.00
2		29.50	27.33	25.00
3		31.00	27.50	28.00
4		29.50	27.50	25.00
5		26.50	27.00	26.00
6		28.50	28.00	26.00
7		28.00	27.00	25.50
	Av.	28.78	27.35	26.21
			Afternoon (2 PM)	
1		35.50	38.00	30.50
2		36.00	35.50	35.00
3		34.50	38.50	31.00
4		34.00	38.00	32.50
5		31.50	32.00	24.50
6		32.50	31.50	24.00
7		35.50	36.50	27.50
	Av.	34.21	35.71	30.71
			Evening (6 PM)	
1		31.00	34.50	32.00
2		34.00	32.50	30.00
3		29.00	31.00	30.00
4		28.00	30.00	28.50
5		27.50	28.00	26.50
6		27.00	28.50	27.50
7		28.50	33.50	27.00
	Av.	29.50	31.15	28.78

Table 2. Effect of water logging* on N, P, K, Ca and Mg content in leaf of maize varieties.

S.No.	Varieties	N		P		K		Ca		Mg	
		C	W	C	W	C	W	C	W	C	W
		Content in leaf,ppm									
1	MMH-83	23300	21400	4800	5700	34100	28900	3000	2933.33	2300	2100
2	SSF-9306	23000	21000	4900	5700	34400	28800	2800	2733.33	2100	1866.67
3	SSF-9374	23100	21166.67	5000	5733.33	34700	28633.33	2600	2700	1900	1933.33
4	PMZ-111	23000	21033.33	5000	5800	34400	28833.33	2900	2633.33	1800	1833.33
5	BIO-9681	23200	21466.67	4700	5733.33	34300	28666.67	2800	2600	2100	1933.33
6	GK-3002	23300	21166.67	4900	5833.33	34200	28300	2800	2773.33	2000	1766.67
7	AH-34	23200	21266.67	4850	5733.33	34400	28933.33	3000	2866.67	2300	2133.33
8	Comp. A-2	23300	21266.67	4900	5700	34300	28833.33	2700	2666.67	2200	1900
9	PRO-301	23100	21100	5000	6000	34400	28633.33	2700	2633.33	2200	2000
10	MMH-82	23100	21100	4800	5800	34300	28566.67	2800	2633.33	2300	2000
11	AH-738	23300	21100	4700	5800	34200	29100	2900	2633.33	2100	2033.33
12	Comp. A-12	23300	21266.67	4900	5866.67	34100	28833.33	2800	2733.33	1800	1866.67
13	Comp. A-15	23000	21233.33	4800	5633.33	34300	29100	2600	2533.33	1900	1900
14	JK-3193	23100	21300	4900	5866.67	34400	28500	2900	2800	2000	2033.33
	Mean	23164.29	21204.76	4864.29	5778.57	34321.42	28759.51	2807.14	2702.34	2071.43	1950.00
	SEm ±	34.61	158.98	105.85	89.03	103.98	65.05	114.93	70.69	86.86	68.51
	C.D. (P = 0.05)	100.61	462.17	307.71	258.8	302.28	189.08	334.12	205.52	252.52	199.16
	C.V. %	0.259	1.29	3.77	2.67	0.53	0.39	7.1	4.53	7.26	6.09

* 5 cm continuous submergence for 3 days

C - Control, - Waterlogged

c) On root growth

The immediate response of maize to water logging was the development of an extensive adventitious root system from the base of the plant, and formation of more gas spaces in the roots. In some of the varieties, adventitious roots developed from several nodes (4-5) of the stem and provided mechanical support under wet and loose soil conditions. The tips of these roots were white, flaccid and swollen, and found floating on water surface mainly to supplement the oxygen demand of the roots.

Root porosity of 14 maize varieties at knee high and tasseling stages under control and waterlogged conditions was determined (**Table 4**). Aerenchyma formation under control and water logged conditions is shown in **Plate 1**. Root porosity under control condition (non-water logged) at knee high stage varied from 7.3 to 7.7%, and at tasseling from 7.30 to 7.9%. Water logging increased root porosity. Values were

8.26 to 10.53% at knee high stage, and 10.30 to 12.50% at tasseling stage. At both stages, it was highest in varieties MMH-83, SSF-9306, and SSF-9374 and lowest in PMZ-111 under control conditions.

d) On plant growth

Reduction in growth, yellowing of leaves (chlorosis), senescence, delayed silking and maturity, reduction in plant height and grain yield, and sometimes eventual death of plants are of common occurrence under flooded conditions. Further, flooding maize plants in the early vegetative and reproductive stages was found to be more harmful to the growth and development than flooding at later stages.

RESPONSES OF MAIZE CULTIVARS TO WATER LOGGING, AND BREEDING STRATEGY

Several methods have been employed to evaluate plant responses to excess soil moisture (water logging). The methods range from measurement of the effect of flooded conditions or excess oil moisture on crop growth (Howell and Hier, 1974 and Jackson *et al.*, 1981), to more sophisticated measurements of oxygen diffusion rates (Chaudhary *et al.*, 1975) or transpiration rates (Wenkert *et al.*, 1981). Practically, crop yield is a useful measure of crop response to water logging. However, until more is known about the mechanisms of injury, it is difficult to predict yields based on the responses of the parameters listed above at different stages of growth. This uncertainty is illustrated by variable reports of maize yield response to water logging. In some studies, flooding young maize plants for one day had no effect on yield (Purvis and Williamson, 1972), while in others (Howell and Hiler, 1974 and Bhan, 1977) flooding for one or two days decreased yields by 20 to 30%. Similarly, when flooding occurred during the flowering stage, yield reductions were observed by some investigators, while none were observed by others. Further, many agronomic crops are able to recover from water logging stress at certain stages of growth. This physiological recovery is the reason a parameter such as respiration rate at any early stage of growth has not been a reliable predictor of harvestable grain yield.

A considerable amount of literature already exists regarding various adaptive mechanisms of crops to tolerate flooding stress. However, the traits identified are either non-repeatable or those whose transfer by conventional breeding methods is not possible. Inheritance studies conducted by Khera *et al.* (1990) showed that tolerance to excess water was genetically controlled, and both additive and non-additive gene actions were important. They found good correlations between grain yield and number of green leaves, ear length, and adventitious root development under water logged conditions. They suggested that these characters can be used in a selection index to screen maize genotypes for water logging stress tolerance.

As already stated, yield reductions caused by flooding may also be influenced by high temperatures reached on clear sunny days. In clear sunny weather, the rate of water absorption by roots (partially injured by hot water) lags behind the rate of transpiration by leaves. As a result of this, mid-day closure of stomata suddenly increases the heat load at the leaf surface and causes wilting of plants. Furthermore, with a rise in ponded water temperature, solubility of oxygen in water also decreases. Thus, the lack of oxygen and consequently the reduced metabolic absorption of water cause rapid water deficit as well as a rise in leaf temperature, which may be responsible for rapid wilting of plants under waterlogged conditions. Hence, selection of maize lines having high stomatal density or "no mid-day stomata closure" should be attempted in future breeding programs. These traits would allow continuous transpiration of water from leaf surfaces, cooling the leaves, and saving plants from rapid wilting under sunny weather conditions.

PROGRESS ON BREEDING FOR WATER LOGGING TOLERANCE

On the basis of preliminary screening for three years against water logging, certain materials were selected (Chotcheng *et al.* 1995). These materials were sown in large size plots in the water logging nursery. In each material, about 50-100 selfs were made using healthy plants. Fifty selfs per material were planted in ear to row fashion and chain crosses were made among the selected materials. Equal quantities of seed of each cross were bulked to form white and yellow pools. First recombination has been made in both these pools. The second recombination is in process during the current *kharif* 1995 season.

During *rabi* 1995 at Hyderabad, S_1 selection method of population improvement would be deployed in order to improve the population, and from each cycle of selection experimental synthetics would be developed.

Table 3. Effect of water logging* on Fe, Zn, Mn, Cu and B content in leaf of maize varieties.

S.No.	Varieties	Fe		Zn		Mn		Cu		B	
		C	W	C	W	C	W	C	W	C	W
		Content in leaf, ppm									
1	MMH-83	204.00	248.23	88.10	71.93	56.20	40.63	11.20	6.67	8.81	7.19
2	SSF-9306	209.00	243.20	85.90	76.87	52.23	39.93	9.40	6.87	8.59	7.67
3	SSF-9374	198.80	246.30	87.80	73.33	50.50	37.67	12.50	8.10	8.78	7.33
4	PMZ-111	202.10	249.10	88.70	74.63	54.10	39.67	11.30	7.17	8.87	7.46
5	BIO-9681	208.00	253.03	86.60	70.47	52.00	40.90	10.40	6.97	8.66	7.05
6	GK-3002	206.00	250.06	85.60	70.57	56.80	40.40	13.60	9.10	8.56	7.06
7	AH-34	209.50	245.77	87.10	71.07	50.60	39.20	12.70	7.50	8.71	7.11
8	Comp. A-2	203.30	249.80	89.80	72.87	53.80	38.47	11.80	7.93	8.98	7.29
9	PRO-301	205.30	253.90	84.70	69.70	51.30	39.93	14.90	8.73	8.47	6.97
10	MMH-82	206.10	251.27	86.50	71.17	50.40	39.63	14.80	8.97	8.65	7.11
11	AH-738	208.00	248.93	86.00	70.83	54.50	42.03	12.90	8.70	8.60	7.09
12	Comp. A-12	207.40	252.97	88.00	72.13	56.30	41.33	13.70	6.20	8.80	7.21
13	Comp. A-15	207.50	249.10	84.80	69.63	55.00	40.53	13.60	8.93	8.48	6.96
14	JK-3193	206.70	251.00	85.10	73.73	53.60	41.47	12.90	8.37	8.57	7.37
	Mean	205.86	249.52	86.76	72.07	53.38	40.13	12.55	7.87	8.67	7.21
	SEm ±	43.77	49.17	5.93	5.76	10.03	6.37	0.94	0.74	1.45	1.19
	C.D. (P = 0.05)	127.26	142.93	17.24	16.74	29.15	18.52	2.75	2.14	3.34	3.45
	C.V. %	36.83	34.13	11.84	13.84	32.54	27.52	13.06	16.23	22.94	28.51

* 5 cm continuous submergence for 3 days

C - Control, W - Waterlogged

Every year new materials having varying origins are being received for testing their water logging tolerance. Materials showing water logging tolerance would be formally used in the breeding programs in two ways:

i) The water logging tolerant materials (in case the number is sizable) having proven good yield potential under control conditions have to be crossed with heterotic testers in order to determine their heterotic group. Thus in each kernel color, two heterotic pools shall be developed. In each pool, inbred lines would be developed in order to evolve water logging tolerant hybrids.

ii) Or else, new materials showing appreciable degree of tolerance to water logging along with good yield potential as observed under control conditions could be introgressed in the existing yellow and white water logging tolerant pools in order to broaden the base of the pools, so that sufficient genetic variability is maintained for the improvement of the population.

CROP MANAGEMENT

Among the various agronomic manipulations tested to reduce the damage due to water logging, ridge planting or flat sowing followed by earthing up proved beneficial. To a great extent, the damage could also be avoided by applying additional nitrogen and some suitable oxidants. Under waterlogged conditions, a level of 500 kg/ha of calcium peroxide (CaO_2) when mixed in soil, and a level of 50% by weight when coated over the seed, improved maize emergence (unpublished data, Pantnagar 1989, 1990). Thus, calcium peroxide - a potential source of oxygen supply under waterlogged conditions, needs large scale testing in field trials.

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Table 4. Root porosity of maize germplasms at knee-high and tasselling stages under control and water logged conditions.

S.No.	Varieties	Knee-high			Tasselling		
		Control, C	Waterlogged, W	W/C x 100	Control, C	Waterlogged, W	W/C x 100
1	MMH-83	7.7	10.00	129.87	7.80	12.30	157.69
2	SSF-9306	7.7	10.53	136.75	7.90	12.50	158.23
3	SSF-9374	7.7	10.10	131.17	7.90	12.30	155.69
4	PMZ-111	7.3	9.40	128.77	7.30	10.40	142.47
5	BIO-9681	7.4	9.30	125.68	7.40	10.40	140.54
6	GK-3002	7.4	9.50	128.38	7.30	10.80	147.95
7	AH-34	7.5	9.80	130.67	7.50	11.80	157.33
8	Comp. A-2	7.6	9.80	128.95	7.60	12.00	157.89
9	PRO-301	7.6	9.70	127.63	7.70	11.43	148.44
10	MMH-82	7.6	9.80	128.95	7.50	11.93	159.06
11	AH-738	7.6	10.40	136.84	7.70	12.40	161.04
12	Comp. A-12	7.4	9.60	129.73	7.40	10.90	147.29
13	Comp. A-15	7.5	9.70	129.33	7.50	11.00	146.67
14	JK-3193	7.5	8.26	110.13	7.40	10.30	139.19
	Mean	7.53	9.70	-	7.56	11.46	-
	SEm ±	0.00159	0.177	-	0.00308	0.0900	-
	C.D. (P = 0.05)	0.00462	0.516	-	0.00897	0.261	-
	C.V. %	0.0365	3.171	-	0.0707	1.360	-

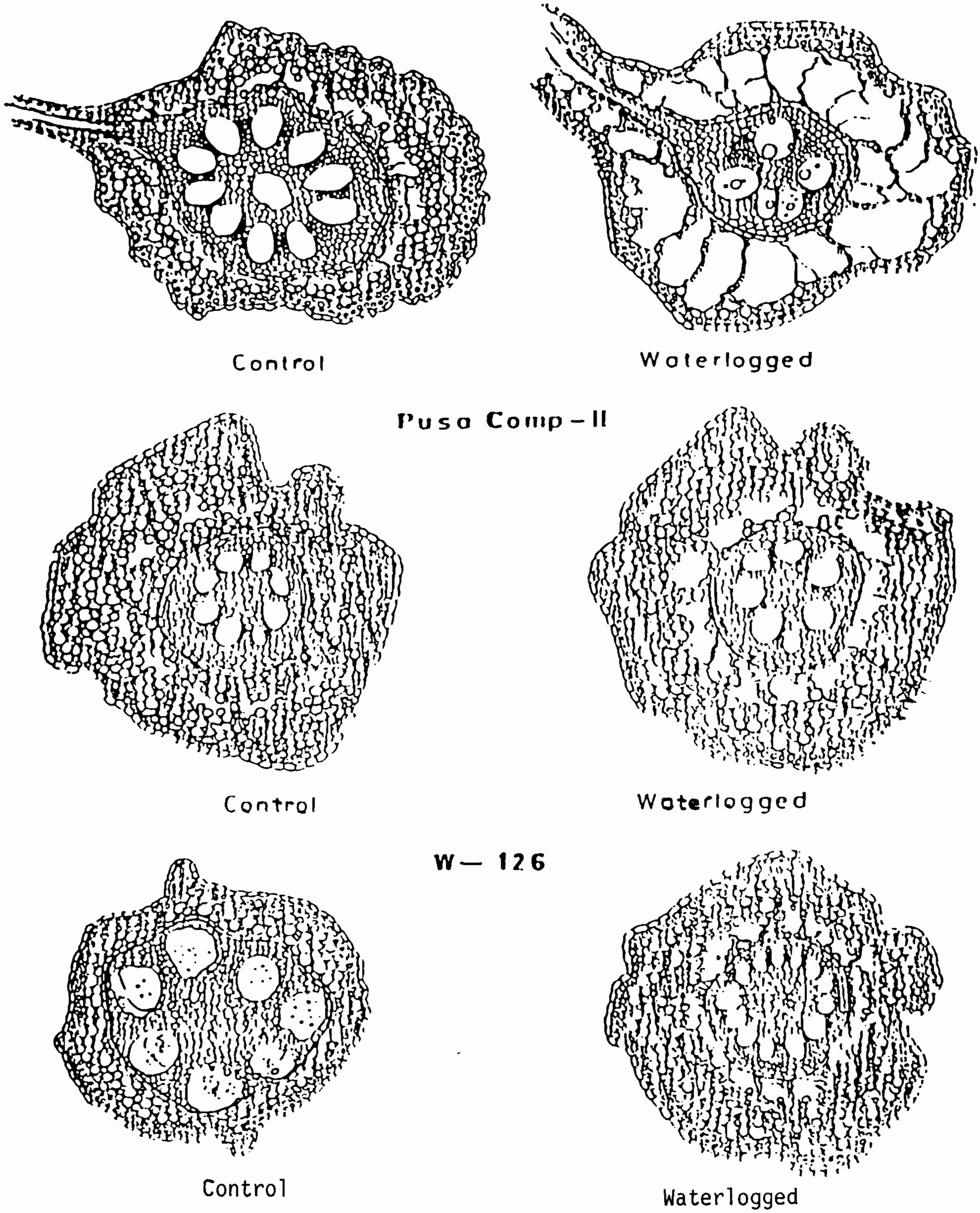

Plate 1. Gas space (aerenchyma) formation under control and waterlogged conditions in different maize germplasms.

MAIZE PRODUCTION IN BANGLADESH

Md. Helalul Islam [1]

Maize has been established as an important crop in Bangladesh. It can be grown successfully in the winter during *rabi* season (15 October-15 December), *kharif* I (15 February-15 March) and *kharif* II (September/October). Thus, maize can potentially be grown on about 2.8 million hectares of high or medium highland, which is not used for the transplanted rice crop. Out of the total potential area, 80 per cent is available during *rabi* and the balance during kharif seasons. Although maize yields are maximum during the winter months, *kharif* yields are also satisfactory. Maize grain price is relatively higher in *kharif*, which compensates for the comparatively lower yield. Eighty per cent of the potential area is in the northwest of Bangladesh and north of Dhaka City.

Maize area and production has been stagnant for many years. But with the initiation of an Integrated Maize Promotion Project (IMPP) since 1992, maize area and production have increased dramatically (**Table 1**). For the first time, different agencies involved in maize production, marketing and utilization were integrated and attempts were made to redress earlier constraints that impeded area expansion. Non-Government Organizations(NGO's), having financial and administrative autonomy, have also been integrated into the system. The present task is achieving sustainability in maize production.

Table 1. Area, production and yield of maize in Bangladesh.

Year	Area (ha)	Production (tons)	Yield (kg/ha)
1989-90	3346	3350	1001
1990-91	3109	3040	978
1991-92	3600	3000	833
1992-93	5060	7000	1383
1993-94	6400	15000	3443
1994-95	9940	29075	2925

Surveys conducted in the recent past estimate the potential demand to be around 470,000 tons (Hart, 1986) or 498,000 tons (Ali Mohammad, 1985). But the safest estimate may be around 270,000 tons/year by the year 2000. Experimental findings suggest that maize can easily fit into several alternative systems of crop rotation, mixed or inter-cropping, and farmers' reaction was also positive for the changed system.

Although maize can be used for food as "chapati", and in a number of other acceptable food items blended with wheat flour in different proportions, the immediate need of the poultry and dairy farms merits careful consideration. The country has 70,000 poultry and 29,500 dairy farms in the private sector, besides 33 poultry farms and about 10 dairy farms under direct control of the Government. It may be noted here that the number of birds in poultry farms varies from 200 to a few thousands, while a minimum of 5 cattle heads make a dairy farm. The diversified uses of maize at different crop growth stages makes it a potential crop for Bangladesh, without causing significant reduction in rice or wheat production.

The increased area and production achieved though IMPP, though not spectacular, proves the immense potential of maize crop. **Table 2** shows some of the salient achievements under IMPP. Thus, it is

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evident that the country now has the trained manpower to handle a large scale production program, and a solid ground has been created for expansion of maize cultivation.

Non-availability of seed, both hybrids and OPV's, has retarded the rate of adoption of maize crop and thus expansion of its area. Bangladesh Agricultural Development Corporation (BADC) is the only Government Agency responsible for maize seed production and distribution. BADC has so far produced and distributed the seeds of OPV's developed by BARI. Maize seed production and distribution for the last five years is as follows:

Table 2. Salient achievements made under IMPP.

Activities	Achievements
1. Demonstration trials (ha) (Department of Agric. Extn. & NGO's)	1660
2. Total number of Thanas covered (The country has 460 thanas)	104
3. Training	
a) Extension officers including those responsible for seed production and marketing	487
b) Field level extension agents, dealers and farmers	8000
4. Marketing session and food demonstrations	110
5. Thana field days (farmers' rallies)	198
6. Mini field days (rallies on demonstration plots)	1316
7. Promotional folders and posters (cultivation methods & uses)	165000
8. Maize shellers distributed	
a) Manual	1350
b) Power	17

Several private sector companies have played a laudable role in maize promotion in the country, but the efforts of a few NGO's have really helped in expanding maize cultivation in remote areas.

The NGO's largely depended on imported hybrid seeds and a small supply of OPV's from BADC, but the shortage of seed supply impeded their maize expansion program. Only one private company (Kushtia Seed Store) imports and distributes hybrid maize seed in the country. It is importing seed of the cultivar Pacific 11 from Thailand, which has been successfully grown in the country. Pacific 44 and Pacific 60 cultivars have also been tried and the results are encouraging. This company is rather reluctant to try more hybrids probably due to apprehension of loss of monopoly. For the 1995-96 season, it is reported the private companies are importing 300 tons of Suwan-2, and the BRAC will import 150 tons to plant its 8,000 ha target. Thailand is the major source of hybrid maize seed for Bangladesh.

But marginal farmers cannot afford costly imported hybrid seeds (Tk. 110.00-120.00/kg), so the hybrid cultivars are generally popular with farmers having credit facilities available to them. The maize seed: grain cost ratio in this instance is about 23:1. Nevertheless, studies on comparative performance and profitability prove (**Table 3**) beyond doubt the superiority of hybrids over composites, not only in research farms, but also in farmers' fields.

Maize hybrids supplied by CIMMYT or under TAMNET activities have displayed potential yields of 8-9 t/ha, compared to the 5-6 t/ha yield potential of composites. BARI has also developed hybrids from inbreds received from IITA, which give a yield of about 7 t/ha. The cultivar requirements in maize for Bangladesh include resistance to drought and high temperature (particularly for *kharif* crop, winter maize crop is relatively free from natural hazards), early maturity with higher yield, tolerance to excess water conditions and cold tolerance for *rabi* maize. Besides, research areas like optimum sowing times in different seasons, cheaper seed storage methods (humidity is a problem, it being a coastal area) etc. also need specific attention.

Year	Seed Supply(tons)
1991	-
1992	138
1993	168
1994	250
1995	340

Table 3. Comparative results from hybrid and composite maize cultivars.

	Site 1 (Jessore)		Site 2 (Rangpur)	
Items	Composite	Hybrid	Composite	Hybrid
Grain yield (kg/ha)	3706	6185	4635	6472
By-product (kg/ha)	5704	6484	6233	6816
Price of grain (Tk./kg)	5.00	5.00	5.00	5.00
Price of by-product (Tk./kg)	0.15	0.15	0.15	0.15
Cost of production (Tk./ha):				
Full cost	14228	19614	15381	20554
Cash cost	6722	11680	8350	13747
Gross return (Tk./ha):				
Value of grain	18530	30925	23175	32360
Value of by-product	855	973	1246	1363
Total value	19385	31898	24421	33723
Gross margin (Tk./ha):				
Full cost basis	5157	12284	9040	13169
Cash cost basis	12663	20218	16071	19976
Benefit cost ratio:				
Full cost basis	1.36	1.67	2.92	2.45
Cash cost basis	2.88	2.73	2.92	2.45

Conclusion

Keeping all other factors favorable, the chief limiting factor for increased maize production in Bangladesh is the supply of improved seeds at a reasonable price. Local seed industries should be developed side by side with Government initiatives for seed production and distribution. Closer collaboration and joint ventures between local agencies and multi-national companies will be a prerequisite to ensure a supply of improved quality seeds, and this achieve higher production.

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Comments/questions:

K. A. Nayeem, India.

Low ear moisture as mentioned by you is not controlled by gene. However, the environment, particularly the humid climate prevailed in Bangladesh, is responsible for "high ear moisture" in maize. What are the problems, or what are damages to grain in humid climate?

Answer: Higher ear moisture or low drying rates delay shelling either by hand or by machine and subject the grains to *aflatoxin*. In dry weather, farmers are advised to delay harvesting to reduce ear moisture in the field. In fact, moisture content determines storability of seed/grain. Ear moisture content is, as far as I know, a genetically controlled character.

C. De Leon, CIMMYT ARMP

You showed several institutions (NGOs) working in promoting maize production in Bangladesh. What is the coordination between these agencies? What varieties they test/promote? Who produces the seed of the selected entries?

Answer: Your question is pertinent and needs some elaboration in reply. IMPP (Integrated Maize Promotion Project) was integrating all activities. IMPP was terminated since June 30, 1995. Coordination, in fact, is very much needed at this time. I coordinate maize research but also help the NGOs in giving technical advice. At, the moment, hybrid seeds are imported from Thailand (Pacific 11) and the NGOs are promoting hybrids only. But arrangements have been made to import Suwan-2 (200 tons) from Thailand by one NGO. Composites (local ones) are also grown by NGOs but in a limited scale.

HYBRID MAIZE PRODUCTION AND MAIZE SEED INDUSTRY IN CHINA.

Shi-huang Zhang[1] and Zong Long Chen [2]

Abstract

Maize production in China increased 700% during 1949-94, going from 13 to 104 m tons annually, while average yields of maize rose 308% (80 kg/ha, or some 6.7% per year) from 1.2 to 4.9 t/ha. The above yield increase paralleled the growth in area sown to registered hybrid maize. More than 95% of national maize hectarage is under hybrids, most of them single crosses.

Seed policies in China have changed twice since 1958, and additional adjustments are in the offing. Before 1978, the seed policy encouraged farmers themselves to handle hybrid seed production, sorting, distribution, and utilization, with only limited and necessary direction or transportation by the local administrations. After 1978, a new policy emphasized specialization in seed production and public management of seed supply and marketing. It comprised four tenets: 1) specialization in seed production, 2) mechanization in seed processing, 3) standardization in quality control, and 4) regionalization in variety distribution.

Now the production and supply of hybrid maize seed has become more commercialized. Most of the stronger companies are clustered and form a seed zone in northern China, where climatic conditions are particularly suitable for maize seed production. Seed yields in the zone are usually much higher, production costs much lower, and seed quality much better than in southern or central China. More than 67% of the hybrid seed production area and more than 73% of the maize seed produced in China come from the seed zone.

The most important challenge which China's seed industry faces is seed quality, especially the genetic purity of hybrid seed. The government is acting to improve and control seed quality. Seed production will be concentrated in a few groups or cooperatives in northern China. They will be given resources to invest in seed processing plants, a quality control system, and improved management of the entire seed production and processing procedure.

Promising directions for seed industry development include the following:

1. Group small companies around a few large-scale corporations to stabilize the market, and invest in modern processing plants to improve seed quality and enhance the ability to complete.

2. Combine breeding research, seed production, and technology dissemination systems. The government is also encouraging the establishment of a private sector for hybrid seed production and marketing to promote competition. Public-private interactions should lead to improved seed quality and stabilize the seed supply and markets in China.

Trends in maize production and yield increases.

Maize ranks third among food grain crops in production and area in China, accounting for 18.7% of the area sown to cereals, and 25.5% of the national cereal production (1993). About 70% of maize produced is used in animal feed, 23% is eaten by humans, and 7 % serves as raw material for industry.

Maize was the first major cereal to undergo rapid and widespread technological transformation in China. Its' production in China increased 700% during 1949-94, increasing from 13 to 104 million tons annually, and making the country the second largest maize producer in the world. Cultivated maize area

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in the country only doubled during the same period, from 10 to 21 million hectares. Average yields of maize during this period rose 308% (80 kg/ha, or about 6.7% per year) from 1.2 to 4.9 t/ha (**Fig. 1**). China accounts for 6% of the world's maize area, 19.6% of the maize production, and has average maize yields 22.6% higher than the world average.

The above yield increase paralleled the growth in area sown to registered hybrid maize. More than 90% of the national maize acreage is under hybrids, most of them single crosses (**Fig. 2**). During the last two decades, single cross hybrids have largely replaced double crosses, and average yields have increased from 2.0 to 4.9 t/ha -- an annual increase of 5.7% (**Table 1**), compared to a 1.0% yearly increase in maize yields for the world as a whole. The increased maize productivity in China may be attributed in part to genetically improved cultivars -- in fact, it is believed that more than two-fifths of the increase is due directly to genetic gains. However, hybrids have also played an indirect role in farmers' adoption of other yield-increasing technologies, like the use of nitrogen fertilizer, irrigation systems, intercropping, high plant density, etc. This is because most registered hybrids perform very well under high plant densities, high levels of nitrogen, and adequate irrigation, whereas local open pollinated varieties (OPV's) do not.

Experience indicates that returns on inputs from using maize hybrids have been remarkably higher than for using other agro-techniques, especially during the early stages of adoption. Many farmers who had limited purchasing power gave first preference to hybrid seed, rather than inputs such as fertilizers, pesticides or farm machines. The common use of maize hybrids in China has even promoted research on heterosis in crops such as sorghum, wheat, rice, rapeseed and some vegetables.

Three stages were characterized by the dominant maize breeding approaches, which emphasized varietal hybridization, double cross, and single cross hybrids, respectively.

Table 1. Maize production in China.

Stage	Type of variety	Period	Yield		Average increase per year	
			Mean	Range	kg/ha	%
I	Varietal hybrids and OPV's	1950-1960	1329	1237-1406	15.4	1.2
II	Double cross hybrids	1961-1969	1573	1309-1842	66.6	5.1
III	Single cross hybrids	1970-1994	3354	2088-4931	118.5	5.6
Overall		1950-1994		1237-4931	84.0	6.8

Seed production and policy.

Seed policies in China have changed twice since 1958, and additional modifications are in the offing. The central government has been encouraging the adoption and expansion of improved varieties and the establishment of seed production systems. Farmers and agricultural cooperatives introduced many improved varieties in the early 1950's. This led the government to issue its first seed management policy in 1958. The policy encouraged farmers to handle seed production, sorting, distribution and utilization, with only limited and necessary direction or transportation by the local administrations.

During the 1960's, when maize scientists and ago-technicians went to the countryside to educate farmers and disseminate double cross hybrids, major emphasis was placed on the policy of self-reliance in seed production. Governments in many counties began to establish public seed companies and agro-technical stations. The newly established seed companies were not strong enough to handle the seed market, they just provided the seed of parental single-crosses, and the agro-technical stations gave guidance to the farmers for seed production of double crosses. In some cases, the farmers produced enough good quality hybrid seed to meet not only their own needs, but also to supply to others in the vicinity. In other cases, the genetic purity and quality of seed did not meet quality control standards, and seed production in required quantities was not always guaranteed. Seed production, quality control, and seed marketing were not well-managed during the Cultural Revolution. At that time too many varieties were developed, distribution was chaotic, and seed quality became poorer.

The State Council and the Ministry of Agriculture had to change the seed policy again in May, 1978 when hybrids had occupied more than 60% of China's maize hectarage, and 80% of hybrids were single crosses. The new policy emphasized specialization in production and public management of seed supply and marketing. It comprised the basic tenets of: specialization in seed production, mechanization in seed processing, standardization in quality control, and regionalization in variety distribution. The policy emphasized the county as the basic unit in a unified seed supply and marketing system, and excluded the private sector from producing or selling hybrid seed.

In effect, however, the above policy only had the force of a recommendation, and many public companies did not observe uniform standards for seed production, quality control and marketing. Therefore, in 1989, the central government promulgated regulations for seed production and quality control. The new statute stipulates that seed production and marketing is a specialized industry which can be undertaken only by public seed companies and by authorized research institutions, and that seed quality should be controlled and certified by the relevant agricultural authorities. The government invested heavily in establishing 85 base counties with appropriate natural conditions and expertise for large-scale production of hybrid maize seed. The government also encouraged public companies to mechanize seed processing. Consequently, during the last decade, the seed industry has progressed, and public companies have helped to establish seed production, processing and marketing groups; these have been equipped with more than 100 seed processing plants.

The seed production zone in northern China.

As China undergoes a significant shift from a planned to a market economy, the production and supply of hybrid maize seed has become more commercialized. Competition among seed companies is more intense than ever. Stronger companies are growing steadily, having benefited from regular government support which began in 1978. These companies are clustered in northern China, where climatic conditions are particularly suitable for maize seed production, and seed groups and cooperatives have been established there. The five most important hybrid seed producers are located in Liaoning, Hebei, Jilin, Shanxi and Inner Mongolia. Local technicians and farmers are usually well trained and experienced in hybrid seed production and management. The suitable climate and reliable irrigation systems in the zone contribute to a higher yield potential for seed production than in southern provinces (**Fig. 3**). Thus, in northern China, seed yields are usually much higher, production costs much lower, and seed quality much better than in southern or central China. Seed consumers in many provinces, therefore, prefer to transport hybrid seed from northern China, rather than producing it locally, and also save much money this way. For example, in Sichuan, Guizhou and Guangxi; only half the demand for hybrid seed is met through local production, and the rest is imported from northern China. The northern zone accounts for 67% of hybrid seed production area (**Fig. 4**), and more than 73% of the maize seed produced in China (**Fig. 5**).

In southern China, only a limited maize area is planted to hybrids, many of which were introduced from northern China. They are not considered the right and best cultivars in southern China, although they perform fairly well there. The provincial academies have also released some improved OPV's and introduced some populations from CIMMYT. Nevertheless, the situation is changing, and breeders have developed and released a number of hybrids. Most of the locally developed hybrids have performed very well in southern conditions. It is expected that hybrids will occupy more area as breeders develop and release many more locally suitable hybrid cultivars. Overall, seed production in southern China is still less developed. Small companies are not able to compete with strong groups in the northern seed zone, and more and more small companies in southern China have to reduce local hybrid seed production and import hybrid seeds from the northern seed zone.

Challenges.

The most important challenge which China's seed industry faces is seed quality, especially the genetic purity of hybrid seed. In some cases, the germination rate of hybrid seed was below the 85% standard, mainly because of severe freezing damage to embryos during post harvest operations, a problem which occurs every few years. However, a good number of companies and groups have managed to solve this critical problem. Over 100 large heated rooms have been or are being built since the mid-1980s. As a result, the germination standard of hybrid seed is gradually improving.

The issue of genetic purity involves not only technical difficulties, but also management and system's problems. In many cases, the isolated plots under seed production or parent line reproduction are not separated by the standard safety distance, and then stock seeds are not pure enough to produce quality hybrid seed. For example, detasseling is sometimes incomplete or done at a late stage. In these cases, inbred seed gets mixed with hybrid seed, and purity can fall to 90% or lower, as measured in special tests. It should be noted, however that the effects of impurities in hybrid seed in farmers' field are not as severe as the figures might suggest. Cropping practices tend to offset and conceal the effects of poor seed purity. For example, farmers usually over-plant maize seed, and most weak seedlings will be removed during thinning early in the crop cycle.

The government is directing its efforts to control and improve seed quality. Seed production is planned to be concentrated in a few groups or cooperatives in northern China, which will be provided with resources to invest in seed processing plants, a quality control system, and improved management of the entire seed production and processing procedure. These groups and public companies will also be empowered to compensate farmers for any losses from eliminating poor plants, or from poor seed produced by incorrect detasseling.

In southern China, the first researchable issue is the adaptation of maize hybrids. High yielding tropical and subtropical hybrids with multiple disease resistance are urgently needed where hybrid coverage is only 50% of the total cultivated area under maize. The second researchable issue is to improve the technology of seed production. The third one is related to the seed quality control and assurance system. Foundation seed production seems to be a weak point in the hybrid seed production system, resulting in low quality seed in southern China, as well as in the northern seed zone.

Alternative choices and reforms in the seed industry.

Maize breeding, seed production, and technology extension constitute three separate systems in China. They proved effective in promoting the extension and adoption of maize hybrids under poor economic conditions in the countryside, especially in the early stages of hybrid maize dissemination. Lately, however, the budget for breeding research is being reduced in real terms. Maize breeders and institutions seldom receive any payment from seed producers, although public companies have made significant profits from hybrids developed through breeding research. For example, at least 100 companies have produced hybrid seed of Zhong Dan No. 2 and Dan Yu 13 cultivars, and made money from these two famous hybrids for more than 20 years. But the breeder's institutions responsible for their development have not received anything. Under these conditions, breeders and breeding institutions are unable to continue their research, and have not released any new hybrids to replace the two mentioned above.

Faced with the great demand for new cultivars, on the one hand, and strained budgets on the other, breeders have fallen into a passive stance. Seed producers need new cultivars to occupy markets characterized by intense competition, but public companies do not have their own cultivars and cannot safeguard their position in the seed market. Under this situation, seed legislation is urgent and necessary in China. Accordingly, seed laws or regulations should be helpful to protect both breeders' rights and company's profits. Also, private companies will not be able to complete with the public sector without an appropriate seed legislation.

Economic transition in China has resulted in a coexistence of central planning's vestiges with an emerging marketing system. The blend of these two contradictory systems makes seed production and management virtually impossible to plan. The demand for hybrid seed is about 0.8 million tons a year, but the seed production capacity is much more than one million tons, provided it is effectively managed. A four-year cycle in hybrid seed production and marketing, characterized by overproduction - balance - short supply - balance is observed in China. Seed production and supply was short in 1993 and got stimulated in 1994, resulting in a balance that year. In 1995, excess production of seed is expected. This fluctuation periodically disrupts the seed market and affects both the farmers and seed producers. The government is investing in a national seed stock system in the northern seed zone to minimize fluctuations in seed production and price.

Promising directions for resolving the difficulties include the following two steps:

1. Grouping small companies around a few large-scale corporations to stabilize the market, and investing in modern processing plants to improve seed quality and enhance the ability to complete.

Combining breeding research, seed production, and technology dissemination systems.

Specialists suggest that seed groups and corporations could be strengthened if they possessed their own hybrids, as well as extension or services systems. Seed sectors and research institutions have formulated three models to combine breeding research, seed production, and technology extension:

1. Some stronger seed companies investing in maize research and setting up their own breeding program. (But most companies lack funds and expertise).

2. Research institutions producing hybrid seed and sharing markets with public companies to supplement their meager budgets and support breeding research. (But most of these institutions are short on capital and are not particularly good at business management).

3. Seed companies cooperating with institutions and providing financial support to assist breeding research. The companies would be given first opportunity for buying new hybrids for commercial production and marketing in permitted areas. (Many companies prefer this model and are trying to take this route).

The government is also encouraging the establishment of a private sector for hybrid seed production and marketing to promote competition. Public-private interactions should lead to improved seed quality and stabilization of seed supply and markets in China. However, practical difficulties must be overcome. Agriculture is a basic industry in China, and cereal production always fluctuates and is influenced by climatic and policy factors. Seed production is not different, and suffers from the same problems. The government will continue to provide subsidies to control seed prices and support the hybrid seed industry, so as to meet the demand for hybrid seed and ensure agricultural production.

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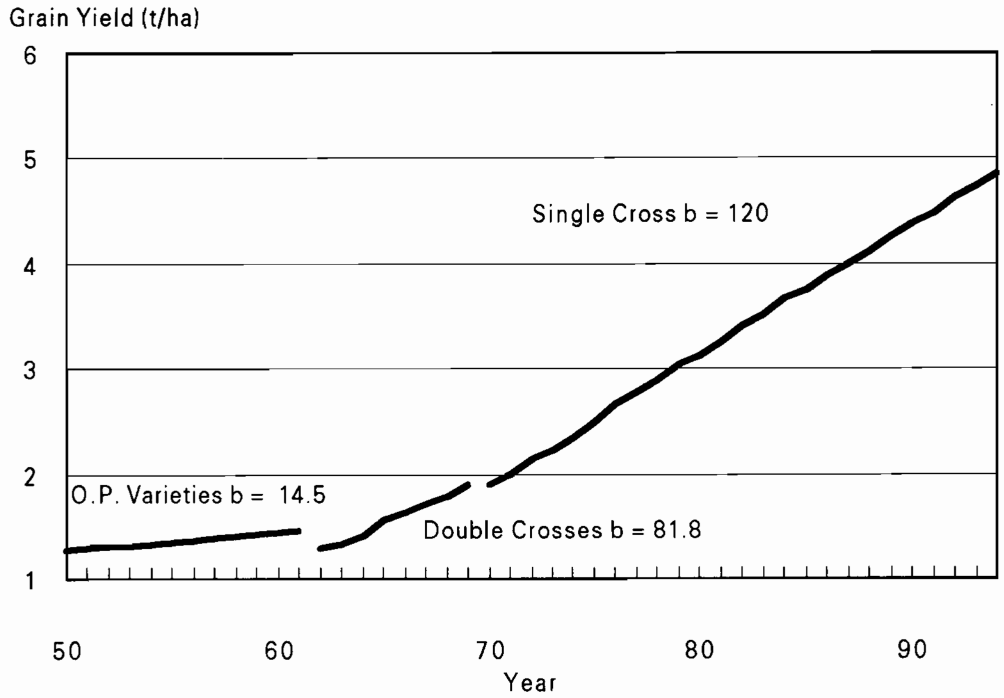

Figure 1. Maize yields in China, 1948-1993.

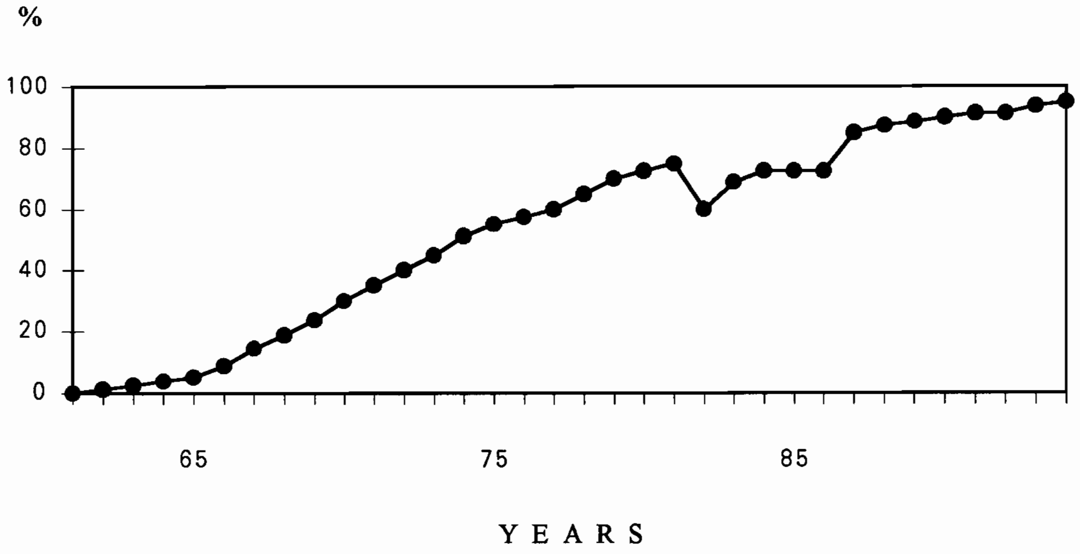

Figure 2. Percentage of maize hectarage planted to hybrids in China, 1961-1994.

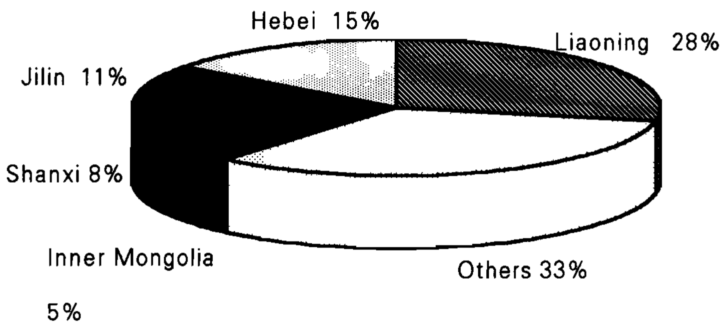

Figure 3. Percentage of the total maize seed production area planted in various provinces of China in 1994.

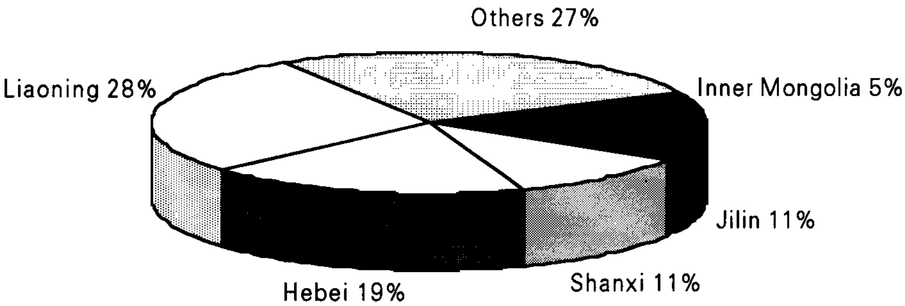

Figure 4. Seed production in selected provinces (1994).

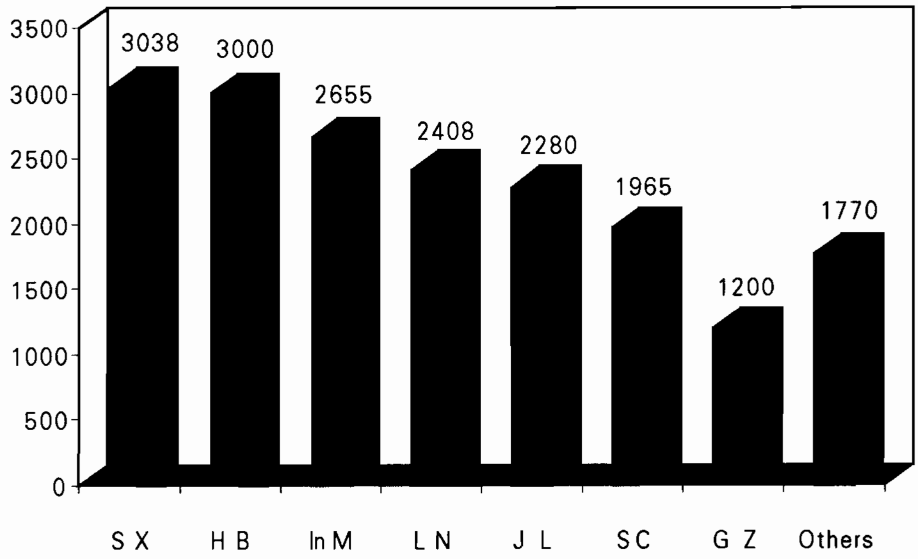

Figure 5. Seed production yield levels (kg/ha) in selected provinces (1994).

SX = Shanxi, HB = Hebei, InM = Inner Mongolia, LN = Liaoning, Jl = Jilin,

SC = Sichuan, and GZ = Guizhou.

Comments/questions:

Sain Dass/V.P. Ahuja, India

1. Seed yield in seed production plot (single cross) is too high i.e. up to 3 t/ha. Is it due to the high *per se* performance of the female parent, or due to wider female: male ratio?

2. What is the female : male ratio used in seed production?

3. Are the single cross hybrids produced by using normal cytoplasm or by male sterile lines? If the male sterility is the basis, then what type of cytoplasm is being used?

Answers:

1. One reason is Chinese maize breeders pay more attention to female line's performance to promote the line productivity *per se*. Another reason is improving the hybrid seed production technology, including increase the male:female ratio, from 1:2 to 1:3 or 1:4 at the moment. Still another reason is seed production usually located on fields with good irrigation systems.

2. I have answered in question 1.

3. Most hybrid seed production used normal cytoplasm. Some hybrids from Hubei and Yunnan provinces used type S cytoplasm.

SEED RESEARCH AND PRODUCTION OF MAIZE IN INDIA.

N. N. Singh and S. Mauria [1]

In the developing world, India is one of the countries which have brought consciousness about the role of seed industry in agriculture. Agriculture occupied an eminent place after India's independence in 1947, and efforts to solve many of the seed related problems were initiated during the first and second five year plan periods. The novel concept of "All India Coordinated Crop Improvement Projects (AICIPs)" began with the launching of coordinated project on maize in 1957. With its' impressive benefits in establishing location-specific technologies after rigorous testing in a number of locations spread over a diversity of agro-climatic situations available in the country, the coordinated concept was extended to a large number of crops, commodities and requirements. The coordinated concept became the key element in making available to the farmers a large number of high yielding varieties of wheat and rice, hybrids of maize, sorghum, pearl millet, cotton, sunflower, etc. and varieties/hybrids in many other crops. From mid-sixties onwards, the development of seed industry and systematic organization of the seed production and distribution system considerably improved the seed scenario in the country. These efforts have helped in increasing progressively the production of food grains, from about 50 m tons in 1950-51 to over 185 m tons in 1994-95, and appreciable increases in many other important crops and commodities.

Notwithstanding the actual production requirements of different commodities, which is no doubt a gigantic task in view of the large and increasing human population and other well-known limitations of Indian agriculture, the setting up of appropriate infrastructure for quality seed production and supply has played an important role in bringing a respectable status to Indian agriculture. The setting up of the National Seeds Corporation in 1963, and later on the State Farms Corporation of India, the network of States' Seed Corporations, Certification agencies, Seed Testing Laboratories, and Seed Law Enforcement under the public sector; and the coming up of large number of private seed companies has played a major role in development of seed industry in India.

The seed industry got activated with the launching of the World Bank aided national Seed Project Phase I in 1976-77, which subsequently followed with the Phase II, and currently in operation the Phase III assistance. This crucial assistance included all the components of seed industry viz. national agriculture research system, and public- and private seed sector. While the public and private sector seed organizations are mainly undertaking the production and marketing of foundation and certified/quality seed, the national agricultural research system under the Indian Council of Agricultural Research (ICAR) is entrusted with the responsibility of development and release of improved cultivars and production of nucleus and breeder seed of released high yielding varieties and parental lines of hybrids. Seed technology research aspects are taken care of in a separate program of ICAR. The financial support of Department of Agriculture and Cooperation (ADC), Government of India (GOI) and the ICAR to all these programs, in fact, got the necessary reinforcement with this assistance from the World Bank.

The All India Coordinated Project on Seed Technology Research of the ICAR, initiated at research centers in different state agricultural universities and research institutes under ICAR, looks at aspects like isolation requirements and other agronomic aspects of seed production, genetic purity of improved cultivars, seed physiology and health, seed processing, packaging, storage, etc. and works on the same coordinated concept as in other coordinated projects of ICAR. The Seed Technology Research Program is further strengthened under the ICAR's special project on 'Promotion of Research and Development Efforts on Hybrids in Selected Crops' in realization of the greater technical requirements of hybrid seed production. Research on seed borne diseases, being critical for the production of quality seed, has been given appropriate emphasis in the coordinated seed technology research program.

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Cultivar development efforts.

1. *Double cross hybrids leading to seed industry establishment.*

In the initial phase, the maize crop improvement program in India introduced a large number of inbred lines and hybrids from USA and other temperate regions. The inbred lines were put into top crosses and were put in multi-location trials alongside exotic and indigenous hybrids, leading to selection of 28 inbred lines for utilization in hybrid development. The introduced hybrids, particularly from southern USA (like NC 27, Texas 26 and Dixie 18), although they displayed higher yield, were not accepted by the Indian farmers due to their dent type grain. Also, these dent grain hybrids had a problem in seed production, as their parental lines were adapted to temperate climate. These difficulties led to collection, characterization, and classification of Indian landraces, and simultaneous efforts for extracting inbred lines, both from indigenous and exotic germplasm. The efforts paid dividends and led to commercial release of the first set of four yellow double cross hybrids in 1961 (Ganga 1, Ganga 101, Deccan and Ranjit). The release of these hybrids was, in fact, the turning point leading to initiation and development of the public sector seed production and supply system, which began with the establishment of National Seeds Corporation - the first wholly owned public sector undertaking of the Govt. of India to facilitate the process of foundation and certified hybrid seed production.

2. *Composite varieties for marginal farmers and for deriving inbred lines.*

Although this first set of hybrids performed very well in the farmers' fields, the success was again limited by the problem encountered in their economic seed production. The short-term approach of developing non-conventional hybrids (double top cross hybrids and hybrids involving early generation inbreds) subsequently also led to the commercial release of two double top cross white hybrids (Hi-starch and Ganga Safed 2) in 1963. At this stage, composite and synthetic populations were also synthesized with the twin objectives of raising the level of base populations for developing agronomically better inbreds, and/or for their commercial cultivation. The composite varieties could cater to the needs of large number of marginal farmers who retain their own seed for subsequent plantings, besides providing the added advantage of wider adaptability for conditions of both difficult and favorable agricultural ecosystems. By 1967, six composites viz. Kisan, Jawahar, Sona, Vijay, Amber and Vikram were released. The composite Vijay became very popular not only in India, but also in the neighboring countries of Pakistan and Nepal.

The next obvious step was enhancement of the performance of composite varieties by accumulating favorable alleles in released composites. In this direction, during 1974, the intra-population improvement program was initiated at the national level in ten elite composites representing various maturity groups. Here, the full-sib family selection scheme was practiced to synthesize improved populations, which led to the release of composites like Diara 3 and MCU 508. It was also observed that full-sibs advanced to F2, in general, gave better results than F1 progenies in subsequent cycles of improvement. However, efforts for extracting inbred lines from the composites, used as base populations, did not give desired results and no suitable hybrids could be developed. Likewise, efforts in extracting superior inbred lines from tropical germplasm were not encouraging.

With this experience, the approach to develop complementary heterotic pools to derive inbred lines was adopted, as it was expected to yield more productive hybrids in a relatively short period of time. In this endeavor, new genetic variability was introduced in the breeding materials. Also, care was taken to introgress materials having multiple disease resistance, for increased frequency of favorable alleles for the important stem borer resistance, and improved tolerance to moisture stress.

3. *Cultivar development for winter maize.*

The widely adaptable composite varieties were found suitable in *rabi* (winter) season as well. It was seen that maize can be successfully grown during *rabi* season in almost all parts of the country, except the hilly regions where temperatures during winter are fairly low. High yields of 10-12 t/ha have been realized in rabi maize cultivation, and yield levels of 6-8 t/ha in the farmers' fields are not uncommon. Thus, winter maize cultivation has become quite popular in certain parts of the country, and in others, there is a strong momentum to go for winter maize. Accordingly, winter maize program was intensified in 1975, and development of heterotic pools exclusively for winter season was initiated in 1980.

Presently, a number of maize hybrids are available for cultivation in the winter season all over the country.

4. *Tackling the problem of inbreeding depression.*

The next problem was poor response of existing heterotic pools to inbreeding depression, which is a critical requirement for development of single cross hybrids whose importance was rediscovered for India during 1980's. In this endeavor, the introduction of a selfing phase in the intra-population improvement program has helped in elimination of deleterious recessives and improving tolerance to inbreeding depression. Also, inter-population improvement in pools possessing different heterotic patterns was initiated for enhancing the cross *per se* performance. Based on this approach, three-way hybrids of great promise have been evolved. Also, many full season and early maturing double cross, three-way, and single cross hybrids in the pipeline have demonstrated high productivity in advanced testing stages. Some of these should become useful for commercial cultivation during summer and winter seasons.

5. *Current emphasis on hybrid research and development.*

Currently, hybrid research and development has received much greater emphasis in maize as also in other successful and potential hybrid crops. In maize, the thrust is on important aspects viz. early maturing *kharif* (rainy season) hybrids with emphasis for their suitability to tribal areas; cold-tolerant full-season hybrids for *rabi* season for north-west plains; hybrids for *rabi* cultivation for north-east plains; and full-season hybrids for both *kharif* and *rabi* for peninsular India. In the overall exercise, the development of about 25 promising advance stage inbreds with yield potential between 1.5-4.0 t/ha (about 15 inbreds with over 3.0 q/ha yield potential) is a significant development. Studies on their general and specific combining ability are in progress. In all, more than 20 hybrids and over 70 composites have been released for commercial cultivation at the central and state levels in India.

Production trends.

Traditionally, maize was grown in India as a staple food destined primarily for home consumption. However, in recent years, considerable changes have occurred in the maize economy as a result of increasing commercial orientation of agriculture and rising demands for diversified end uses of maize, especially feed and industrial uses. At the same time, substantial investment in maize research has generated a wealth of improved production technologies, which have provided farmers with the means to respond to changing demand forces.

1. ***Area.***

The country's maize area increased steadily from 3 m ha in 1951 to nearly 6 m ha in 1970, increasing at an average annual rate of 2.9%. However, after 1970's, no further maize area growth occurred during the following two decades. Nevertheless, there have been changes in the quality of land used for growing maize. During the late 1960's and early 1970s, maize cultivation shifted to more marginal lands of relatively low productivity as farmers reserved high quality land for more profitable crops. Subsequently, however, some of these marginal lands were gradually put under irrigation, and the proportion of irrigated maize area rose from 16% in 1970 to 21% in 1990. An important development during the period has been the rise in importance of winter maize. Winter maize cultivation has assumed considerable importance in northern states, especially in Bihar and parts of eastern Uttar Pradesh.

2. ***Productivity.***

From 1950's uptil late 1960's, maize productivity registered a relatively long period of stable growth. However, beginning in late 1960's, maize yields suddenly began to exhibit wide year-to-year fluctuations. This is the period of displacement of maize from irrigated lands to more marginal lands with appearance of miracle wheat and rice varieties of the Green Revolution. Despite the increased variability of land available to maize and vagaries of rainfall, the yield trend continued strongly upward, with yield growth averaging 1.9% during 1971-92. The factors contributing to the positive yield trend were increased use of inputs (particularly fertilizer) and greater use of improved maize cultivars. However, national average yields (about 1.7 t/ha) in India remain quite low by world standards. In 1992, maize yields for India as a whole were only two-thirds of the average maize yield for all developing countries, and less than half of the average yield achieved in Asia.

3. ***Production.***

Maize production in India since 1951 reflects the combined effects of the area and yield growth patterns. During the 1950's and 1960's, maize production grew at an impressive annual rate of 5.5%. Beginning in 1970, the production growth slowed considerably as the area planted to maize ceased to expand. Nonetheless, continuing yield growth continued to fuel production growth averaging just under 2% per year during the past two decades. By 1992, national maize production surpassed 10 m tons, but wide year-to-year fluctuations remain a characteristic feature. These fluctuations have led to considerable variability in maize prices, which discourages risk-averse farmers from using optimal level of inputs.

Seed situation.

At an average seed rate of 20 kg/ha, the seed requirement for 6 m ha area under maize is about 120,000 t. Against this, the certified/quality seed distributed in 1992-93, as per statistics available from DAC (Dept. of Agric. and Cooperation), Govt. of India, is only 15,000 t, which means a meeting of only 12.5% of the total requirement. Of this total seed figure, the hybrid share is reportedly about 60% against about 40% for the composite varieties. On the other hand, the share of maize area in difficult ecologies of Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh is about 60% as against 40% area under climates favorable for maize in other states. With the larger tendency to grow widely adaptable composite varieties in difficult ecologies, 40% seed availability in 60% area is obviously owning to lesser potential for seed sales in this pocket. The farmers' tendency to save seed from previous year's crop produce is understandable wherever composite varieties are used. Owing to poor economics of composite maize production, shortage of fresh seed availability and lack of adequate popularization efforts for newly released cultivars, the farmers' tendency to use seed from previous year's crop continues for up to 4-5 years. On the other hand, it is also true that there is drastic reduction in seed vigor and viability, and consequently productivity, after 2-3 years of such practice.

Lack of availability of suitable early maturing productive hybrids as well as hybrids/composites for other specific requirements in this region is another critical factor preventing any substantial gain in productivity. Nevertheless, there is some diversity in cultivars available for this region and concerted development efforts with equal emphasis on adoption of recommended agronomic package of practices is critical for harnessing higher production from this important maize belt.

The seed statistics available and indicated above do not largely include contributions of the private seed sector, whose presence in Indian seed sector is increasing with time. Guesstimates indicate coverage of about 35% area with high yielding cultivars, and out of this, about 11-12% area is covered with improved hybrids. Thus, the overall supply of quality seed in the country is more than the 12.5% indicated earlier. Nevertheless, there remains considerable gap in seed demand and supply. From its' side, the Govt. of India had fixed vertical seed replacement targets for all major crops including maize, which is being monitored by the Seed Division, DAC, Govt. of India. However, some more thoughts for making the targets realistic have come to the fore. Seed replacement target fixation should be including factors like seed deterioration in 2-3 years time, capacity of seed multiplication system at different stages of seed production, merit/potential of available cultivars and seed production potential in each case, and lastly the commitment for ensuring target achievement.

In the 40% of the area with favorable agro-ecologies, the increasing seed supply from the private sector is considerably improving the efforts initiated by the Govt. of India. However, there is still great scope for adoption of high yielding hybrids by the farmers in these states. The fixation of vertical seed replacement targets for this region has to essentially keep in view the role played by the private sector from which there are obvious difficulties in getting reliable seed statistics.

It is also true that maize breeder seed production almost tripled during the last five years - from 7.9 quintals in 1986-87 to 21.2 quintals in 1991-92. In 1989-90, the production was as much as 59.8 quintals. As against this, the certified/quality seed production in total cereals is nearly stagnant at about 4.5 m quintals during the last five years. The same trend for stagnation of maize production also, only emphasizes the requirement of increasing efficiency in seed multiplication. Basic issues related to seed production and popularization have been dwelt with at length in different fora, and need to be attended to for making any major impact on the maize seed scenario in the country.

Seed technology research.

Under the All India Coordinated Program on Seed Technology Research of ICAR, researches on different aspects of maximizing seed production, control of seed borne diseases, seed storage, etc. are undertaken. Seed technology research in maize could receive limited attention in this broad-based coordinated project. Some progress made in this direction is indicated below. However, it is also true that recommendations in seed technology research would vary for different cultivars, seasons, situations, and systems.

1. *Location and season for seed production.*

Like most other crops, maize seed production can be undertaken in assured areas of irrigation and in areas where untimely rains during seed ripening do not affect seed quality. The latter is the reason for poor quality seed produced in main *kharif* season in states like Maharashtra where seed production, as a result, is continuously decreasing. In contrast, quality seed production in *rabi* season in states like Andhra Pradesh and Karnataka is increasing because rains cease when the crop is in the flag-leaf stage and the atmospheric humidity is also low during seed maturation stage. Besides, seed production in *rabi* season helps in quick realization of money invested in seed production by sale of seed is the main *kharif* season.

The concentration of seed production in one or two states is an important concern for India. In the long term, it may create problems of disease and insect pest development. Accordingly, the identification of alternative areas of seed production is important for both augmentation of quantum of seed produced, as well as to take care of the ecological problem of crop vulnerability to disease and insect pests. In this direction, concerted efforts in seed production research in other potential areas, such as *rabi* season in north Bihar and eastern Uttar Pradesh, in areas with assured irrigation in dry region of Rajasthan, Gujarat, Haryana, western Punjab, Madhya Pradesh, Orissa and West Bengal, or in *kharif* season in hilly tracts, are necessary.

2. *Maximization of seed yield.*

Agronomic aspects of maximizing seed yield include isolation requirements, male-female row planting ratios, synchronization of flowering of male and female parents for hybrid seed production, optimum plant population density, appropriate doses of fertilizer requirement, effect and use of micronutrients, disease and insect pest management schedules, physiological indicators for seed harvesting, minimum damage threshing, etc. Available information on these aspects is provided below.

An isolation of 300-500 m or a time isolation of 6-8 days restricted contamination to 1% or less in hybrid maize seed production (Sharma and Dadlani, 1995). However, staggered sowing is not feasible in large seed production plots. In *kharif* season, when the rains are frequent, the planting ratio of 2:6 (M:F) is found to give maximum seed yield for hybrid maize at a few diverse locations (Anonymous, 1991). Response to flowering manipulation for hybrid seed production using treatments like pre-sowing seed soaking, leaf cutting, and seed soaking and drying for 24-36 hrs, etc. has been observed (Bansal *et al.*, 1993) and needs to be pursued. Pre-sowing hydration treatment using ascorbic acids MgSo4 and KCl (Kulkarni and Eshanna, 1988) have also improved seed yield and quality.

Optimum plant density for maximum seed yield could vary on soils of different agricultural suitability for cultivars of different maturity, and should be studied. Standardization of fertilizer requirement for yield maximization should include role of micronutrients like zinc, manganese and molybednum, which are known to increase seed yield and its components (Kvyatkovskii, 1988; Pailik, 1987; Welch, 1986). It is also known that zinc spray increases yield of maize inbred CM 202 (widely used in India in different hybrids) by 4-5 quintals. All these aspects need to be specifically looked into for maximizing seed yield, particularly for the development of three-way and single cross hybrids, which can rapidly increase maize production. Use of growth regulators and their interaction with environmental factors also need to be studied (Kotting *et al.*, 1988).

As regards the control of diseases in seed production plots, precise information has to be generated. More research is needed, although control schedules have already been developed for effective control of diseases of economic importance in different agro-climatic situations. For example, hybrid seed production would become difficult in south India, especially Karnataka and Tamil Nadu during *kharif* season, because of the problem of downy mildew. Seed treatment with metalaxyl is necessary in such areas. Similarly, use of chemicals like mancozeb or zineb is found effective and may be economical to control turcicum leaf blight, rust and some other foliar diseases prevalent in south India. Economics of such diseases has to be worked out to popularize use of these chemicals in increasing the seed yield. Likewise, the effects of chemicals on seed viability and in controlling seed borne diseases (important seed borne fungi have been recorded by Handoo and Aulakh, 1979) are also to be studied to recommend fungicide schedules for seed treatment. Also, more studies on effect of ageing on seed vigor and viability are necessary for purposes of revalidation of seed lots (Hussaini *et al.*, 1988). Studies on effect of late sowing in winter on seed germination, crop vigor and seed yield are also required for enhancing seed productivity in the important winter season.

In seed harvesting, moisture content is a real test for judging the right stage of maize maturity. Accordingly, there is a need to find the ideal moisture content for shelling (Mashauri *et al.*, 1992). In hills, maize can be harvested earlier than visual maturity without reduction in yield (Chakor and Awasthi 1985). Accordingly, there is need for establishing physiological indicators for seed harvesting. Mechanization in harvesting and processing, increasingly being resorted to in the developed countries, is thus certainly an area to study especially its economic impact through damage to pericarp and whole seed in view of increasing labor costs. Popovic and Milicevic (1987) have discussed the factors influencing seed damage and ways to minimize the damage. Thus, research in this direction can be rewarding in the long term. Similarly, a comparison of hand/machine detasseling versus use of chemical hybridizing agents for controlled pollination in hybrid seed production plots is required for utilization in the long run and as discussed by Mabbette (1993) and Flores *et al.* (1993).

In the area of seed processing, seed drying, standardization of threshing drum speed, seed fortification, etc. are important areas for research. Indole acetic acid and ascorbic acid hold promise in seed fortification (Eshanna and Kulkarni, 1990) for maximizing seed yield. Seed grading is another area for ensuring seed quality, and preliminary studies conducted in this direction (Hussaini *et al.*, 1984; Shashidhara *et al.*, 1988) need to be pursued.

Thus, for maximization of seed yield, all these responsible factors need to be taken into account for developing location/situation-specific technologies for different hybrids. The ideal would be to systematically pursue such studies by more number of concerned agencies and develop predictive models on seed production for different agro-climatic requirements.

3. *Seed storage.*

Drying seed to about 7% moisture content and packaging in 700 gauge polythene bags is found to maintain germination above 80% for up to 3 years at room temperature (Anonymous, 1995). Similarly, the use of commercial cold stores for maintenance of germinability of maize seeds has been discussed by Singh and Singh (1992), and has suggested the possibility of storing carried over high value seeds for up to 52 months in commercial cold stores, in the absence of seed stores with low levels of temperature and relative humidity. Seeds produced in coastal areas have invariably shown poor storability. Thus, methods to prolong storability of seed produced in such areas also need to worked out.

4. *Variety identification and genetic purity test.*

Isozyme analysis is a valuable tool in assessing genetic purity of maize inbreds. Isozyme results were found 1.6 times more accurate than field morphological observations for outcross detection, and four times greater in accuracy for prediction of off types (Orman *et al.*, 1991). Thus, maize seed quality assurance programs should use information from both isozyme analysis and field observations when deciding whether inbred lots are suitable for use in hybrid seed production. A small beginning has been made in characterization of inbred lines and hybrids on the basis of polymorphism in soluble proteins and isozyme patterns (Tiwari *et al.*, 1995). Thus, diagnostic morphological characters of promising maize inbred lines (Hussaini *et al.*, 1990) in conjunction with electrophoresis to ascertain genetic purity can go a long way in facilitating the process of seed certification and quality control. In fact, characterization of released materials should be done in the manner of meeting international requirements of intellectual property protection of cultivars.

In brief, seed technology research requirements in maize list a long agenda of items in view of the diversity of cultivars and agro-climatic situations/systems, and the task has to be accomplished through priority setting. The requirement is so large that a systematic program with equal involvement of benefitted seed multiplication agencies is critical for appreciable gains from maize seed technology research.

Future outlook.

During the past, Indian maize development program largely relied on composite varieties. In the present times, there is a trend towards use of hybrid maize in India, particularly in the southern and eastern parts of the country (in Andhra Pradesh, Karnataka, and in winter season in Bihar). Overall, it is estimated that composites and hybrids are used on a 50:50 basis. Important constraints in increased hybrid use in India are small farm holdings and low income of farms, marginal farming conditions with inadequacy of irrigation, and lack of hybrids suitable for some maize growing conditions. Hybrid availability particularly in early maturity group and also to some extent in medium maturity group is a critical area where private sector efforts are largely absent and the public sector is able to do little in view of the obvious difficulties. In such a scenario, policy initiatives to provide a challenging business environment for investment by private seed companies is the first pre-requisite to make any real headway in the near future. The initiatives should simultaneously provide needed improvements and incentives for the public sector so that at least the available technologies are put to effective use.

Maize development program is particularly weak for drought/excess water affected areas in states of Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh, which occupy nearly 60% of the total maize area in the country. Involvement of non-government organizations as well as encouraging private sector to assist the public seed sector is necessary for appreciable gains from technology transfer in this region. For favorable agro-ecologies in south and eastern India, it is worth mentioning that hybrids with realizable yield potential of around 5 t/ha are already available. Thus, basic issues related to seed production and popularization are crucial for these areas as well.

In so far as the cultivar requirement in maize is concerned, the development of three-way and single cross hybrids are critical areas for obtaining consistent gains in maize production. For winter maize, the efforts for judicious and systematic introgression of temperate germplasm in tropical maize has to be strengthened to significantly increase winter maize area. Regarding breeding for early maturity, there is also a need to understand the physiological and genetic basis of earliness, and to investigate the ways and means to break the purported linkage between earliness and low grain yield, or at least reduce the adverse effects of earliness on grain yield.

The long agenda of seed technology research as well as other aspects viz. economic threshold injury by pests and diseases, durable resistance, and integrated nutrient and pest management also needs priority setting and task accomplishment with equal involvement of seed multiplication agencies.

In a nutshell, the stated research and production requirements are undoubtedly a tall order, and witnessing faster gains essentially requires cooperation and collaboration of all agencies including the private seed sector. Maize development for specialized uses is an area to encourage increasing involvement of maize seed industry and for improving the economics of even the small farmer. This sector should help in generating resources for other important maize research and development areas. Lastly, it may be mentioned that genetic potential in maize is yet to be exploited to any considerable degree in India, which is in a way a fortunate situation for anticipating a better future for maize in India.

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Comments/questions:

K.A. Nayeem

Nicking is an important aspect for ease in seed production of promising maize hybrids. Every year 2-3 maize hybrids are identified, but due to seed production problems at particular location, where sponsor breeder is stationed, the spread of this hybrid is held up. My suggestion would be to formulate a parental trial at AVT stage, so that locations could be identified, where parents nick well. The observations like pollen-shed period, silking, and grain yield should be recorded for such trials. This data should be incorporated in the release proposal. Secondly, I want to suggest, one location in each zone should be entrusted with an experiment on parental behavior, taking data every 10 days interval.

MAIZE SEED SITUATION IN INDONESIA.

Sania Saenong, Sarasutha and Marsum M. Dahlan [1]

Abstract

Maize in Indonesia is the second crop after rice. The total production of maize in Indonesia reached 6,560,118 t in 1994, while in 1984 the production was 5,287,825 t, a growth rate of 3.96% per year. The increasing demand for maize either for foods or feeds (agro-industry) necessitated that Indonesia import maize. The import of maize has sharply increased from 59,251 t in 1984 to 1,109,300 t in 1994, meanwhile, the export of maize was reduced from 159,853 t in 1984 to 34,100 t in 1994. Net imports in 1994 were 1,075,200 t, with a value of US$146,918,000. This situation has lead Indonesia to strive to increase maize production to meet the demand.

The harvested area of maize in 1994 was 3,046,992 ha, with an average yield of 2.15 t/ha. The main reason for the low yields is that 70.1% of the area in 1981 was planted to a local variety with low yielding potential. It was reduced to 56% in 1992, since improved varieties, including hybrid maize, were being promoted through an intensification program for maize production. Although most farmers do believe that high quality seed of high yielding varieties is a key factor to increase yield, still in some regions high quality seed in adequate quantity could not be provided at the right time and the right place with an acceptable price. The price ratio between seeds and grains is quite high, i.e. Rp. 3,500 to 5,000 for hybrid seeds per kg, while the price of grain is Rp. 423 to 476 per kg (1 US$ = Rp. 2,265). The government used to subsidize hybrid seed at the rate of Rp. 500/kg, but it was given only from wet season 1984/85 to wet season 1985/86. Therefore, some farmers still prefer to use their own seeds. However, in the regions where seeds of improved varieties were being produced, such as in East Java, the utilization of improved variety seeds was also increased over the year, especially hybrid seeds. The amount of commercial seeds produced by the private sector and the State Seed corporation (Sang Hyang Seri) is still low (4.03% of the total seed required). These data indicated that there is a great opportunity to produce seeds of improved varieties, and to increase the used of high quality seed of high yielding varieties, especially outside Java. Most seed companies at present are located in East Java.

Maize in Indonesia is the second most important food crop after rice. The total production of maize in Indonesia reached 6,560,118 t in 1994, from a 1984 production of only 5,287,825 t (**Table 1**), with an average growth rate at 3.96% per year. In the same period (1984-94), the average yield also increased from 1.71 t/ha in 1984 to 2.15 t/ha in 1994. Although the yield has increased at the rate of 2.35% per year during this period, total maize production displayed fluctuations over the years, mainly due to weather conditions, especially drought.

Another problem related to weather conditions is that the harvest time of rainfed maize coincides with rainy season which affects grain quality. It was reported that the moisture content of the grain at harvest period varied from 20-28% in areas planted to rainfed (upland) which is harvested with the onset of the rainy season (BIMAS, 1995, a, b). Dahlan (1993) reported that about 79% of the maize area is classified as maize planted in rainfed uplands. It is very difficult to sun dry high moisture maize under such conditions, and spoiling affects both the quantity and quality of the harvested grain. About 11% of maize is grown on irrigated lowland after rice, and the balance 10% of the maize is cultivated in rainfed lowland after rice.

This condition leads to large fluctuations in maize supply, and hence in grain prices, which have been harmful to the growing poultry industry, and have caused Indonesia to alternate between being a net

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exporter and importer of maize, in order to provide a steady supply of maize (Kasryno and Siregar, 1988). In view of the fact that demand for maize, either for food or feed, increased rapidly, the import of maize sharply increased from 59,251 t in 1984 to 1,109,300 t in 1994, with net imports of 1,075,200 t (**Table 2**).

Table 1. Area, production, and average yield of maize in Indonesia, 1969-94.

Year	Area harvested (,000 ha)	Production (,000 t)	Average yield (t/ha)
1969	2,435.0	2,293.0	0.94
1970	2,939.0	2,825.0	0.96
1971	2,627.0	2,606.0	0.99
1972	2,160.0	2,254.0	1.04
1973	3,433.0	3,690.0	1.07
1974	2,667.0	3,011.0	1.13
1975	2,449.9	2,902.9	1.19
1976	2,095.1	2,572.1	1.23
1977	2,566.5	3.142.7	1.22
1978	3,024.6	4,029.2	1.33
1979	2,593.6	3,605.5	1.39
1980	2,734.9	3,990.9	1.46
1981	2,955.0	4,509.3	1.43
1982	2,061.3	3,234.8	1.57
1983	3,002.2	5,086.9	1.70
1984	3,086.2	5,287.8	1.71
1985	2,440.0	4,329.5	1.77
1986	3,142.8	5,920.4	1.88
1987	2,626.0	5,155.7	1.96
1988	3,405.8	6,651.9	1.96
1989	2,944.2	6,192.5	2.10
1990	2,550.6	5,484.9	2.15
1991	2,909.1	6,225.9	2.15
1992	3,248.3	7,038.2	2.17
1993	2,939.5	6,459.7	2.20
1994	3,047.0	6,560.1	2.15

Source: CBS (1974, 1987, 1989, 1991), Kasrayno and Siregar (1988), Anonymous (1995).

The demand situation has led Indonesia to increase domestic production of maize through programs initiated since Pelita VI (Five Years Development Plan VI), which started in 1994. At the end of Pelita VI in 1998, the demand for maize, estimated at 9,362,000 t, is expected to be fulfilled, if the targets set for maize production (**Table 3**) are achieved. By 1998, the maize area would expand to 3.9 m ha, and productivity would increase to 2.4 t/ha. High quality maize seed, among other inputs, is essential. Efforts to increase maize production through the development of improved cultivars have been given a high priority. Since 1945, 29 open-pollinated varieties (OPV's) and 11 hybrids have been released through the National Seed Board (**Table 4**).

Table 2. Export and import (t) of maize in Indonesia 1984-94.

Year	Export	Import	Net imports
1984	159,853	59,251	- 100,602
1985	3,489	49,863	46,374
1986	4,433	57,369	52,936
1987	4,680	220,998	216,318
1988	37,404	63,454	26,050
1989	232,093	33,340	- 198,753
1990	136,641	515	- 136,126
1991	30,742	323,176	292,434
1992	136,664	55,498	- 81,166
1993	52,088	494,446	442,358
1994	34,100	1,109,300	1,075,200

Figures in negative indicate net exports.
Source: Anonymous (1995): BINUS (1995a).

Table 3. Projection of area harvested, productivity, production and demand of maize in Pelita VI (1994-1998) in Indonesia.

Year	Area harvested (ha)	Productivity (t/ha)	Production (t)	Demand (t)
1994	3,630,000	2.28	8,288,000	8,179,000
1995	3,704,000	2.32	8,601,000	8,457,000
1996	3,779,000	2.36	8,925,000	8,745,000
1997	3,856,000	2.40	9,261,000	9,053,000
1998	3,935,000	2.40	9,611,000	9,362,000

Source: BIMAS (1995a).

Seed scenario

Seed distribution is carried out through the Government Agency (Extension Service) called '*Balai Benih Induk*' (Seed Center), the private sector and the State Seed Corporation (Sang Hyang Seri). In so far as the seed of hybrid cultivars is concerned, two private companies, Pioneer and Bright Indonesia Seed Industry (BISI), produce their own hybrids, while the State Seed Corporation (Sang Hyang Seri) produces Cargill hybrids. East Java is the major area for seed production. Total hybrid maize seed production in East Java in 1994-95 was 4,296 t (BPSB 1995). CIMMYT reported the share of local varieties in Indonesia to be 56% in 1992 (CIMMYT, 1994). It should be noted that some "local varieties" have a higher yield potential than the true local because of introgression of improved varieties.

In 1985-87 open-pollinated varieties predominated, especially the Arjuna variety, which occupied 18% of the planted area in 1985-86, and increased to 20.36% in 1986-87. One the other hand, hybrid maize, first released in 1983 (C1 hybrid), occupied only 1.9% (30,240 ha in 1985-86) and increased to

2.97% (43,884 ha) in 1986-87. In East Java province, the center of maize seed production, the share of local varieties was much lower (50.17%) compared to the average share at Indonesia level (70.11%).

Table 4a. Improved open pollinated and synthetic varieties of maize released in Indonesia from 1945 to the present.

No.	Variety	Year released	Maturity (days)	Average yield (t/ha)	Downy mildew reaction	Institution/ seed company
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Open Pollinated						
1.	Menado Kuning	Before 1945	110	1.1 *	S	CRIFC
2.	Jawa Timur Kuning	Before 1945	85	1.0 *	MR	CRIFC
3.	Maya	Before 1945	95	1.1 *	S	CRIFC
4.	Genjah Warangan	Before 1945	80	0.8 *	S	CRIFC
5.	Baster Kuning **	1951-60	130	3.3	S	CRIFC
6.	Kania Putih**	1951-60	150	3.3	-	CRIFC
7.	Penduduk Ngale	1951-60	85	0.8 *	S	CRIFC
8.	Malin	1951-60	100	3.0	S	CRIFC
9.	Perta	1956	110	1.7 *	S	CRIFC
10.	Metro	1956	110	3.3	S	CRIFC
11.	Harapan	1964	105	3.3	S	CRIFC
12.	Bima **	1966	140	3.7	-	CRIFC
13.	Pandu **	1966	130	3.7	-	CRIFC
14.	Permadi (Bogor Syntetic)	1966	96	3.3	S	CRIFC
15.	Bogor composit 2	1969	105	3.6	S	CRIFC
16.	Harapan Baru	1978	105	3.6	R	CRIFC
17.	Arjuna	1980	90	4.3	R	CRIFC
18.	Bromo	1980	90	3.8	R	CRIFC
19.	Parikesit	1981	105	3.8	R	CRIFC
20.	Sadewa	1983	86	3.7	MR	CRIFC
21.	Nakula	1983	85	3.6	R	CRIFC
22.	Abimanyu	1983	80	3.3	R	CRIFC
23.	Kalingga	1985	96	5.4	R	CRIFC
24.	Wiyasa	1985	96	5.3	R	CRIFC
25.	Rama	1989	95	5.5	R	MARIF
26.	Bayu	1991	87	4.0	R	CRIFC
27.	Antasena	1992	95	5.0	MR	CRIFC
28.	Wisanggeni	1995	90	5.3	R	MARIF
29.	Bisma	1995	96	5.7	-	CRIFC

S = Susceptible, R = Resistant and MR = Moderately resistant
CRIFC = Central Research Institute for Food Crops
MARIF = Malang Research Institute for Food Crops
BISI = Bright Indonesia Seed Industry
BAU = Bogor Agriculture University
TC = Top Cross
SC = Single Cross
TWC = Three Way Cross
DC = Double cross
• = No fertilizer ** = Suitable for highland
- = No data

Table 4 b. Varieties of hybrid maize released in Indonesia from 1983 to the present.

Hybrids					
1. C-1	1983	100	5.8	R	Cargill (TC)
2. Pioneer-1	1985	100	5.6	R	Pioneer (TWC)
3. CPI-1	1985	100	6.2	R	BISI (TC)
4. IPB-4	1985	97	5.4	R	BAU (SC)
5. Pioneer-2	1986	100	5.9	R	Pioneer (TWC)
6. C-2	1989	100	6.4	R	Cargill (TWC)
7. C-3	1992	98	6.4	R	Cargill (TWC)
8. P-3	1992	98	6.4	R	Pioneer (DC)
9. CPI-2	1992	97	6.2	R	BISI (TWC)
10. Semar-1	1992	96	6.4	R	MARIF (TWC)
11. Semar-2	1992	90	6.0	R	MARIF (TWC)

S = Susceptible, R = Resistant and MR = Moderately resistant
CRIFC = Central Research Institute for Food Crops
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DC = Double cross
• = No fertilizer ** = Suitable for highland
\- = No data

Since the first release of a hybrid maize cultivar in 1983 (C1 hybrid), a top cross hybrid maize from Cargill, the Government has been actively making efforts to increase the usage of hybrid maize cultivars through its intensification program. In 1995-96, area projected for hybrid maize is 1,008,000 ha, on both lowland and upland areas and covering eleven provinces. Major expansion is planned for East Java (500,000 ha), followed by Central Java, West Java and Lampung. To implement this program, the estimated seed requirement is 20,160 t (**Table 5**). This program provides a good opportunity for the private sector to produce hybrid maize seed since the capacity of Sang Hyang Seri, the State Seed Corporation, is only 200 t/year (Subandi *et al.*, 1987). The maximum capacity of BISI company in producing maize seed is 10,000 t/year (BISI, 1995). However, BISI's maize seed production in 1995 was only 5,155 t (2,124 t of OPV 'Arjuna' and 3,031 t of CIP 1 and CIP 2 hybrids).

Maize seed production in Indonesia was 2,652.35 t in 1989. It was only 2.83% of the total seed required. There were wide fluctuations in seed production during 1989-93, but it did increase up to 4,003.65 t in 1993 (4.03% of the total seed required). Overall, the growth rate of seed production was 14.54% in this period. For certified seed, the share of hybrid seed produced every year (1989-93) was more than 50%, and reached 69.6% in 1992. The progress of certified hybrid seed production from 1989-93 was much higher (19.55% per year) compared to that of certified OPV seeds (2.78% per year). The highest annual growth rate, 120.76%, was for production of labeled seeds (**Table 6**).

In East Java province, where most of the seed companies particularly produced hybrid seed, the share of hybrid seed produced was higher than OPV's (**Table** 7). During 1995-96, the Government is implementing a program of maize intensification to speed up the rate of increase of maize production. Hybrid maize is projected to be planted in 1,008,000 ha. Hybrid maize seed required is approximately 20,160 t (BIMAS, 1995).

Shipping seeds outside Java involves high risk of loss of viability, particularly when maize seed is harvested during rainy season with poor facilities for seed drying. Seed producers such as BISI and Pioneer companies in East Java can overcome this problem, because they have good seed processing facilities.

Maize in Indonesia is being planted every month (**Table 8**), with a distinct peak in Oct.-Dec. for the upland plantings.

Seed industry prospects.

The success of Governments' breeding program has resulted in generating a number of high yielding varieties of food crops, including maize. Through the intensification program guided by the extension service, most of these high yielding varieties have been speedily increased, particularly for the rice crop. The spreading of improved varieties of maize is quite slow compared to rice, although most of the farmers recognize the importance of high quality maize seed.

Table 5. Hybrid maize projected for 1995-96 through intensification program in Indonesia.

Province	Area (ha) projection			Projection of seed
	Lowland [1]	Upland [2]	Total	required (t)
North Sumatra	3,000	10,000	13,000	260
South Sumatra	3,000	7,000	10,000	200
Lampung	15,000	85,000	100,000	2,000
West Java	45,000	55,000	100,000	2,000
Central Java	160,000	90,000	250,000	5,000
D.I. Jogyakarta	1,000	1,000	5,000	100
East Java	115,000	385,000	500,000	10,000
Bali	1,000	2,000	3,000	60
East Nusa Tenggara	500	1,500	2,000	40
North Sulawesi	500	4,500	5,000	100
South Sulawesi	3,000	17,000	20,000	400
Total areas	347,000 (34.4%)	651,000 (65.6%)	1,008,000 (100%)	20,160
Quantity of seed required (t)	6,940	13,020	20,160	

Source: BIMAS (1995a)
Note: [1] Dry season planting, [2] Wet season planting.

In 1992, the share of improved maize varieties planted by farmers reached 44% (CIMMYT, 1994). A major share of seed of these improved varieties planted by farmers is purchased from the market as grain. Some of these seeds were retained from crops grown the previous year. Also common is exchange of seeds with other farmers. **Table 6** indicates that the percentage of seed produced by the private sector and government institutions in 1993 was only 4.03% (4,003.653 t out of 99,372.240 t) of the seed required. The total maize seed requirement is estimated to be growing at a rate of 1.53% per year. These data indicate a large potential for the seed business. The potential role of seed companies for the rapid spread of high yielding varieties has been recognized. It is clearly understood that there is a great need to hasten the development of the seed industry. At present, the Government of Indonesia has given significant attention to the development and use of hybrid maize, considering the present average yield of maize at only 2.15 t/ha, compared to expected hybrid maize yields of more than 6 t/ha in many provinces.

Access to seed marketing.

The uncertainty of maize seed demand has been blamed as one of the reasons for poor marketing of maize seed. To overcome this uncertainty and to increase the access of seeds marketing, the Government of Indonesia is presently facilitating partnership in business among seed producers, seed growers, and maize users (poultry feed industries) and farmers' groups. Seven members of the Association of Poultry

Table 6. Maize seed required and produced during 1989-93 in Indonesia.

Year	Total seed required (t)	Seed produced (t)				Percent requirement met
		Certified seed		Labeled seed [1]	Total	
		Hybrids	OPV's			
1989	93,568.92	1,357.121 (51.17)*	1,213.572	81.56	2,652.353	2.83
1990	97,767.87	1,294.670 (56.80)	942.192	42.58	2,279.442	2.33
1991	97,940.58	1,798.966 (55.91)	1,226.864	191.80	3,217.630	3.29
1992	98,063.76	1,913.941 (69.62)	635.520	199.57	2,749.031	2.80
1993	99,372.24	2,630.996 (65.72)	821.187	551.47	4,003.653	4.03
Growth rate (%/year)	1.53	19.15	-2.78	120.76	14.54	

Source: Tarigan (1995), BIMAS (1995a).

Notes: * Values in parenthesis indicate percentage of the total seed produced in the same year.

[1] Commercial seeds which have been labeled based on procedure of field standards and laboratory evaluation.

and Feed Industry are responsible for purchasing farmer's grain and providing seeds for planting: 1) PT. Metro Inti Sejahtera, will be responsibled for Lampung and Central Java provinces, 2) PT. Cargill Ind., in Lampung, Central Java, East Java and South Sulawesi, 3) CV. Subur, in Lampung and East Java, 4) PT. Satwa Boga Sampurna Feedmill, in Lampung, 5) PT. Sinta Prima, in Lampung and East Java, 6) PT. Charoen Pokphan, in Lampung, Central Java, East Java, South Sulawesi and North Sumatra, 7) PT. Dharmala, in Central Java. This system has been very well implemented in Lampung and North Sumatra provinces.

Kasryno *et al.*, (1989) reported that the most efficient maize producing regions are in Bali/Nusa Tenggara, South Sulawesi and Kalimantan. Land in these three regions is relatively more abundant than in Java and Sumatra, where many companies are dealing with maize production. Certainly, the future prospects of the seed industry in these three regions need to be considered.

Problems faced by maize seed producers/farmers.

Several problems are being faced by maize seed producers in Indonesia. The uncertainly of maize seed demand is mainly caused by fluctuations in area planted under maize. This is partly owning to the development of other crops in the same area. To overcome this problem, farmers need to know the minimum yield of maize required to make it more profitable than alternative crops (**Table 9**). High seed cost (Rp. 2,500/kg for OPV's and Rp.3,500-5000/kg for hybrids, and inability of farmers to purchase seed on a cash basis is another important constraint. The seed company PT. BISI (BISI, 1995) has produced maize seed since 1985 and lists the following constraints:

1. No guarantee to the private company to develop a line and produce parent stock for development of maize hybrids.
2. Very small size of land owned by farmers (0.3 ha/household). Small farm size is an especially big problem in East Java province.
3. Problems in seed certification/labeling.
4. Uncertain rainfall.
5. Changes in the estimated seed demand due to fluctuation in the area planted
6. Difficulties in seed distribution, especially in the remote areas.
7. There is a perception that F2 seed can be planted to give a fairly good yield.

Table 7. Certified and labeled maize seeds (tons) produced during 1992-94 in East Java province, Indonesia.

	1992/93	1993/94	1994/95
Open pollinated			
1. Arjuna (CS/LS)	849.221	802.030	1,799.361
2. Local (LS)	-	-	8.500
Hybrid			
1. CPI-1	810.130	499.390	674.000
2. CPI-2	-	719.300	1,541.450
3. C-2	718.810	444.610	-
4. C-3	-	-	469.480
5. P-2	481.485	670.385	166.450
6. P-3	-	44.709	-
7. P-4	-	4.375	935.025
8. P-5	-	179.250	469.272
9. Semar-1	-	1.160	2.980
10. Semar-2	-	16.454	27.120
11. TA-7	-	-	10.650
Sub-total:			
Open pollinated	849.221	802.030	1,807.861
	(29.70)*	(23.22)	(29.62)
Hybrid	2,010.425	2,651.633	4,296.427
	(70.30)	(76.78)	(70.38)
Total	2,859.646	3,453.663	6,104.288
	(100)	(100)	(100)

Source: Seed Certification and Quality Control Service of East Java province (1995).

Notes: CS = Certified Seed; LS = Labeled Seed.

* = Values in parenthesis indicate percentage.

Table 8. Monthly distribution of area planted to maize in Indonesia in 1992.

Month	Areas planted (ha)		Total (ha)
	Lowland	Upland	
January	7,634	158,630	166,264
February	9,097	139,879	148,976
March	10,240	221,522	231,762
April	25,490	159,193	184,683
May	78,544	95,698	174,242
June	81,600	67,483	149,083
July	96,153	55,297	151,450
August	69,358	55,912	125,270
September	100,302	172,334	272,636
October	91,763	508,682	600,445
November	28,322	583,992	612,314
December	16,589	435,078	451,667
Total	615,092	2,653.700	3,268.792
Percentage (%)	(18.82)	(81.18)	(100.00)

Source: BIMAS (1995a).

Table 9. Comparative advantage based on minimum yield of maize obtained per hectare which could compete against existing crops grown in each province.

Existing crops	Minimum yield of maize (t/ha)						
	Indonesia	West Java	Central Java	East Java	Sumatra	Bali and Nusa Tenggara	South Sulawesi
Maize Against:							
Rice	4.58	4.18	4.08	4.48	4.95	5.08	3.38
Cassava	4.22	4.67	-	2.68	3.54	4.53	5.64
Sweet potato	4.96	4.37	5.21	4.34	4.44	4.91	-
Groundnut	4.12	3.59	3.03	-	5.29	5.06	8.79
Soybean	3.56	3.67	4.03	3.72	3.79	3.43	4.18
Mungbean	-	2.89	3.13	-	3.35	2.88	-

Source of data: Directorate of Farm Prod. and Post Harvest for Food Crops and Horticulture, BINUS (1995). (Analysed using formulae of Manwan *et al.*, 1990).

Important constraints faced by the farmers are:

1. Unavailability of quality seed supply at the proper time and place.
2. Limited knowledge of farmers about the advantages of using quality seed of im- proved varieties.
3. Farmers feel that the price of maize seed is too high compared to the price of maize grain.
4. Inability of large number of farmers to purchase the optimum inputs needed for maize production, especially for hybrid maize.

5. Most of the hybrid maize cultivars are of longer duration compared to the OPV's. In some cases, it disturbs the proper planting of the sequence crop in general practice.

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Maize Crop Production in Lao Peoples Democratic Republic

Kham Sangtem [1]

Lao P.D.R is a land-locked, mountainous country in South-Asia with a surface area of 238,800 km^2 and including 917,700 ha of arable land. Its north part is mostly highlands, whereas significant plains exist in the central region and in the south, especially in Savannakhet Province. The most fertile soils are found close to the banks of the Mekong River, which runs the length of the country, along its tributary the Nam Ngum River, and on the Boloven Plateau in the south. Lao P.D.R is influenced by a monsoon system which creates two seasons per year. There is a rainy season from June-October, and a dry season from November through May. The country's population of 4.5 million is growing at an annual rate of 2.9%. Eighty-five to 90% of the population lives in widely scattered rural settlements.

The economy of Lao PDR is predominantly agricultural, oriented towards meeting the subsistence requirements of the farmers. However, under the New Economic Mechanism, agricultural production and rural development are contemplated to move progressively from subsistence to Market Economy. In order to develop the rural areas and to witness realization of the development policies, the government emphasized the importance of agriculture and forestry to the economy. It recognizes the farm household as the main unit of agricultural production, and visualizes the need for proper incentives and support to achieve the objectives of productivity, stability, sustainability and equity.

The government is presently implementing its New Economic Mechanism. Its major objective is to disengage the State from production activities, and to favor private sector production by providing the legal framework, appropriate macro-economic measures, and the needed infrastructure so as to facilitate the country's movement towards a market economy. Under the New Economic Mechanism, the Government has the following three main programs to be realized:

1. The Food Production Program up to the year 2000 A.D. In this program the Government will set up six Rice Production Projects, in the six basins along the Mekong River covering an area of 307,680 ha. The areas identified are capable of sufficient production of rice to meet the requirements of the whole country.
2. Stabilization of the upland rice and maize cultivation, with emphasis on permanent cultivation, especially for the hilly areas.
3. Limiting the use of shifting cultivation by introducing a farming system approach, including fruit trees, plantations, livestock farming etc.

Place of Maize in Agriculture of Lao PDR.

Maize is considered as one of the potential domestic cash crops. Maize as feed is being promoted for the development of agro-based industry. Maize as food is also promoted as an alternative to rice in order to attain self-sufficiency in food production.

Total area under maize production in 1994 was about 37,500 ha with an average yield of 2.06 t/ha. In contrast, the main crop, rice, is grown on an area of 638,900 ha with average yield of 2.59 t/ha in 1994.

Acrisols are the major soil type used for maize cultivation in the main production area in provinces adjoining the Mekong River in northern, central and south Laos. These are moderately acidic soils with low levels of N, K, organic matter and CEC, and low to moderate levels of available P.

The climate of the main maize producing area is classified as wet tropical. Total annual rainfall in the maize area ranges between 300-1400 mm, with about 80% falling in the three month period of July-September. Rainfall distribution is usually bimodal, with a dry period often occurring between mid-June and mid-July.

Varieties and Cropping System.

There is considerable genetic diversity in maize cultivars grown by the farmers. Local pest-resistant varieties of white flint and waxy types are principally grown for food, where as yellow flint varieties are

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grown for feed. Maize varieties with different maturation periods are grown, and many times intercropped with other field crops or perennials. Maize grown for food in the highlands supplements rice in the diet and compensates for rice shortages. Maize-based cropping systems include: 1) waxy and sometimes sweet types in mixed cropping systems with other food crops planted near village households in the lowlands, 2) waxy type short duration cultivars for fresh cob sale around Vientiane, Luang Prabang etc. on river banks as sole or mixed crops mostly during the dry season, 3) feed maize grain in alluvial soils as pure stands in the Vientiane plan and northern region mainly for the Ngon Animal Feed Mill (using maize improved cultivars like HDK 4, and from Thailand SW1 and NS1), and 4) highland maize for both food and feed under shifting cultivation in association with upland rice (some farmers in this system grow maize varieties with different maturity durations and do not follow mixed cropping). The main disease problem in the lowlands is downy mildew. Among the insect pests, the Asian maize borer is the most important.

More than 50 per cent of the maize crop is utilized as human food. The main barriers to marketing are related to transportation, storage and processing problems. Most of the sweet corn production is marketed fresh as ear corn and baby corn, and is sold at the village level. It is either boiled or roasted for home consumption. Both the grain and the stalks are used for animal feed.

Important constraints in augmenting maize production are:

1. Insufficient access to credit for intensive cropping.
2. Insufficient support services in terms of research and extension.
3. Great ethnic diversity among maize growers.
4. Inbreeding depression of local varieties with continuous usage.
5. High incidence of downy mildew disease in the lowlands, particularly in improved varieties.
6. Diversity in agro-ecological conditions in different maize cropping systems.
7. Relatively low fertility of upland soils in general.

It is recommended that the Government encourages crop improvement research with help from international agencies. Steps are being taken to develop a research team for maize breeding through training of personnel outside the country.

TAMNET Trial Results.

Three hybrids from Indonesia and 7 hybrids from Thailand had average yields of 3200 to 4600 kg/ha. One hybrid each from China and the Philippines, and 3 hybrids from Thailand had average yields of 2870 to 3063 kg/ha. In comparison, the maize variety (HDK4) from Lao an PDR had average yield of 1777 kg/ha. In general, these low yields are due to excess rain and low solar radiation in the middle of season.

Conclusions.

Being largely a subsistence agriculture, Lao PDR aims at identifying a range of suitable OPV's for farmers in different environments. For food maize, early to medium maturity with downy mildew resistance is the general requirement, besides grain quality and higher yields. The country wishes to establish a gene bank for germplasm collections in collaboration with international institutions, and would like to introduce and evaluate improved cultivars from other countries. The country would like to continue collaborating with TAMNET, since there is little experience of growing hybrid maize in Lao PDR.

MAIZE SEED PRODUCTION IN MYANMAR

Khin Mar Lay, John Ba Maw and Toe Aung [1]

Abstract

Maize, being the second most important cereal crop in Myanmar, is grown for local consumption and for export. With the gradual development of livestock industry in Myanmar, exports have been dwindling for the past few years. Before 1980, improved cultivars covered less than 10% of the total sown acreage. In 1995, they covered about 47% of the total area. Predominant cultivars are the derivatives of CIMMYTs' populations 22 and 28, and Suwan 1. Hybrids cover less than 1% of the total area, but there is scope for area expansion in future. Maize seed is jointly produced by three sister organizations under the Agric. Res. Div., Seed Div. and Extension Div. Total commercial maize seed production for 1995 is projected at 100 t for hybrids and 550 t of OPV's. This quantity will meet approx. 20% of the total maize seed requirement. There is no private seed company producing commercial maize seed for local use. A joint hybrid seed production for export program is underway between Myanmar Agric. Service and Pacific Seed (Thai). In order to have a strong and viable seed production system in Myanmar, a collaborative effort of Res., Extension and Seed Div. is needed, among other things.

In the Union of Myanmar, maize is the second most important cereal crop after rice. During 1994-95, it was planted on 171,531 ha with a total production of 285,304 t, giving a national average yield of 1.7 t/ha (**Table 1**). The bulk of the maize grain production in the country is utilized in cattle and livestock feed industries. A small portion is also used as human food (less than 20%), particularly in the rice deficit areas when, during periods of rice shortage, maize is coarsely ground and mixed with rice for cooking. Although maize has been an export commodity for many years, the exportable surplus has come down drastically during the last few years, primarily due to increased demand for domestic consumption, particularly for livestock and poultry feed.

Cultivar scenario.

Before the introduction of improved open pollinated varieties in the 1960's, Myanmar farmers had to depend on low yielding local varieties. The improved variety Guatemala was introduced in 1958, UPCA in 1973, and TKS1- a locally developed synthetic, was released in 1973. These improved cultivars covered less than 10% of the total maize area at that time. There was no viable seed production system. Agric. Res. Inst. (ARI) in cooperation with the Applied Res. Div. (ARD) took the responsibility of producing quality seed of improved varieties at their respective Central and State Farms. However, as the area under these varieties was limited, there was not much demand for their seed.

During the 1980's, several high yielding OPV's with different maturity duration and adaptation were released out of different introductions. In 1992, two single cross hybrids were successfully developed and released through the national program. Among the high yielding released OPV's, Shwe war 1 (a derivative of CIMMYT Pop. 28), Shwe war 7 (a derivative of Pop.22), and Akari (a derivative of Suwan-1), are now being extensively grown by the farmers. In 1995, they covered about 47% of the total maize area. The planted area under hybrid maize is still negligible (2,227 ha in 1995-96). However, there is scope for area expansion in future, provided there is a sound infrastructure for hybrid seed production. The role of the government in maize seed production is presented schematically in **Figs. 1 and 2**.

Present seed production situation.

Until now there is no direct involvement of domestic or foreign private sector to produce and supply high quality maize seed. However, apart from government supplied quality seed, a small amount of

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quality seed, mainly hybrids, is imported and sold at a high cost through border trade with China and Thailand. Myanmar farmers mainly obtain maize seeds from seed saved from the previous year's produce, or through exchange with neighboring farmers, local grain collectors, or the government.

Table 1. Maize area, production and yield during 1982-83 to 1994-95.

Year	Sown area (ha)	Harvested area (ha)	Yield (t/ha)	Production (t)
1982-83	170,863	135,963	1.75	239,702
1983-84	207,837	180,877	1.70	310,206
1984-85	228,687	186,251	1.63	303,945
1985-86	199,250	170,940	1.75	299,425
1986-87	178,751	159,193	1.80	286,089
1987-88	159,908	134,790	1.65	224,157
1988-89	137,912	120,915	1.61	193,396
1989-90	133,242	133,627	1.58	194,137
1990-91	140,721	125,153	1.51	198,667
1991-92	140,183	124,120	1.53	191,565
1992-93	155,876	137,235	1.53	208,756
1993-94	149,975	133,591	1.53	205,026
1994-95	171,531	166,830	1.70	285,305

Source: Myanmar Agric. Service, Planning and Statistics Div.

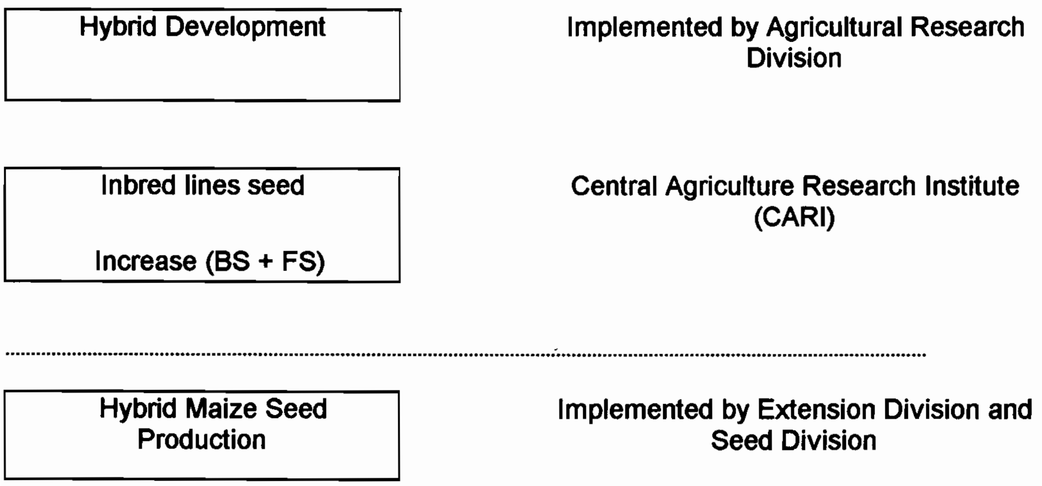

Fig. 1. Hybrid maize seed production scheme.

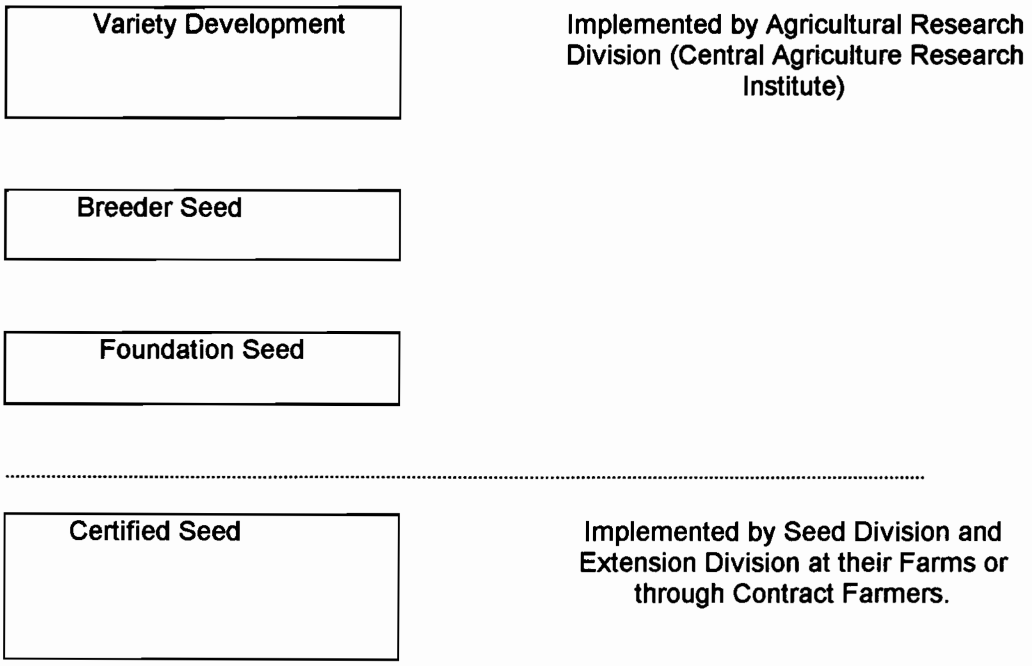

Fig. 2. OPV seed production scheme.

The government's role in supply of quality maize seed is about 10% of the total maize seed requirement. Quality seed production is jointly carried out by Agric. Res. Div., Seed Div. and Extension Div. of the Myanmar Agric. Service (MAS). The Agric. Res. Div. (Central Agric. Res. Inst.) produces the basic seed, i.e. breeder and foundation seed for OPV's and seed of inbred lines for the hybrids. The Seed Div. and the Ext. Div. produce the commercial seed for the farmers.

Co-operation with Pacific Seeds (Thai).

A joint hybrid seed production program for export was initiated in 1994-95 between Myanmar Agric. Service (MAS) and Pacific Seeds (Thai). Under the agreement, Pacific Seed supplies inbred parent seed and agrees to purchase the whole produce of hybrid seed that meets the prescribed quality standards. In 1994-95, through this project, Myanmar exported 59 t of hybrid maize seed. In 1995-96, it is projected to export 325 t. There are good prospects of expanding this project in future.

Constraints and researchable issues in seed production and supply.

Problems associated with quality maize seed production and supply in Myanmar are as follows:

1. There is no seed law which prescribes the minimum quality standards for seeds coming in the market or distributed by the government.
2. Farmers tend to save their own seeds from year to year, even in the case of hybrids.
3. Farmers' knowledge about quality seed is lacking. Except for hybrid seed, farmers generally do not want to spend more money on seed. (Promotion of the use of quality seed through demonstrations and other extension methods is essential).
4. Effects of different planting ratios on seed yield and of seed grading have to be studied for hybrid seed production.
5. Impact of genetic impurities on ultimate hybrid performance needs also to be studied.
6. Seed storage facilities are inadequate for storage of breeder and basic seed at research stations.
7. A combined effort of Research, Extension and Seed Div. of MAS is required to create a successful seed production program for Myanmar.

MAIZE SEED SITUATION IN NEPAL.

R. P. Sapkota [1] and K. Adhikari [2]

Abstract

This paper reviews the past, present and future OPV maize seed production and dissemination situations in Nepal, in relation to population improvement and production management research. In Nepal, maize seed production and distribution schemes are directly maintained and strengthened by public sectors. Production and marketing of maize improved seed is very slow, and low compared to other cereals.

Maize equals rice as a staple cereal food in Nepalese hills, where growth in demand for maize grain is increasing each year. Production lags seriously behind demand. Average improved maize seed planted area in Nepal was 54% in the year 1993-94. Farmers yields using improved seed (1.9 t/ha) are low compared to on-station productivity of improved varieties, but higher than the productivity of local seed (1.4 t/ha). Opportunity for rapid improved maize seed replacement by farmers through decentralized and public collaborative small-scale producer groups, specifically in the hills, is viewed likely to be successful in order to increase the maize production and productivity. In additional, an agro-ecological zone specific variety improvement thrust specifically for the hills is needed. With additional resources, the National Maize Research System (NMRS) may undertake hybrid maize research and collaborate with private seed company for seed marketing in potential and accessible areas of Nepal.

After rice, maize is the second most important staple cereal food crop of the Nepalese people. Nationally, maize is produced on 754,099 ha with annual production of about 1.25 million metric tons, and productivity of 1.7 t/ha (**Table 1**). Agro-ecologically, distribution of maize area is 8, 72 and 20% in mountains, hills and Terai (lowlands) areas respectively. In the mid and high hills of Nepal, maize equals rice as the major staple food. Average maize production and productivity is remaining constant in hills and mountains, but is steadily increasing in Terai area. This is due to contribution of winter maize which is gaining popularity in recent years in the accessible high production potential areas of Terai belt.

The hills, where maize is the main crop in the rainfed marginal lands (Bari/Pakho), are by far the most important agro-ecological zone for maize production in Nepal. In this zone, maize-millet in a double cropping or relay cropping patterns is generally practiced. Other crops grown with maize include soybean, other legumes and potato. Maize production is gradually being pushed to poorer, steeper lands due to population pressure, and maize area has expanded rapidly during the period 1984-90.

National maize research system (NMRS).

For strengthening maize research and development, the National Maize Research Program (NMRP) came into existence as a full fledged Commodity Program in Rampur and Chitwan areas in 1970. Since then, maize breeding and production agronomy research acquired new momentum and began international collaboration with CIMMYT, Mexico and other sources to improve and broaden the germplasm base through local collections and introductions. The main objective of maize breeding research, since the inception of NMRP, has been to develop high yielding, stress tolerant and widely adaptable cultivars with development of agronomic package of practices for different agro-ecological zones.

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Presently, Nepal is developing its maize cultivars from base populations at NMRP Rampur, Lumle Agric. Station (Mid & High hills), Pakhribas Agric. Station (Mid & High hills) and HCRP Kavre Dolkha (Mid hills).

Table 1. Area, production and yield of cereal crops in Nepal.

(Units = Area-ha, Prod. - tons, Yield - kg/ha)

Year	Paddy			Maize			Wheat		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
1984-85	1376860	2709430	1968	578720	819850	1417	451890	533720	1181
1985-86	1391040	2804490	2016	614680	873750	1421	482820	598000	1239
1986-87	1333360	2372020	1779	626710	868350	1386	535530	701040	1309
1987-88	1423290	2981780	2095	673810	901500	1338	596750	744600	1248
1988-89	1450470	3283210	2264	721870	1071610	1484	599290	830050	1385
1989-90	1432850	3389670	2366	751170	1200990	1599	604240	845960	1415
1990-91	1455170	3502160	2407	757710	1230950	1625	597240	835970	1410
1991-92	1411810	3222540	2283	754090	1204710	1598	571260	761960	1334
1992-93	1262110	2584900	2048	775220	1290500	1665	613980	765000	1246
1993-94	1450449	3495589	2410	754099	1253830	1663	611309	898892	1470

Source: Statistical Inform. on Nepalese Agric., 1993-94. HMG/MOA. Agric. Statistics Div., Singha, Durbar, Kathmandu, Nepal.

The seven maize population are:

High hill population: Ganesh-2 (yellow flints),
Mid hill population: Manakamana-1 (white flint),
Terai/inner Terai populations: Rampur-1 (white flint) and
Rampur-2 (yellow flint)

Early maturing populations: Arun-1 (white flint),
Arun-4 (yellow flint), and
Arun-2 (yellow flint).

NMRP is maintaining and improving these populations through modified ear-to-row selection schemes. The production potential and important agronomic characteristics of open pollinated maize varieties, developed and recommended for cultivation from the above base populations for general production, are given in **Table 2**.

Maize seed research and production program.

Systematic cereal seed production in Nepal was initiated in the public sector in the early seventies. Improved seed programs were then entrusted to Agric. Input Corp. (AIC), in addition to its responsibility for fertilizers. Since October 1988, the Nepal Seed Act came into effect, and the Nepal Agric. Res. Council (NARC), an autonomous Organization, has been created with responsibility for agriculture and seed research. The National Seed Board (NSB) has been created to oversee the development of a sound seed program. NSB is a seed policy setting body and monitors and guides the working of the national seed program.

National Seed Program. Major elements of the national seed program are indicated below:

Component	Organization
Seed legislation	Nepal Seed Act
Strategy & policy coordination	NSB/MOA
Seed program planning & monitoring	NBS

Variety development & maintenance	NARC
Breeder & foundation seed production	NARC
Seed testing services	NARC/DOAD
Seed certification	NSB/MOA
Seed technology research	NARC
Technical backstopping	NARC
Seed extension/demand generation	DOAD
Seed industry development	NSB/AIC/Private Sector
Seed marketing & distribution	AIC
Seed producers services	DOAD/AIC
Small-scale farmers'	
Seed production	NSB/DOAD

Table 2. Important agronomic characteristics of improved maize cultivars.

Cultivar	Av. yield (t/ha)	Maturity Days	Plant hgt. (cm)	Grain color	Year Recommended	Area where recommended	Parentage
Rampur yellow	3.4-4.0	105	220	Yellow	1966	Terai	J-1
Khumal yellow	3.0-4.5	130	220	Orange	1966	Mid hills	Antigua Gp-1 x Guatemala
Kakani yellow	3.0-4.0	180	230	Orange	1966	High hills	" Gp-2 x "
Hetauda comp.	3.0-4.0	120	220	Yellow	1972	Terai foot hills	Exotic x Local Races
Rampur comp.	3.0-4.5	110	210	Orange	1975	" "	Thai Comp.1 x Suwan 1
Sarlahi seto	3.0-4.0	120	240	Yellow	1978	" "	Phil., DMR-2
Janaki maize	4.0-5.0	150	220	Orange	1978	Terai, winter	Rampur 7434
Arun-2	2.5-3.5	90	195	Yellow	1982	Terai, mid hills	Uncac 242 x Phil.DMR Amriolo
Manakamana-1	3.4-4.5	135	210	White	1986	Mid hills	Exotic x Local landraces
Rampur-2	3.0-4.5	110	210	White	1989	Terai food hills	"
Ganesh-2	3.0-4.0	175	220	Milky	1989	Mid & high hills	"
Manakamana-2	3.5-4.5	130	215	Orange	1993	Mid hills	"
Rampur-1	3.0-4.0	110	210	Orange	1995	Terai & hills	"
Arun-1	2.5-3.5	90	195	White	1995	Terai & Hills	"
Arun-4	2.5-3.5	90	195	White	Pre-release		

As Nepal's maize growing landscape is rugged and remote, it is not a simple task to provide improved maize seed to farmers. The situation is further aggravated by the preponderance of small scale farmers. The maize cropland is situated at altitudes ranging from 100 to 2000 m above sea level, and encompasses wide environmental variations. To face effectively these realities, it is necessary for Nepal to have an innovative maize production and marketing strategy.

The maintenance of varietal purity of released open pollinated maize cultivars and production of breeder and foundation seeds is the responsibility of NMRP at its ten research stations. Cultivar-wise responsibilities are allocated to these stations.

Station	Variety
1. Lumle Agricultural Research Center	Ganesh-2, Kakani yellow
2. NMRP Rampur	Rampur Comp., Arun-2, Rampur-1
3. Hort. Research Station Pokhara	Manakamana-1
4. R.A.T.C. Khairenitar	Khumal yellow, Arun-2
5. RARS, Parwanipur	Rampur Composite
6. Pakhribas Agri. Res. Center	Manakamana-1
7. Nation Hill Crop Res. Prog.	Rampur Composite
8. ARS, Surkhet	Arun-2, Manakamana-1
9. ARS, Kapurkot	Manakamana-1
10. RARS, Nepalganj	Arun-2

Nepal's OPV's are managed through the breeder, foundation, and certified seed stages. The responsibility for maintaining the purity of breeder seed, as long as the variety is in production, rests with NMRP breeders. **Table 3** shows the amounts of breeder and foundation seed produced at the three main research stations.

Table 3. Amount of (MT) breeder (BS) and foundation seeds (FS) production status during four years period at NMRP Rampur, LAC and PAC.

Variety	1991-92		1992-93		1993-94		1994-95	
	BS	FS	BS	FS	BS	FS	BS	FS
A. NMRP Rampur:								
Rampur composite	0.37	4.98	0.32	6.0	0.26	6.55	0.82	1.82
Arun-2	0.20	1.70	0.41	8.92	0.33	6.29	0.30	1.78
Rampur-2	0.09	0.73	0.05	1.04	0.10	0.88	0.09	1.06
Arun-1	0.03	0.05	0.19	0.39	0.04	0.07	0.20	0.45
Rampur-1	0.03	0.05	0.17	0.49	-	-	0.04	0.60
Arun-4	-	-	-	-	0.18	0.60	0.150	0.70
Total	0.92	7.51	1.14	16.84	0.91	14.39	1.6	6.41
B. LAC:								
Ganesh-2	-	-	0.037	0.395	0.077	0.885	0.116	0.740
Mana-1	-	-	0.045	0.445	0.009	0.429	0.010	0.980
Arun-2	-	-	0.027	0.492	0.020	0.387	-	0.049
Makalu-2	-	-	0.020	0.138	0.029	0.124	0.027	0.153
Kakani yellow	-	-	0.016	0.063	-	0.103	-	0.098
Arun-1	-	-	0.010	0.553	0.030	0.487	0.010	0.360
Rampur-2	-	-	0.048	0.095	-	0.909	0.050	0.405
Total			0.203	2.181	0.165	3,227	0.103	2.785
C. PAC:								
Mana-1	-	3.466	-	2.164	-	3.065	-	-
Arun-1	-	1.183	-	-	-	0.967	-	-
Pool 9A	-	-	-	-	-	0.934	-	-
Total		4,649		2,164		4,966		

NMRP sells foundation seeds to AIC, DOAD/ADO's, NGO's, private growers etc. who organize the production of certified seed through progressive contract farmers in accessible areas of Terai and mid hills. Certified seed production plots are inspected by Seed Technology and Improvement Program (STIP) of DOA, which also conducts seed quality tests as per processed standards and provides certification tags.

The certified/improved maize seed produced by contract farmers is bought by AIC at a price 15% higher than the local market price plus a quality premium of up to 15% over and above the buying price. This seed is processed by the Corporation at its processing units. STIP conducts quality tests and seed lots are graded for calculation of premium. Processed seeds are given tags by STIP after final analyses of seed samples. Seed lots are then stored in seed *godowns* (warehouses) and sold to commercial grain producing farmers through '*Sajhas*' (Cooperatives) and private dealers throughout the Terai and hills of Nepal.

Improved maize seed sales have declined from 1989-90 onwards. AIC is buying much more improved maize seed than it can sell to farmers. In other words, AIC maize seed is not being accepted by the farmers as planned. High seed cost is a major deterrent for farmers, and many times leads to situations in which quantities of left-over seed are greater than seed sold by AIC.

Maize area planted to improved seed is almost 6 times higher than that planted to local cultivars in the Terai area, whereas it is slightly lower than local cultivars both in mountains and hills. The productivity level of improved maize is higher in all the agro-ecological zones. In all, about 54% of the maize area is covered by improved cultivars.

Presently, private sector participation in organized seed business in Nepal is almost negligible. Only a few seed traders are purchasing Indian hybrid maize seed from any source and marketing to Terai farmers in winter, and they make good profits. Mr. K. K. Gyawali, Managing Director, Nepal Seed Co., Ltd. has listed eight constraints for the private seed sector:

1. Shortage of foundation seed.
2. Unavailability of technical know-how about varieties.
3. Lack of information regarding actual cost of production and profitability in the business.
4. Small land holding for seed production.
5. Isolation problem for OPV's and hybrid maize seed production.
6. Lack of initiatives and encouragement from public organizations.
7. Lack of banking systems involvement for different types of credit.
8. Lack of storage facilities at different levels of marketing channels.

Problems and researchable issues.

1. **Lack of decentralized maize seed supply scheme**: Any significant gains from maize production are not possible unless seed of released varieties is made available to the farmers in desired quantities at the proper time. The quality seed of improved varieties needs to be made available to farmers by developing village level seed production groups. This could be coordinated by NMRP with related agencies and projects. Inadequate resources at NARC/NMRP are the basic stumbling block.

2. **Narrow focus on development of improved varieties**. Most of the NMRP work is limited to development of materials from limited base populations. This work has not employed a system's approach that considers maize as part of a complex cropping system. Further improvement and selection of experimental varieties is not major agro-ecological zone specific. In other words, population improvement needs to be done in the environments in which new cultivars are to be planted.

3. **Need for maize crop management research thrusts**. In the farmers' conditions, all crop residues are removed and used as fuel. At the same time, very little chemical fertilizer is added to maize, especially in the hills. Thus basic studies have to be initiated to improve soil fertility through research on proper crop residue management, agro-forestry systems, maize based cropping systems etc.

4. **Research and development for hybrid maize**. The pressure to develop hybrid maize for high production potential areas in Terai and mid hills is building up. NMRP needs additional resources and should justify the requirement by conducting a detailed feasibility study on hybrid research. Involvement of private seed companies also needs to be explored.

5. **Maize seed replacement frequency**. The optimum maize seed replacement frequency needs to be worked out keeping socio-economic necessities of the farmers in view. Ultimately, the stronger tendency to use farm-saved seed will be gradually reduced by developing adequate seed production and supply systems.

6. **Seed storage studies**. Methods feasible for farmers need to initiated and recommended. Storage methods that safely reduce losses from insect pests and spoilage need to be researched for both dent and flint maize grain types.

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MAIZE SEED SITUATION IN THE PHILIPPINES

Manuel L. Logrono [1], Ester L. Lopez [2] and Fabiola Alejandro [3]

As the second most important crop, maize assumes an important role in the farming sector in the Philippines and the macro-economy as a whole. Several reasons accounting for the strategic importance of this crop are: i) it is the main food staple for 20% of the population and is the chief supplement to rice consumption in areas and periods of rice scarcity, ii) one-third of the total Filipino farmers (80% of whom are living below the poverty level) depend on maize as the major source of their livelihood, and iii) it is a major ingredient in animal feed and as raw material for various industrial products. In recent years, the increasing demand for maize has been fueled by the country's rapid expansion of poultry and livestock industries.

Unfortunately, the maize industry in the Philippines has been beset with major problems that cause low productivity and marginal profitability. Among the identified constraints is the very low adoption of modern production technologies, particularly new and superior maize cultivars.

This paper discusses the maize seed production and distribution system in the Philippines including the progress, problems and researchable areas for the maize seed industry.

Maize production situation

Trends in maize production in the Philippines are presented in **Table 1**. Total maize area in 1994 was estimated at about 3 m ha, producing a total of about 4.5 m tons of grain at an average yield of 1.5 t/ha. Among the major island groups, Mindanao accounts for 66 and 73% of the country's total area and production, respectively. Among the top maize producing regions are Southern Mindanao (region 11), Central Mindanao (region 10), Cagayan Valley (region 2), and Northern Mindanao (region 12). These four regions contribute 70% of the total maize production (**Fig. 1**).

The general trend indicates an increase in the maize area between 1985-1990, and a sudden decrease during 1991-1994. The ten-year data revealed that there was a negative annual growth rate (-2.9%) in maize area. The reduction has been mainly attributed to the shifting from maize to other crops, and the utilization of farmlands for non-agricultural purposes.

In 1985, white maize grain accounted for about 80 and 72% of the total maize area and production, respectively. In 1994, its share of the total area and production dropped to 62 and 46%, or an average growth rate of -2.9 and -1.6%, respectively. On the other hand, yellow maize grain posted a growth rate of 6.6 and 15.5%, respectively, in the same period. These trends are reflected in the dramatic increase of average yield per unit area for yellow maize from 1.39 t/ha in 1985 to 2.13 t/ha in 1994 (**Fig. 2**). The increase in total production during the past 10 years is therefore mainly attributed to the increased output of yellow maize, the demand of which tremendously increased with rapid expansion of hog and poultry production. About 79% of the total maize output in 1992-93 was used for animal feed. The data also indicate higher average yields for yellow maize compared to white maize. This is attributed to the increased adoption of yellow maize hybrids, which incidentally were given more focus in research and development efforts, particularly in the private sector.

The seed industry act

In 1992, the Philippines Congress passed Republic Act No. 7308, otherwise known as the Seed Industry Act of 1992, which declares the policy of the State to promote and accelerate the development of the seed industry. Under this Act, the government shall a) conserve and develop the plant genetic resources of the nation, b) encourage and hasten the organization of all sectors engaged in the seed industry, integrate all their activities, and provide assistance to them; c) consider the seed industry as a preferred area of investment, d) encourage the private sector in seed research and development, and mass

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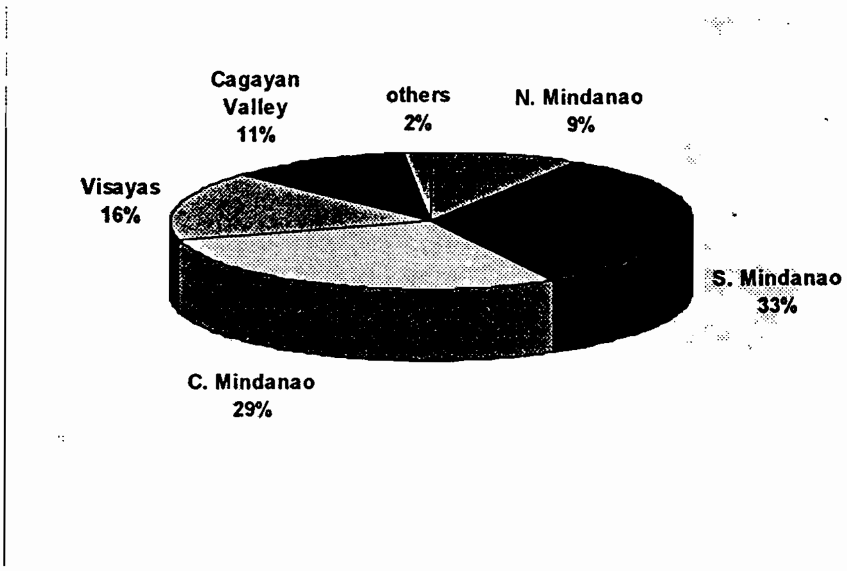

Figure 1. Average share of selected maize producing region relative to the total production, 1986-1991

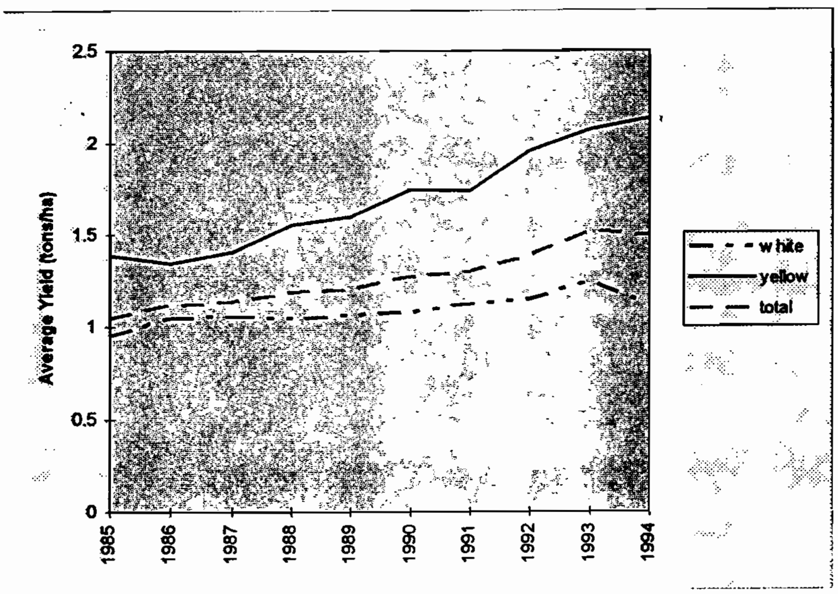

Figure 2. Trends in the national average yield of maize. 1985-1994

production and distribution of good quality seeds, and e) provide protection to the local seed industry against unfair competition from imported seeds.

One salient feature of the Act is the creation of the National Seed Industry Council (NSIC) to replace the existing Philippine Seed Board (PSB). The Council is empowered among others to a) formulate policies that will stimulate plant breeding activities for the development of genetic resources for the country; b) encourage persons, associations, cooperatives and corporations engaged in genetic resources conservation, varietal development, seed production and processing, quality control, storage, marketing, and distribution of seeds to adopt systems and practices leading to improved quality of seeds for distribution to the farmers, and c) formulate a comprehensive medium and long-term national seed industry development program in order to achieve self sufficiency in the supply of quality seeds.

Table 1. Maize production in the Philippines, 1985-1994.

Year	Area (million ha)			Production (million tonnes)			Average Yield (t/ha)		
	White	Yellow	Total	White	Yellow	Total	White	Yellow	Total
1985	2.630	0.684	3.314	2.846	0.953	3.439	0.95	1.39	1.04
1986	2.739	0.806	3.545	2.838	1.084	3.922	1.04	1.34	1.11
1987	2.779	0.786	3.564	2.912	1.103	4.015	1.05	1.40	1.13
1988	2.721	1.001	3.722	2.828	1.554	4.382	1.04	1.55	1.18
1989	2.755	1.009	3.764	2.911	1.610	4.522	1.06	1.60	1.20
1990	2.740	1.080	3.820	2.970	1.890	4.854	1.08	1.75	1.27
1991	2.580	1.010	3.590	2.910	1.750	4.660	1.12	1.74	1.30
1992	2.350	0.980	3.330	2.700	1.919	4.619	1.15	1.96	1.39
1993	2.098	1.051	3.149	2.627	2.171	4.798	1.25	2.07	1.52
1994	1.866	1.137	3.005	2.090	2.429	4.519	1.12	2.13	1.50
Av. growth rate (%)	-2.9	6.6	-0.93	-1.6	15.5	3.1	1.8	7.4	4.4

Source: Bureau of Agricultural Statistics.

respectively, in the same period. These trends are reflected in the dramatic increase of average yield per unit area for yellow maize from 1.39 t/ha in 1985 to 2.13 t/ha in 1994 (**Fig. 2**). The increase in total production during the past 10 years is therefore mainly attributed to the increased output of yellow maize, the demand of which tremendously increased with rapid expansion of hog and poultry production. About 79% of the total maize output in 1992-93 was used for animal feed. The data also indicate higher average yields for yellow maize compared to white maize. This is attributed to the increased adoption of yellow maize hybrids, which incidentally were given more focus in research and development efforts, particularly in the private sector.

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Maize improvement research institutions.

1. <u>Public Research Institutions</u>.

Maize improvement research in the Philippines began right after the establishment of the University of the Philippines College of Agriculture (UPCA) at Los Banos. The early improvement program was characterized by the development and improvement of open-pollinated varieties (OPV's). Among the early high yielding varieties released were the UPCA var series that were popular in the 1960's. Then came the downy mildew resistant (DMR) composites that made possible the introduction of varieties in maize areas with high incidence of the disease.

Attempts by UPCA to develop maize hybrids actually started in the 1950's with a modest program that culminated in the testing of double cross hybrids (Hayes, 1963). By the 1970's, several downy mildew resistant inbreds and hybrids were developed (Lantin *et al.*, 1983). Utilization of those hybrids by the farmers, however, did not take off because of problems in seed production and promotion.

With the establishment of the Institute of Plant Breeding (IPB) in 1975, new generations of high yielding and pest resistant OPV's were developed and approved for release by the PSB. However, realizing the need to dramatically increase maize production in view of the burgeoning population, IPB embarked on a very ambitious program of developing hybrid cultivars in which seed production is easy, and characteristics of the hybrids are acceptable to the farmers and consumers (Logrono, 1984). The establishment or IPB's research stations (besides its main station in College, Laguna) in CMU, Bukidnon, SMIARC-ROS, Tupi, South Cotabato, and Cagayan Valley has greatly facilitated the development of cultivars with wide adaptation.

Other major public research institutions that established regional breeding stations are as follows:

i). Ilagan Experiment Station (CVIARC), Dept. of Agric., Isabella, Region 2 (Cagayan Valley in North Luzon).
ii). La Granja Expt. Stat., Bureau of Plant Industry, La Granja, Negros Occidental, Region VII (Central Visayas).
iii). Visayas State College of Agric. (VISCA), Baybay, Leyte, Region 8 (Eastern Visayas).
iv). Univ. of Southern Mindanao Agric. Res. Stat. (USMARC), Univ. of Southern Mindanao, Kabacan, North Cotabato, Region 12 (Central Mindanao).
v). Central Mindanao Univ. (CMU), Musuan, Bukidnon.

Breeding programs of the above-mentioned institutions have been geared towards the development of open-pollinated varieties (composites). Recently, however, USMARC and CVIARC are starting their own hybrid development programs. At present, only the IPB has developed and released hybrid cultivars which are now commercialized by private seed growers.

2. <u>Private seed companies</u>.

The potential market for hybrid maize seeds in the Philippines attracted multinational seed companies, and lately local seed companies, who put up research, production, and marketing facilities in the country. At present, there are six multinationals and four local seed companies which are involved in the hybrid maize business in the Philippines. However, only three multinationals (Pioneer, Cargill, and Bioseed) and two local companies (Cornworld and Far East) have put up their own breeding programs, and are commercially producing and marketing hybrid seeds. Ayala Genetic Research Inc. (AGRI) and Tropical Corn Technology Corp. (TROPICORN) are actively engaged in hybrid maize research, but with no commercial seed production activities at present. Other companies are limited to testing of hybrids developed in other countries.

Maize varieties released by seed companies/insititutions and their present utilization.

The number of maize hybrids and OPV's officially approved for release by the National Seed Industry Council is given in **Table 2**. From 1984 to 1995, a total of 92 varieties (64 hybrids and 28 OPV's) were approved by NSIC. Most of the NSIC-approved hybrids were double or three-way cross hybrids. In 1995, the first single cross hybrid (IPB 911) was approved for released by NSIC.

It is also interesting to note that the average performance of hybrids improved over the years. The average performance of OPV's, however, is somewhat erratic. Hybrids outperformed the OPV's by an average of 1.13 t/ha, i.e. about a 21% yield advantage.

Table 2. Number of maize varieties approved for release by the National Seed Industry Council.

Year	Hybrids	OPV's	Total	Mean Yield (t/ha)	
				Hybrids	OPV's
1984	8	0	8	5.85	-
1985	2	1	3	6.42	5.07
1986	4	0	4	6.55	-
1987	2	1	3	5.59	4.97
1988	4	1	5	6.02	4.69
1989	0	1	1	-	5.24
1990	6	3	9	6.48	4.91
1991	7	6	13	6.78	5.38
1992	3	0	3	6.36	-
1993	14	11	25	6.72	5.61
1994	9	3	12	7.27	5.52
1995	5	1	6	6.18	5.36
Total Mean	64	28	92	6.51	5.38

Recent estimates indicated that the number of varieties produced and marketed at commercial levels are about 14 for hybrids and 10 for OPV's, which represent only 26% of the total varieties approved for release by NSIC. There are, of course, a few varieties that did not pass through the NSIC mechanism but nevertheless are produced in a limited volume in specific areas.

Compared to other Asian countries, the use of high quality seeds of hybrids and improved OPV's has been limited so far. Costales (1993) indicated that only 12% of the total maize area was planted to hybrids and PSB-approved OPV's. The rest was planted to farmers' selection (native varieties, F2's etc.). Recent estimates, however, point towards a dramatic increase in the hybrid maize area in the Philippines

(**Table 3**). The area planted to hybrids rose from 38,611 ha in 1982 to 422,222 ha in 1994. This year, the hybrid area is expected to reach 527,777 ha, or 17.6% of the total harvested area. The substantial increase in hybrid seed utilization from 1993-1995 was due to procurement by the Dept. of Agric. for its Grains Production Enhancement Program (GPEP). **Table 4** indicates the total volume of seeds procured and total area planted under GPEP. The hybrid seed subsidy accounted for 75% and 39% of the total hybrid seed market in 1993 and 1994, respectively.

The average growth rate of hybrid utilization (33.1%, **Table 3**) is very impressive, but the area devoted to hybrids relative to the total harvested area is still very low (at 14% in 1994, **Table 5**). It should be noted that Thailand and the Philippines basically started hybrid adoption almost at the same time. However, by 1990, 25% of the maize area in Thailand was planted to hybrids vs. 7% in the Philippines (Ansaldo, 1993). At present, Thailand has a hybrid utilization rate of more than 50%, about 70% of which is already in the single cross category.

Table 3. Hybrid adoption in the Philippines.

Year	Seed Produced (metric tons)	Area Planted (ha)	% of Total Area	% Change (area)
1982	695	38,611	1.10	-
1983	900	50,000	2.13	29.5
1984	1,200	66,666	1.68	33.3
1985	1,474	81,888	2.47	22.8
1986	1,910	106,111	3.00	29.6
1987	2,882	160,111	4.49	50.9
1988	3,759	208,833	5.61	30.4
1989	5,087	282,611	7.51	35.3
1990	6,289	349,388	9.15	66.8
1991	2,089	116,055	3.23	-66.7
1992	4,100	227,777	6.84	96.3
1993	4,650	258,333	8.20	13.4
1994	7,600	422,222	14.05	63.4
1995	9,500	527,777	17.59	25.0
Average growth rate				33.1

Source: Ayala Agric. Dev't. Corp., Pioneer Hybrid Ag.ric. Technology.

Table 4. Seed subsidy component of Grains Productivity Enhancement Program (GPEP).

Phase (Year)	Hybrid			OPV		
	Seed Vol . (metric tons)	Area Planted (ha)	% of Total Hybrid Area	Seed Vol. (metric tons)	Area Planted (ha)	% of Total OPV Area
I (1993)	3,488	193,813	75	1,263	63,183	2.2
II (1994	2,971	165,057	39	898	44,924	1.7

Source: Dept. of Agric. Govt. of Philippines.

Table 5 indicates that the certified seed utilization rate in the Philippines was around 22.38% of the total area in 1994, for both hybrids and OPV's. Despite the increasing seed price (**Fig.** 4), hybrid technology provided the much needed impetus in the increased adoption of high quality maize seeds.

The estimates for certified seed production of improved OPV's in 1994 are shown in **Table 6**. The flow of Philippine Seed Board approved OPV's from breeding centers to maize farmers is depicted in **Fig. 5**. It should be pointed out that some of the research institutions derived their estimates for the expected certified seed production from the total foundation/registered seeds sold to the seed growers. A total of 5,014 t were produced, which could plant 250,700 ha or 8.33% of the total maize area. Private seed growers produced 97% of the total seed volume.

Table 5. Certified seed utilization in the Philippines, 1994.

Source	Volume (metric tons)	Area Planted (ha)	% of Total Area
Hybrid	7,600	422,222	14.05
Imp. OPV's	5,014	250,700	8.33
Total	12,614	672,922	22.28

Table 6. Improved OPV seed utilization in the Philippines (1994 estimate).

Source	Volume (metric tons)	Area Planted (ha)	% of Total Area
Public Institutions	197	9,850	0.33
Private Growers	4,817	240,850	8.0
Total	5,014	250,700	8.33

Source: BPI, IPB, and personal communication from other stations.

Seed production and distribution system.

1. Cultivars developed by public research institutions.

In the case of OPV's, the general seed production and distribution scheme is presented in **Fig. 5**. Seed production activities are mostly done by the Dept. of Agric. - Bureau of Plant Industry (DA-BPI Stations (seed farms), maize breeding centers, and by the supervised private seed growers in different regions of the country. Normally, the foundation seeds coming from the breeding institutions are seed increased in the BPI stations or at the private seed growers farm to produce either registered or certified seeds. The maize farmers buy their seeds directly from the two entities, or from the private seed distributors or dealers in their localities. A few private seed growers have their own distribution or marketing arm. Most of them rely on government production programs for marketing their seeds.

In the case of the IPB, the main production and distribution arm is the National Seed Foundation (NSF). **Fig. 6** illustrates the flow of different types of maize seeds from the Cereals Division down to the

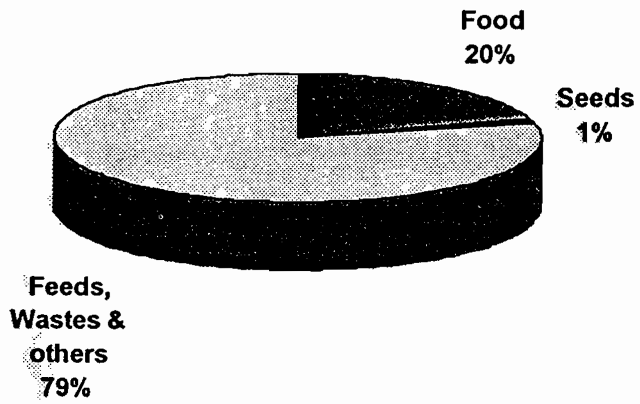


Figure 3. Corn supply and use based on the 1992-1993 stock inventory (%).

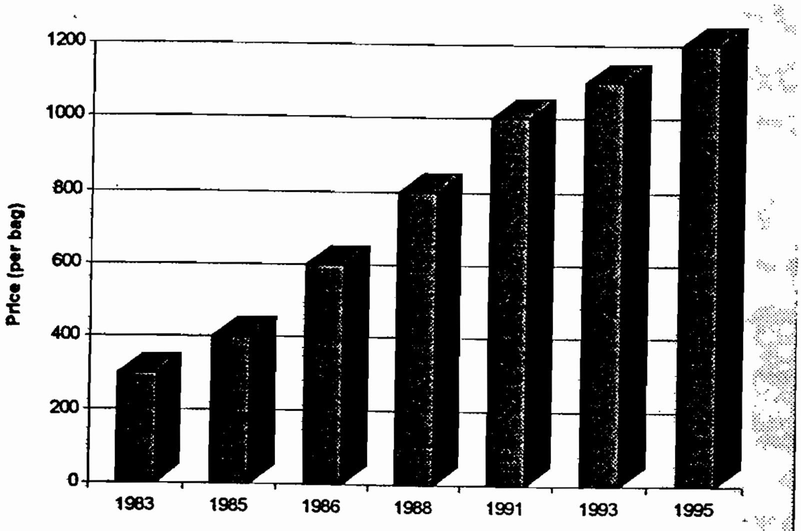
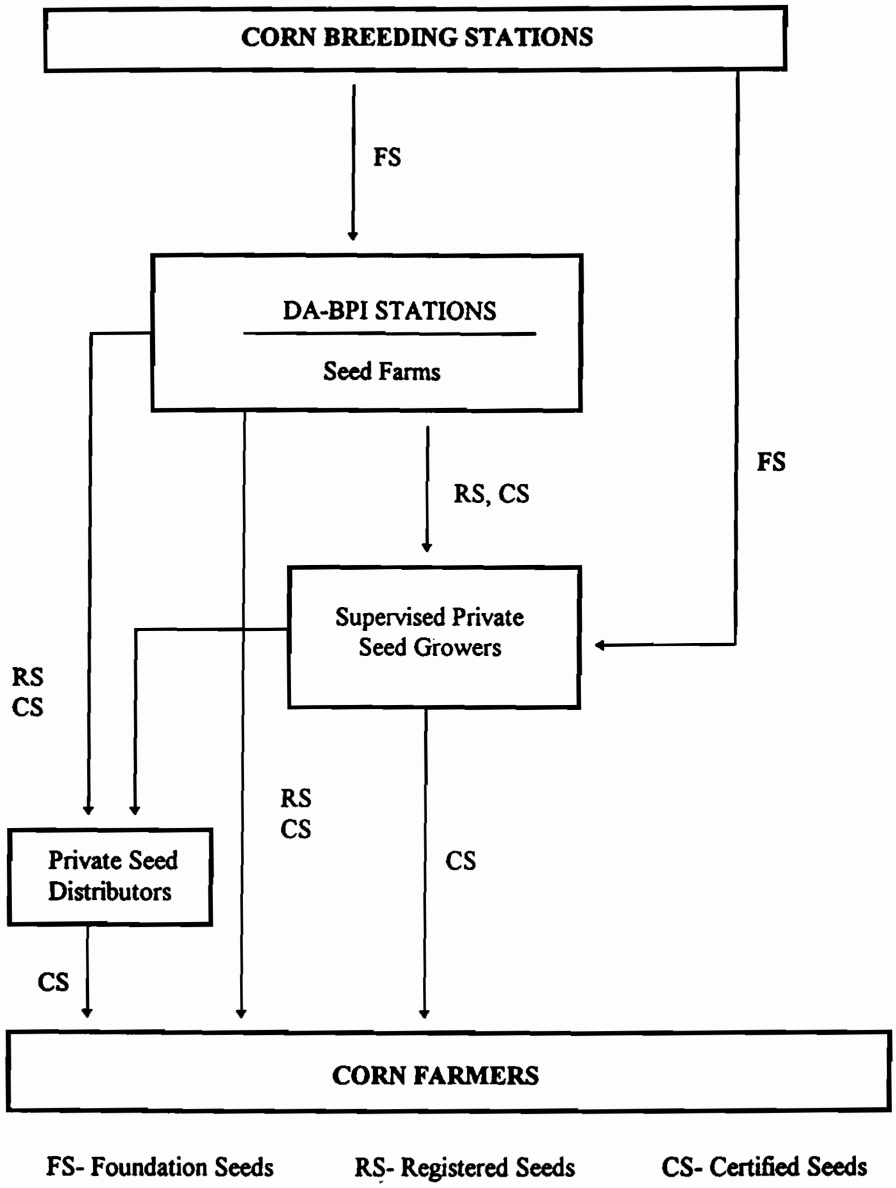


Figure 4 Selling price of hybrid maize seed per bag (18.0 kg)



Source: ASAP, 1993

Figure 5 Flow of Philippines Seed Board (PSB) approved OPV's from breeding centers to the farmers maize farmers. For OPV's, the main seed growers are the BPI and private growers scattered throughout the major maize growing areas. The seed growers pay a fixed price for the foundation seeds (P.20/kg). The price of certified seeds varies from region to region (ranging from P.15-20/kg).

In the case of the IPB hybrids, two seed production models can be availed of by the private seed growers. In the first model, IPB provides the breeder seed to the grower who in turn produces the foundation and certified seed. The seed grower may subcontract the certified (F1) seed production to other parties, but processing and distribution/marketing are handled by him/her. In the second model, only the foundation seed produced by NSF is provided to the seed growers. The certified seed production scheme is similar to the first model. In any case, IPB monitors all the seed production activities of the seed growers to ensure that only high quality seed is sold to the farmers. At present, there are eight private seed growers for IPB maize hybrids. A total of 53,000 bags (954 t) were in fact produced by them for the regular market and for the GPEP. This year, 46,000 bags are expected to be produced for the GPEP.

During the first two years of hybrid seed production, IPB charged a fixed rate of royalty based on the volume of foundation seeds used. This year, an out-put based system is being implemented wherein the royalties are based on the volume of certified seed produced. Funds generated from royalties have been used to support the research programs of IPB, thus enhancing its research and development capabilities.

Despite inherent limitations, the seed of public hybrids was quickly produced and commercialized on a relatively bigger scale. This could be attributed to several factors, such as the active participation of the private seed growers, willingness of the private growers to invest in production and processing facilities, effective promotion in the countryside, and the inclusion of hybrids in the maize production program of the government.

2. Cultivars developed by private seed companies.

Except for one company, all seed production, distribution and marketing activities in the private sector are done by the company or sister/affiliated companies (**Fig. 7**). The R & D (Research and Development) group usually handles the parental stock or foundation seed production, which is passed on to the production and processing group. The seed production group normally subcontracts the job to contract growers. The company usually provides the inputs, which are deducted from the gross receipts due to the farmers after harvest. Contract growers are paid per kilogram of fresh cobs (ranging from P.3.15 to 3.60/kg) harvested. Major seed companies have their own processing plants and marketing network to process and market the seeds to the farmers (**Fig. 6**).

Problems and researchable issues.

The relatively low utilization of high quality seeds of superior maize cultivars in the Philippines has been attributed to 1) an inadequate seed production and distribution system, 2) the very low purchasing power of maize farmers (80% are living below the poverty level, hence they do not have enough cash to buy seeds), 3) inaccessibility due to poor or non-existent road system, 4) lack of knowledge on the distinct advantages of using certified seeds, and 5) lack of credit support.

The most important problems in seed production are as follows: a) difficulty in sourcing of foundation or registered seeds, b) isolation problems, especially in rainfed areas, c) high costs of inputs, such as fertilizers and pesticides, d) lack of irrigation facilities, e) susceptibility of inbreds to stresses which usually results in nicking problems, and f) lack of seed inspectors which delays the processing and distribution of seeds.

Problems associated with processing and storage include a) lack of equipment such as dryers, shellers, cleaners, etc., b) improper seed treatment resulting in poor germination, inferior packaging materials (especially the ones used for OPV's) and c) the lack of cold storage facilities for long term storage.

Marketing and distribution are usually the concerns of small growers who cannot avail a reliable transport system. The high cost of shipping, particularly from Mindanao to Luzon, also discouraged independent small seed growers from expanding their market.

Other policy issues include the full implementation of the seed act, particularly the provision of incentives to seed producers, and the interest of the private sector to establish a plant variety protection

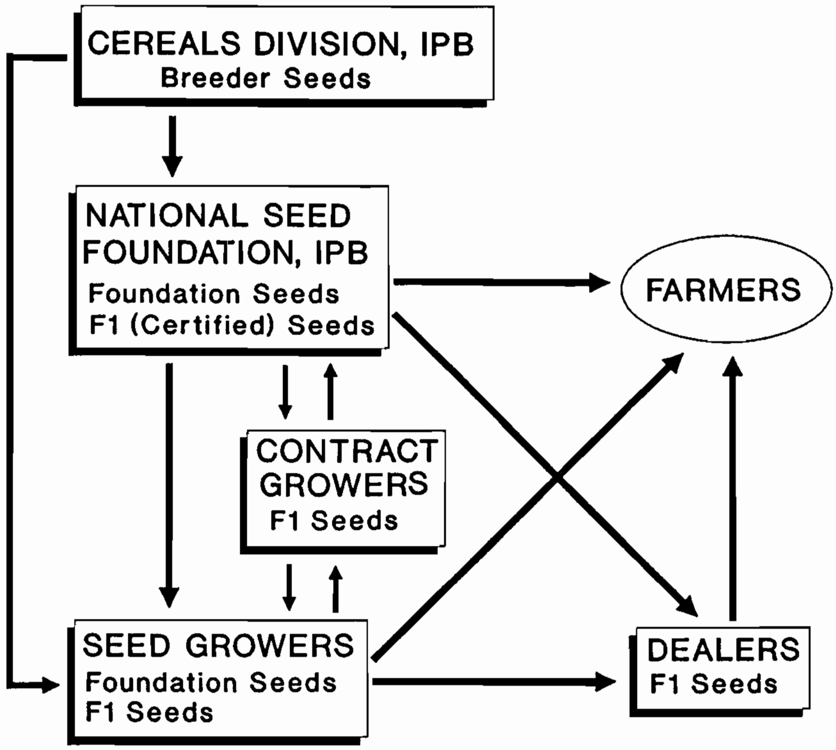


Figure 6. Seed production and distribution system fro IPB-bred corn hybrids.

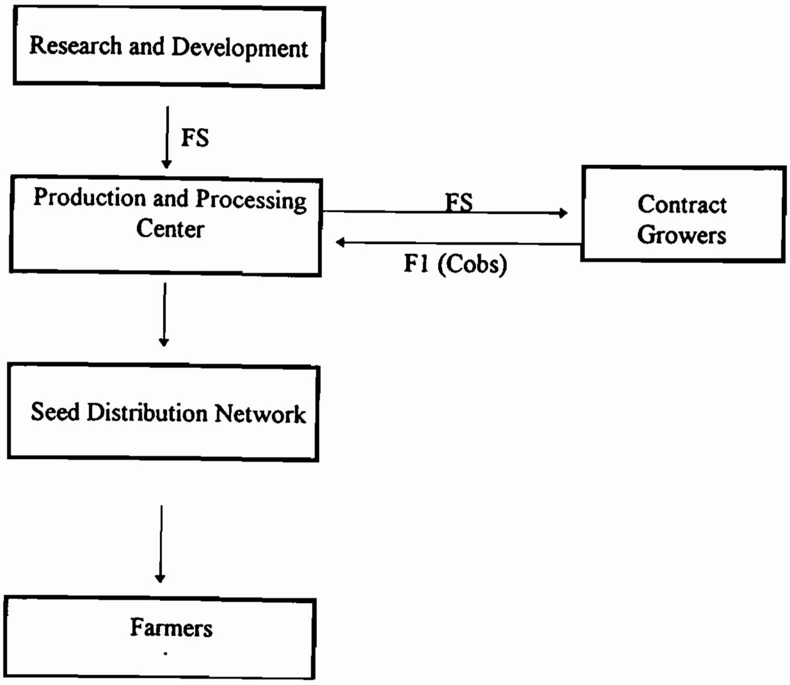


Figure 7. Hybrid corn seed production and distribution scheme of the private seed companies in the Philippines.

system in the Philippines. With its membership in WTO, the Philippines is obliged to create an effective *sui generis* system for the protection of intellectual property rights.

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Comments/questions:

Marsum Dahlan, Indonesia.

How is the relationship between IPB and National Seed Foundation? Is there any royalty? How is the arrangement of the royalty?

Answer: The National Seed Foundation is an integrated unit of the Institute of Plant Breeding and serves as the production and marketing arm of the Institute. It produces the Foundation seeds such needed by the private seed growers. The royalty is production based, i.e. IPB charges royalty based on the volume of certified seed produced by the seed growers. The royalty is remitted directly to IPB trust fund which would be plowed back to corn improvement research.

Mogens Lemonius, FAO/Danida, Thailand

Your supply of quality seed per ha maize area is lower than in many other countries - Do you expect the introduction of 1992 seed industry act and establishment of your National Seed Industry will lead to a move efficient seed supply to Philippines maize sector?

Answer: Efficient seed supply and Seed Act (INSIC).Under the Seed Act, seed production is considered as preferred area for investment. As such, it can avail of a special tariff rate for importing processing facilities and other farm equipment and "tax holidays". These should encourage private seed companies to venture into seed production, thus enhancing seed supply in the country. Moreover, one of the components of the National Seed Industry Program adopted by the NSIC is seed production, distribution and marketing. Here, cooperatives and specialized farmer groups are trained for more efficient maize seed production. With the initial mass of trained seed growers and with the favorable market environment for maize seed such as that of the Grain Production Enhancement Program of the DA, the establishment of an efficient supply system will not be long, and hopefully this will enhance the maize seed supply institution in the Philippines.

MAIZE SEED SITUATION IN SRI LANKA

S. L. Weerasena [1]

Abstract

Cross-pollinated crops such as maize require a higher percentage of seed replacement every season compared to self pollinated crops, in order to ensure high yields. The low yield (1.39 t/ha) experienced in Sri Lanka may be due to several reasons, including the low seed replacement rate.

A number of OPV's with promising yield potential have been released. However, their maintenance and seed availability have not been satisfactory due to inherent deficiencies in a state-dominated seed industry.

Hybrids are desired and would facilitate private seed enterprises to enter production. However, organizational problems in seed production, and inability of the newly emerging seed companies to effectively compete with the established, subsidized state seed program will affect hybrid popularization. A modern seed policy that allows rapid commercialization of the seed industry is being drafted.

Maize is grown largely by small farmers in the dry plains which experience bimodal rainfall. It is cultivated on about 50,000 ha during the major rainy season between October and January. Maize fits in the shifting cultivation system still being practiced in some areas, and in the sedentary farming systems where mixed cropping is routine. It is also grown as a monocrop, and to a limited extent during the dry season (*Yala*), from April to August, as an alternate to rice in water-deficit areas. Maize crop yields have been low. Only marginal yield increases have been realized since 1976, when per hectare yields were less than one ton. In 1993, average national productivity was 1.39 t/ha. Most (75-90%) farmers use non-certified, farmer-saved seeds.

The need for a maize improvement program in Sri Lanka was recognized in the early 1950's. The selection from a local gene pool in early 1960's resulted in the release of the first open pollinated variety, T-48, with better grain quality and earliness than traditional varieties. A rudimentary seed production and distribution system was launched for popularization of the variety. Government farms were the focal points of production, while distribution was carried out by the extension services of the DOA. Close links were established with the Inter-Asian Corn Improvement Center in Thailand, and with CIMMYT in Mexico since 1968 for varietal improvement. Introduction of germplasm through the collaborative program has resulted in several new varieties. The varietal improvement program continues only in the DOA.

All varieties are open-pollinated types. Officially released varieties are Bhadra-1 (selection from Thai Comp.), Cupurico x Flint Comp., Comp. 6, Poza Rica 7931 and Across 7929. Of these, Composite 6 and Across 7929 possessed higher yield potential than Bhadra -1, while Poza Rica 7931 proved to be an early maturing, high yielding variety. Although nine quality protein varieties obtained from CIMMYT have been tested, none have been released to date. Hybrids (varietal crosses) with a yield potential of 6.5 t/ha were found (Hindagala, 1986). However, no hybrids have been released.

The need for an organized seed production effort which encompasses maintenance breeding as one of the objectives has to be emphasized. Varietal maintenance is an additional burden on the breeder unless another organization of the state or private sector undertakes the task.

Even the officially released varieties are virtually non-existents, having succumbed to absence of maintenance breeding efforts in the country. The seed certification system, although existing in Sri Lanka, is not able to support seed enterprise development, owning to deficiencies in varietal maintenance.

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The total maize seed requirement in Sri Lanka is approximately 750,000 kg. The DOA continues to be the single producer and supplier of maize seed in the country, but only 6.7% of seed requirement was produced under their program in 1994 (**Table 1**). Earlier, in 1985, only 6.5% requirement was met by this system. Thus, the seed supply situation has remained stagnant during the last ten years.

Table 1. Maize seed production 1994.

Variety	State seed farms DOA	Contract grown DOA	Private sector	Quantity accepted for certification
Bhadra	13.10	0	0	26081
Composite 6 (Ruwan)	20.35	6.50	0	24369
Roza Rica 7931 (Aruna)	0.01	0	0	12
Across 7929 (Muthu)	0.85	0	0	194
Total	34.31	6.50	0	50656

Source: Seed Certification and Plant Protection Center, DOA.

The seed industry in Sri Lanka was liberalized in 1984 with the expectation that the private sector would gradually relieve the state from this burden. However, until 1990, seed companies were complacent with earnings from selling imported vegetable seeds. A major reason for the continued reluctance of companies to forge into cereal seed markets is the fact that they have to compete with the established production and distribution network of the DOA. Seeds produced by the state carry hidden subsidies, and therefore, the private sector cannot effectively compete in the market. The price difference between grain and seed appears insufficient to compensate for the extra expenditure in systematic cultivation, roguing, quality control, processing, drying and storage necessary for seeds.

The private sector has not invested in plant breeding. Seed companies are compelled to provide higher sales incentives to retailers than those offered by the DOA, which substantially increases coats. The average sales commission offered by companies is 25%, compared to 10% by the DOA to its distributors. Seed certification services are provided by the DOA for a fee.

The state does not interfere in seed pricing and market forces determine retail prices. However, the DOA is sensitive to political issues involved in upward revision of seed prices, and tends to market seeds below cost. Private seed producers view this as the major bottleneck to future investments. The other disincentives to investment in maize seed production are lack of breeders' rights, and non-availability of tested hybrids for undertaking local seed production.

Two private companies have recently imported hybrid maize seed from Thailand with adequate quarantine precautions. However, farmers' acceptance has been low because of high seed cost and non-impressive crop performance under subsistence conditions. Performance testing or farmer preference trials were not adequately conducted prior to importation. In addition, hybrid seeds were distributed without extension support or targeting the high input-using farmer groups.

A new seed policy has been drafted. It is expected to facilitate commercialization of the seed industry by providing many incentives for private investment.

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Comments/questions:

C. De Leon, CIMMYT ARMP
How much involvement of seed companies is there in Sri Lanka to promote maize seed production?

Answer: Presently, no seed company or cooperative is active in maize seed. However, by the end of this year one or two companies will be investing in maize seed production.

MAIZE SEED PRODUCTION AND MARKETING IN TAIWAN.

Tseng, Ching-Tien [1] and Lu, Hung-Shung [2]

Abstract

After the government launched a "six-year diversification program for rice production" in 1984, the maize planting acreage increased rapidly and remains annually about 63,000-65,000 ha until now. Right now about 84,000 kg of hybrid maize seeds are produced to meet the requirements for cultivation each year. For simplifying the hybrid maize seed production, the varieties released for cultivation are single cross instead of double cross hybrids. The breeding institutes such as Taiwan Agricultural Research Institute (TARI) and Maize Research Center, and Tainan District Agriculture Improvement Station (DAIS) maintain the inbred lines. Taiwan Seed Service (TSS) is responsible for hybrid maize seed production and processing. For supplying enough good quality hybrid maize seeds a modern seed processing plant has been established; it consists of seventeen dryers for ear maize and seed maize each. The processing plant can handle 2,000-25,000 metric tons of seed maize in one year. The Provincial Seed Testing Laboratory (PSTL) is in charge of the inspections of both seed fields and processed seeds. PSTL will issue certificates to the processed seeds if they pass inspection. The certified maize seeds are sold to the farmers through County Farmers' Associations. The maize seed price per kg was US$1.96 to 4.46 according to the kind of variety.

Introduction.

The size of the Island of Taiwan is about 14,000 square miles, and it is short of arable land. About three-fourths of the land area of the Island consists of forest-capped mountains and hills. The main parts of the arable land lies on the plain. Geographically the Island is located in tropical and subtropical areas, this makes multiple cropping systems possible here. Thus farmers could use the limited arable land to produce enough food to feed well a population of 21 m people. However, as economic development progresses and living standards have increased, in the last decade the people in Taiwan have gradually changed their dietary habits from carbohydrate to protein-rich food. These have created the market for the development of the animal husbandry industry. For livestock production about 4,720,000 t of maize is imported annually as feed for poultry, pork and dairy cattle etc. Meanwhile, the decrease in rice consumption per capita has led to an over-production of rice, generating a great pressure on the government financial budget. In order to alleviate the pressure caused by rice over-production the government initiated a "six-year diversification program for rice production". Under this program one metric ton of rice grain is subsidized for every hectare of paddy field diverted to cultivate maize, and maize grain is purchased by the government at a guaranteed price. To ensure the success of the program the government also realized it is essential to provide good quality hybrid maize seed, and its availability to the farmers at the desired time, at the right place, and at an affordable price. To achieve these goals with the grant aid of Council of Agriculture, the systems of producing, processing and distributing hybrid maize seed have been well established in this country. Highlights in hybrid maize cultivation, hybrid maize seed production and processing, its quality control and marketing from the 1950's to the 1990's are presented in this paper.

Historical view of hybrid maize cultivation.

The maize planting acreage before 1940's was around 2,000 ha in Taiwan (**Fig. 1**). It slowly increased since 1952 and reached 50,000 ha in 1975. Since then, the planting acreage decreased and dropped to about 20,000 ha in 1979 (Agric. yearbook 1950, 1980). With the continuous increase in economic growth in the last decade and the encouragement of a guaranteed purchased price policy, the

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maize planting acreage increased rapidly in 1984, and reached 67,000 ha in 1989, which was the record high for maize cultivation in Taiwan (**Fig. 1**).

Maize and rice were closely related to each other in planting acreage and production. Rice planting acreage was 50,200 ha in 1945 and increased rapidly to 70,000 ha in 1950 (**Fig. 1**). It was fluctuated between 76,000 and 78,000 ha during the period of 1951 to 1970. As maize planting hectarage started to increase in 1984 and expanded to paddy fields, rice planting acreage started to decrease in the same year, and dropped to about 47,000 ha in 1989 which was the lowest record in rice production for this country (Agric. yearbook 1950-1990).

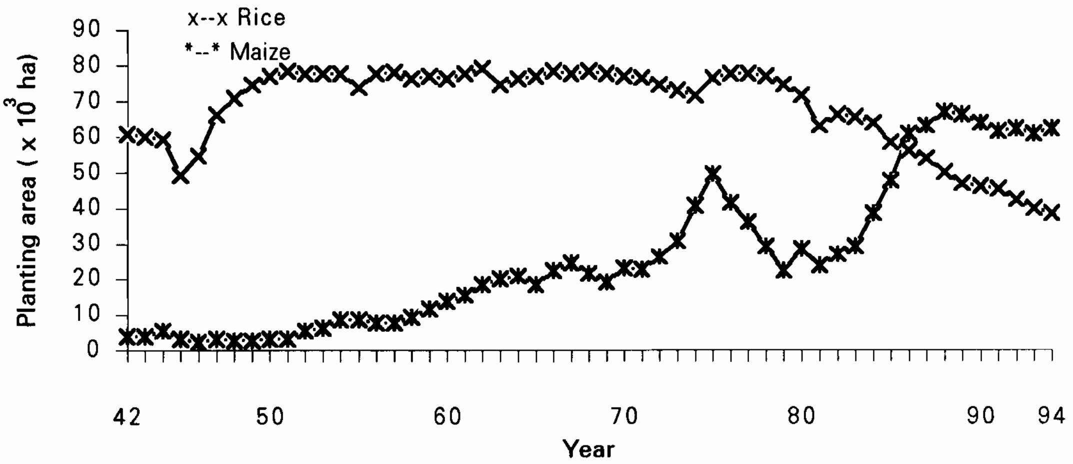

Fig. 1. Annual changes in maize and rice planting areas in Taiwan, 1942-1994.

Per unit area yield for both rice and maize has increased steadily since 1945 (**Fig. 2**). Grain production per hectare for rice and maize in 1945 were 1,273 kg and 509 kg, respectively; the rice yield was 2.5 times higher than that of maize. The yield ratios of rice to maize in 1955, 1965, 1975 and 1988 were 1.91, 1.38, 1.14 and 0.97, respectively. In order words, the difference in yield ratio of both crops was the largest in 1945. However, since then the yield ratio difference between the crops was gradually narrowed down. Per unit area yield of maize became higher than that of rice in 1988. The grain production per hectare for rice and maize in 1988 were 3,916 kg and 4,023 kg, respectively (Agric. yearbook 1950-1990).

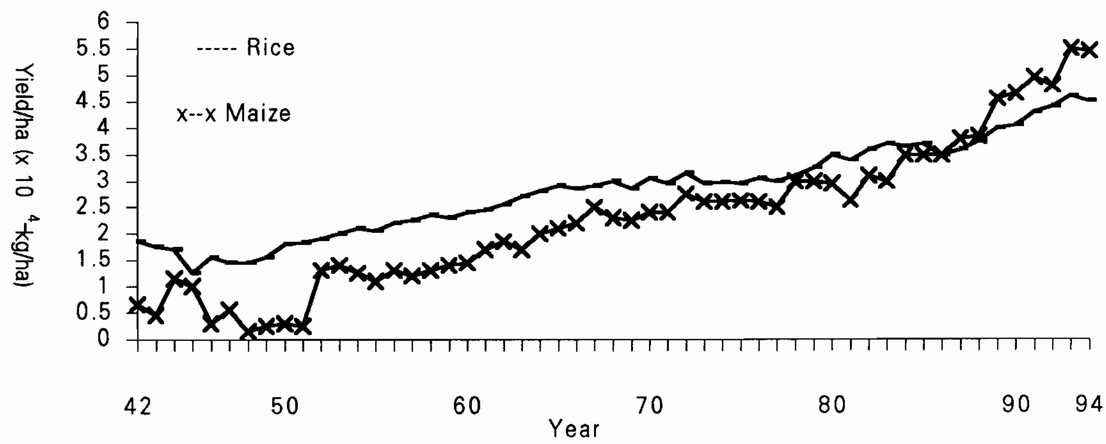

Fig. 2. Annual changes in yield per hectare of both maize and rice in Taiwan (1942-1994).

The annual maize grain production before 1960 was below 20,000 t (**Fig. 3**). It reached 60,000 t in 1970 and continuously increased to 137,000 t in 1975. After that, the maize grain production decreased until it began to increase in 1981, and reached the highest record of 262,000 t in 1989. During the period from 1945 to 1976, the annual rice production increased rapidly from 120,000 t to 271,200 t then declined gradually to 184,500 t in 1989 (Agric. yearbook 1950-1990) (**Fig. 3**).

The data show that for maize and rice production the planting hectarage had much more influence on maize production than yield per hectare. Rice production was also influenced by the planting hectarage before 1950. However, in the period from 1951 to 1976, the increase in rice production was mainly due to the improvement of per unit area yield. From then on, the rice planting acreage rapidly declined, consequently the rice production decreased. But as the rice consumption per capita decreased annually, it has led to the fact that rice production exceeded people's consumption.

For implementing the "six-year diversification program for rice production" program in 1984, other measures such as improvement of maize varieties, mechanization of cultural practices, adjustment of cropping systems, and hybrid maize seed production were all actively undertaken. Maize planting acreage and its grain production increased rapidly after the diversification program had been in effect. Maize cultivation season was changed from winter crop to spring and fall crops.

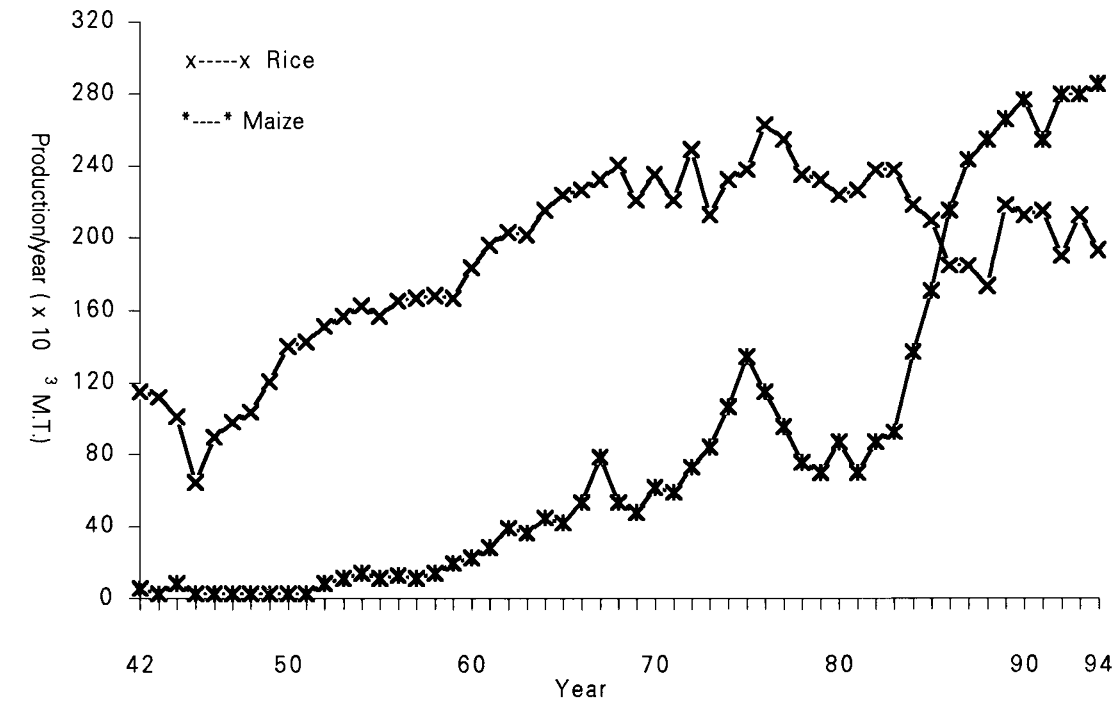

Fig. 3. Annual changes in maize and rice grain production in Taiwan (1942-1994).

The percentage of domestic maize production in annual consumption before 1963 was over 85% but as the consumption amount increased the percentage decreased. It was less than 10% in 1969 and from then on it stayed at an average of 4-6% (**Fig. 4**). Even with the diversification program most of the maize consumed domestically was imported.

The amount of imported maize before 1971 was below 600,000 t. It ranged between 1,000,000 and 2,000,000 t during the period of 1972 to 1976. Since then, imported maize continuously increased and reached 3,000,000 t in 1983. The highest imported amount was about 4,720,000 t in 1988. The maize self-sufficiency rate was only 5.6% in that year (Agric. yearbook 1960-1990).

Hybrid maize seed production.

The first maize hybrid was developed and released in 1960. It was the double-cross hybrid Tainan No.5. It is an early maturing variety, and was planted as a winter crop. Before the government launched the "six-year diversification program for rice production" in 1984, the demand for hybrid maize seed was small. From then on, due to the encouragement's of guaranteed purchased price and the government subsidization, the maize planting acreage increased rapidly. As a result, the requirements for hybrid maize seeds increased annually and reached 1,026,088 kg in 1986 (**Fig. 5**). Nowadays, the varieties released to farmers are single cross instead of double cross hybrids. These single cross hybrids such as Tainan No. 17 and Tainung No.1 are high-yielding, medium maturity, and disease and insect pest resistance. They are now the popular varieties in the major maize production areas in Taiwan. For producing enough good quality maize seeds to supply the demand, the following production procedures (**Fig. 6**) have to be undertaken in a strict way.

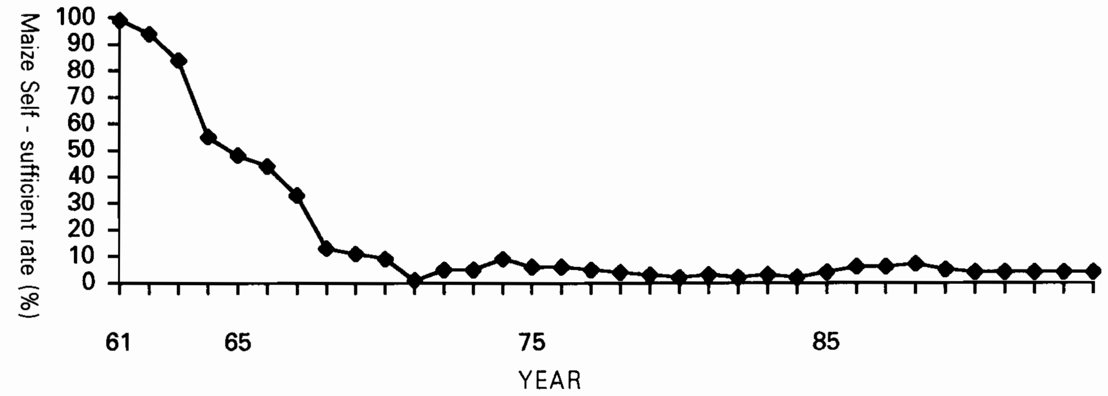

Fig. 4. Annual changes in maize self-sufficiency rate in Taiwan (1942-1994).

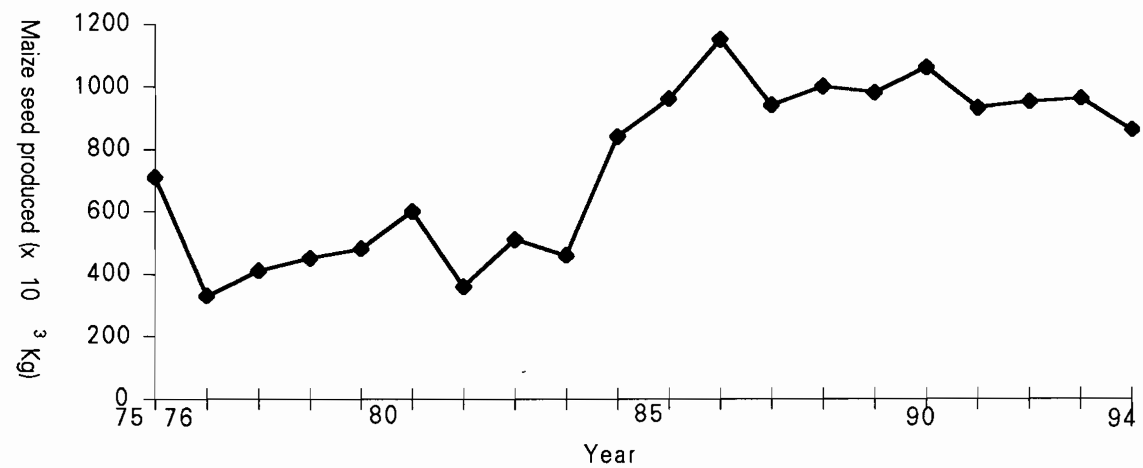

Fig. 5. Annual changes in hybrid maize seed production in Taiwan, 1975-1994.

1. Inbred line increase.

Taiwan Agric. Res. Inst. (TARI) and Maize Res. Center, Tainan Dist. Agric. Improv. Stat. (DAIS) maintain the inbred lines by continued selfing of representative plants, or by careful roguing for plant type and then sib mating between plants in the row.

Inbred lines may be increased by hand-pollination or by growing the inbred in an isolated plot. The common practices is to increase the inbred in an isolated plot or small field, and by hand-pollination within the plot. The hand-pollinated seed is held for planting future inbred increase plots, and the inbred seed crop is used for producing single crosses.

2. Planting and growing seed maize.

Taiwan Seed Service (TSS) is responsible for planting and growing seed maize. The cultural practices in growing a seed field are essentially the same as for growing feed maize. Special activities are to be followed to reduce the risk of low yields (Airy, 1955; Kuo 1992).

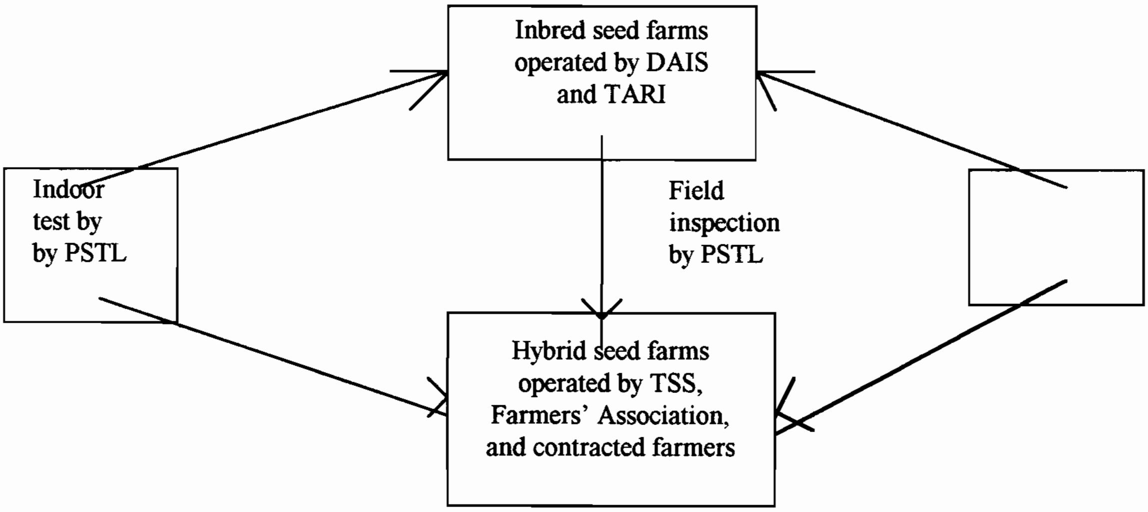

Fig. 6. The hybrid maize seed multiplication and certifications system in Taiwan.

1) Selection of high-yielding areas within the county, good fields within a growing area, and good farmers.
2) Avoidance of droughty light soils, poorly drained fields or fields subject to flooding.
3) Planting stands which are adequate but not heavy enough to increase the risk of drought damage.
4) Applying enough basal fertilizer: 400 kg/ha of ammonium sulfate and CaH_2P0_4, 150 kg/ha of KCL and a top dressing of 400 kg/ha of ammonium sulfate.
5) Control of insects, especially soil-borne insects such as cutworms, and maize borers.

1. Isolation of seed fields.

Isolation of seed field is used to avoid the contamination of seed maize by other pollen sources. Isolating the seed field can be achieved by (Gacitua, 1946): Planting the seed field a minimum distance of 300 m from pollen source of other lines. Planting at a different date to obtain isolation from other lines when there is not adequate distance between them.

2. Roguing.

Off type plants must be rogued from the field before pollination to maintain the genetic purity of inbred seed. Off-types can result from volunteer plants of a previous crop grown in the field; undesired cross-pollination in the previous seed crop, or mixing of seed from different genotypes during planting or harvest.

3. Row ratio in seed fields.

Female maize is the line used for ear parent. Male maize is the line planted as a pollen source. The common row ratios of female to male maize in seed fields are 1:3, 1:4, 1:5, 1:6 etc. Occasionally, the ratio is eight rows of female to two rows of male. When the male lacks vigor, is planted at a different date, or tends to shed limited amounts of pollen, the row ratio is reduced to four rows of female to two rows of male.

4. Detasseling in seed fields.

Proper detasseling of the female rows in the seed fields is necessary to effect a cross mating. Failure to remove the female maize tassels prior to pollen shedding once silks have emerged on the female maize ear shoot, may result in inbreeding followed by a 25 to 33% reduction in yield of the progeny (Airy, 1950). Detasseling is started as soon as the tassel has emerged and can be grasped by hand. This stage usually occurs when the lower tassel branches begin to spread. Detasseling must be done prior to emergence of silks in the female plants. The tassels are removed by a steady upward pull and dropped to the ground.

5. Harvest.

Harvesting of hybrid seed requires proper timing to avoid yield loss, seed mixtures and damage to the seed. Maize seed is harvested as soon as the kernels reach physiological maturity, which occurs when moisture is approximately 30 to 38%. Harvest the seed crop as soon as it is mature. This 1) reduces risk of delays due to adverse weather conditions, 2) losses from insect damage, and 3) losses from ear and stalk rots and other diseases. All of these factors contribute to the quality of the seed crop.

Seed maize ears usually are harvested with pickers that leave a part of the husk intact, instead of with combines that shell the grain. The advantages of ear harvest are: 1) seed can be harvested at a high moisture level without excessive seed damage, 2) damaged, diseased, and off-type seed can be removed by sorting ears before drying, 3) ears can be dried more uniformly than shelled seed, and 4) harvest of ears instead of grain results in higher seed quality.

Maize seed processing.

As part of the diversification program, TSS received a grant from the Council of Agriculture and established a modern seed processing plant. The processing plant can handle about 2,000-2,500 t of seed maize in one year. The detailed processing procedures are described as follows (**Fig. 7**) (Huang 1992, Kuo 1992):

1. Seed drying .

The equipment for seed drying consist of ear and seed dryers. At physiological maturity, maize ears with 28-35% moisture content are harvested and dried in ear dryers to 18-20% before shelling. Seventeen ear dryers have been installed in TSS. Each ear dryer circulates with 38-42 ^{0}C hot air. It can reduce moisture content of 15-20 t of maize ears from 35% to 18-20% in 48-60 hrs. Shelled seed maize usually has a moisture content of 18-20%, but it should be reduced to about 11% before being packed and placed in cool storage. Seventeen seed dryers have been established. These use 38-42 ^{0}C hot air; with each can reduce moisture content of 10-15 t from 18-20% to 11% in 35-40 hrs. To prevent seed cracking while being dried maize seeds should be fanned with cool air for 30 to 60 min. before being placed in the storage room. The efficiency of maize ear and seed dryers is shown in Table 1.

2. Shelling.

To prevent seed breaking or cracking the moisture content inside the seeds should be reduced to 18-20% before maize ears are shelled, and shell at slow speed (375 RPM). 10-15 t of maize ears can be shelled in one hour.

3. Grading.

Before bagging, the shelled seeds are placed into the air screen cleaner first, then passed over a series of sloping shaker screens with different hole sizes to remove unwanted seeds and other materials. The hole sizes range from #16-22.

4. Seed treatment and bagging.

For protecting the maize plants from downy mildew *Peronosclerospora sacchari*, the graded maize seeds have to be treated with 17.5% W.P. Apron. Experimental results (**Table 2**) show that 5 cc of 17.5%

W.P. Apron mixed with 10 cc water for treating 1 kg maize seeds gave satisfactory effectiveness against downy mildew (Chang 1980). The treated maize seeds are dyed a red color to indicate sowing use only. Then the treated seeds are dried by hot air before being packed into cloth bags (60 kg/bag).

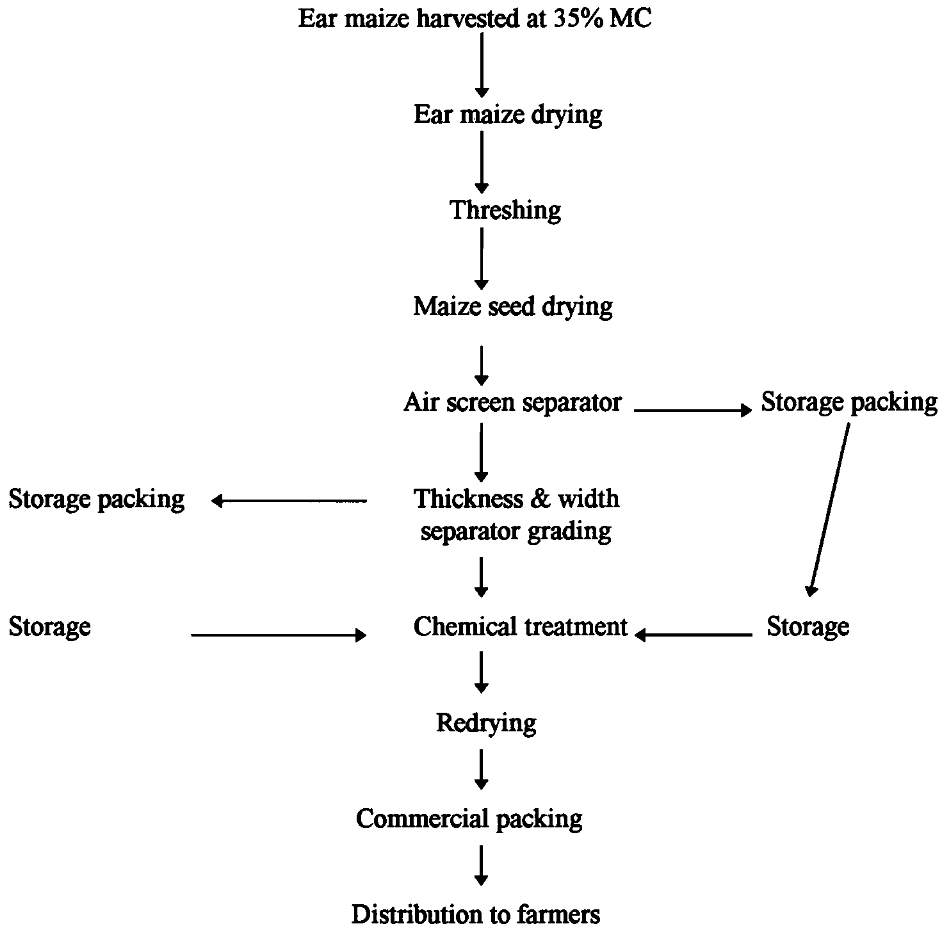

Fig. 7. Procedures for hybrid maize seed processing.

The cloth bags are lined with plastic bags. The treated seeds stored for 12 months still effect germination well (**Table 3**). After being inspected by Provincial Seed Testing Laboratory (PSTL) and the Dept. of Agric. and Forestry, the maize seeds are packed and stored in cool rooms (15 C and 55% R.H.).

Table 1. Efficiency of dryers for maize ears and grains.

Type of dryer	Capacity (t)	Time needed to reduce 35% MC to 20% in ear and MC 20% to 11% in seed (hr.)
Maize ear	15.0-20.0 (35% MC)	48-60
Maize seed	10.0-15.0 (18-20%MC)	35-40

Maize seed marketing.

There are two parallel seed development systems in Taiwan. One is for staple crops such as rice, maize, sorghum, peanuts, soybeans, sweet potato, etc. This requires a large volume, but with low unit price and profit margin. It did not attract the private sector. Therefore, its' research, seed multiplication and marketing were handled by the government. The other is for horticultural crops such as vegetables and flowers. This involved a massive number of species. Because of its higher economic value, it has become the main body for Taiwan seed trade development operated by the private sector.

Table 3. Effects on germination of seed maize treated with Apron and storage duration.

Storage temp.	Treatment	Storage duration (Month) 1	4	8	12	Ave.	S.D.
6°C	[a] TA_5	94.2a	90.0ab	90.2a	91.3ab	92.0	1.8
	[b] TA_2	94.0a	94.5a	91.3a	91.8ab	93.2	1.3
9°C	[c] CK_0	95.8a	93.0ab	91.2a	92.3ab	94.2	1.7
15°C	TA_5	95.3a	88.9 b	91.4a	92.0ab	92.8	1.9
	TA_2	95.3a	90.8ab	92.4a	92.2ab	93.7	1.8
20°C	CK_0	95.3a	92.0ab	92.2a	91.2ab	93.8	1.3
25°C	TA_5	94.0a	90.7ab	91.0a	90.3ab	92.3	1.7
	TA_2	95.5a	90.0ab	91.5a	92.2ab	93.2	1.7
28°C	CK_0	95.2a	94.3a	94.2a	88.3 b	93.7	2.0
	Ave.	95.3	92.1	91.8	91.7	93.3	

Means in the same column followed by same letter not are significant at 0.05 probability level.

[a] TA_5 : 17.5% W.P. Apron 5cc + 10cc H_20/1 kg seed.

[b] TA_2 : 17.5% W.P. Apron 2cc + 10cc H_20/1 kg seed.

[c] CK_0 : 10cc H_20/1 kg seed.

Hybrid maize is categorized as staple crop. The economic value of seed maize in the market is low as compared with horticultural crops. TSS is responsible for hybrid maize seed production and processing. PSTL is in charge of both seed field and processed seed inspections. After passing the inspections, PSTL will issue certificates to the approved processed maize seeds. The certified maize seed will be sold to the farmers through the county Farmers' Associations (**Fig. 9**). Hybrid maize seed prices per kg varied among varieties, they were sold from US$1.96 to 4.46 according to the kind of variety (**Table 4**).

Concluding words

The importance of good quality seed to agricultural development does not need further elaboration. Taiwan seed industry has a long way to go before reaching the level of the developed countries. Because of this lower level of development and the smaller scale farming in Taiwan, its' experience may be useful to the late comers without being too advanced or sophisticated. We, the people of Taiwan, as members of

3. Indoor test **(Fig. 8)**

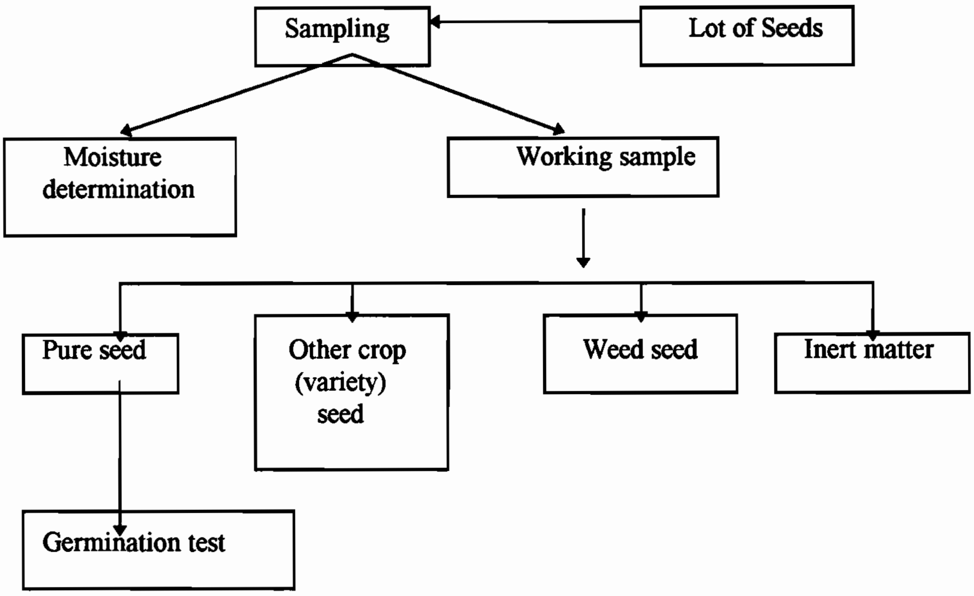

Fig. 8. The procedures of indoor testing for seed maize quality.

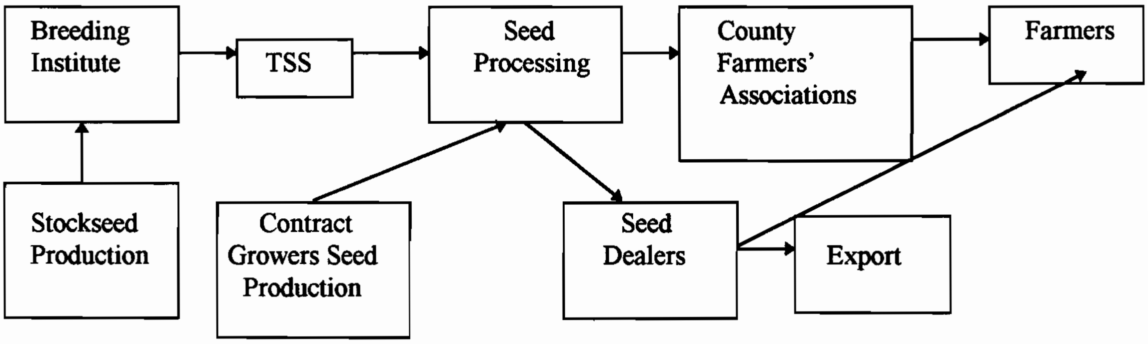

Fig. 9. Hybrid maize seed production and marketing flow chart.

this even-globalizing world, are willing to share our experience with all friends, to reciprocate the assistance received from the world community. Hopefully this may assist in a way to a better circulation of information and good seed. Hence there will be better agricultural productivity and well-being for the people of the developing countries.

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Table 4. Hybrid maize seed prices (US$/kg) of extension varieties (1985-1994)

Year	Tainan No. 5	Tainan No. 11	Tainung No. 351	Tainan No. 16	Tainan No. 17	Tainung No. 1
1985	2.42	1.96	2.88	2.88		
1986	2.42	1.96	2.88	2.88		
1987	2.42	1.96	2.88	2.88		
1988	2.42	1.96	2.88	2.88		
1989	2.42	1.96	2.88	-	4.23	
1990	3.30	1.96	2.88	-	5.23	3.23
1991	3.30	1.96	2.88	-	5.23	4.46
1992	3.30	1.96	2.88	-	5.23	4.46
1993	3.30	1.96	2.88	-	4.46	4.46
1994	3.30	1.96	2.88	-	4.00	4.46

MAIZE SEED PRODUCTION IN THAILAND.

Chamnan Chutkaew [1], Teerasak Manupeerapan [2], Thomya Thonglueng [3]

Abstract

Maize seed production in Thailand involves both the public and private sectors. The public sector is the Dept. of Agric., the Dept. of Agric. Extension, and Kasetsart Univ. The private sector consists of six large private seed companies and other smaller local companies. Good seed of High Yielding Varieties (HYV's), especially hybrid seed, is of great importance because of a decrease in the maize planted area, a low average yield per unit area, and a supply of good seed inadequate to meet the demand. The country needs maize seed for planting on upland and lowland (paddy fields), and seed for special purposes, e.g. baby maize. The maize seed needs for upland planting are approximately 40,000 t/year. The maximum annual seed production for OPV's and hybrids were 2,902 t and 12,000 t, respectively, which supplied approximately 37% of the demand.

The distribution channels of seed from producers to farmers are grain merchants, agro-chemical shops, key farmers, agricultural cooperatives, the Bank of Agriculture and Agricultural Cooperatives (BAAC) and Government Seed Centers. The inbred lines are available at KU for a nominal royalty paid to the university. Through collaboration in research and development as TEAMWORK in national and international programs, viz. Inter-Asian Corn Program (IACP), Asian Regional Maize Program (ARMP), Tropical Asian Maize Network (TAMNET), and Asia-Pacific Seed Association (APSA), it has been possible to identify good varieties and hybrids and to distribute good germplasm and/or seed to member countries. Training of junior maize scientists and exchange of visiting scientists in both field maize and baby corn would help groom future generations of researchers.

Over the past four decades, (1950-1993), maize has become one of the leading economic crops of Thailand, second only to rice, important both as an export crop and as an animal foodstuff. The maximum export of maize grain was 3,981,440 t in 1986, and the maximum value of maize grain exports was Baht 10,149,816,000 in 1984 (**Table 1**). Also important is canned baby corn, exports of which have risen from only 67 t, worth Baht 800,000, in 1974, to 46,963 t, worth Baht 963,730,000 in 1994 (**Table 2**). In addition, fresh baby corn earned Thailand a maximum of Baht 47,900,000 in 1992 (**Table 3**).

The country's average maize planted area has increased during each of the past four decades (**Table 1**). However, average yields of 1.98, 1.95 and 2.33 t/ha for the past three decades, respectively, are not satisfactory. As a result, the increased demand for good quality grain by the rapidly growing feed industry in Thailand led to imports of more than 300,000 t of maize grain from the People's Republic of China in 1992. Another 200,000 t of maize grain was imported in 1995.

There is thus an urgent need for research and development work on high-yielding cultivars with resistance to diseases and pests and wider adaptability. One possibility for such cultivars is to plant them during the dry winter season in paddy fields where irrigation water is available.

Seed production and supply.

Although maize is one of the leading economic crops, the planted area declined after 1991 because of replacement by other crops like sugarcane and cassava, drought hazards and the decreasing price of maize grain. Thus, to compensate for the reduction of planted area, a diversity of high-yielding cultivars of maize is required for farmers. It is estimated that maize seed demands for uplands are approximately

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40,000 t/year, not including seed requirements for baby corn and for maize grown in paddy fields (Chutkaew and Paroda, 1994).

Major maize seed production agencies in Thailand are as follows:

Public sector. Kasetsart Univ. (KU) produces foundation seed of open-pollinated varieties and hybrids for both the public and private sectors. Seed production varies from year to year, the maximum being 639 t in 1988 (**Table 4**). Inbred line production for sale to seed producers is also undertaken by KU. KU has so far released 44 inbred lines (Ki 1-Ki 44).

Table 1. Maize production and exports of Thailand, 1980-1993.

Year	Planted area (,000 rai)	Production (,000 t)	Exports (,000 t)	Yield kg/rai	Value (,000 Baht) [1]
1980	1,434	2,998	2,094	335	7,200,830
1981	1,567	3,449	2,200	352	8,235,775
1982	1,679	3,002	2,300	368	8,230,850
1983	1,688	3,552	2,269	363	8,386,784
1984	1,817	4,226	2,431	389	10,149,816
1985	1,980	4,934	2,575	412	7,609,049
1986	1,786	4,309	2,375	380	9,176,194
1987	1,751	2,781	2,050	328	3,866,564
1988	1,835	4,675	2,550	408	3,713,600
1989	1,786	4,393	2,456	393	4,087,412
1990	1,746	3,722	2,406	385	4,141,260
1991	1,475	3,793	2,713	434	3,913,280
1992	1,351	3,672	2,969	475	531,125
1993	1,339	3,328	2,731	437	718,982
Average	1,749	3,832	2,456	372	7,064,626

[1] 25 Baht = 1 US dollar.

Source: Center for Agricultural Statistics, Office of Agricultural Economics, Ministry of Agricultural and Cooperatives, Thailand.

The Dept. of Agric. (DOA) produces foundation seed of open-pollinated varieties for both the public and the private sectors. Maximum production was 110 t in 1992 (**Table 5**). Seed Div., Dept. of Agric. Extension (DOAE) is also engaged in maize seed production and distribution on a non-profit basis, the seed being used in such government programs as disaster (drought and flood) relief, natural good-variety seed exchange projects and crop promotion projects. Maximum open-pollinated variety production was 2,650 t in 1991 (**Table 5**).

The primary objectives and responsibilities of the public sector seed production are as follows:

a). to multiply high quality seed improved high yielding varieties;

b). to encourage and promote farmers' understanding and use of high quality seed of improved varieties;

c). to act as a center for seed technology that provides technical training for agricultural specialists, workers, farmers, students and the public in production, processing, storage, and use of high quality seed, and also seed testing and analysis services; and

d). to cooperate with other agencies concerned with seeds, crops, agriculture, and national economic and social development for both domestic and foreign markets.

Table 2. Quantity and value of Thailand's exports of canned baby corn, 1974-1995.

Year	Quantity (t)	Value (million Baht)
1974	67.00	0.80
1975	57.50	1.40
1976	234.50	3.60
1977	552.50	8.90
1978	489.40	9.50
1979	865.90	17.30
1980	916.50	21,40
1981	962.30	22.40
1982	1,495.71	36.60
1983	4,014.21	89.60
1984	4,468.30	101.10
1985	6,280.60	141.50
1986	11,316.90	230.60
1987	17,251.30	335.50
1988	25,615.90	489.90
1989	33,322.52	710.92
1990	26,794.59	536.79
1991	41,145.19	961.49
1992	36,766.29	826.17
1993	34,557.34	756.20
1994	46,963.06	963.73
1995 (Jan.-Apr.)	18,146.81	383.72

[1] US$ = 25 Baht.
Source: Dept. of Export Promotion, Min. of Commerce, Thailand.

ii) **Private sector.** Major maize seed supply companies operating in Thailand are Charoen Pokphan (CP), Cargill, Ciba Geigy, Pacific Seeds, Pioneer, and Uniseeds, besides many small seed companies.

Total seed production of both OPV's and hybrids, by public and private seed sectors, was about 12,490 t in 1994 (**Table 6**). Against the total maize seed demand of about 40,000 t/year, hybrid maize seed usage was only about 30% in 1994 (**Table** 7).

Despite the presence of six large private seed companies, government infrastructure for seed production and supply, and many small seed companies, the low average national maize yields and production are unsatisfactory. This may be attributed to lack of high yielding varieties (HYV), insufficient quantities of HYV seed reaching farmers, unfavorable environmental conditions (like drought and floods), inappropriate government policies, and administrative problems. The success of maize research and development in Thailand (Chutkaew, 1989, 1993; Chutkaew *et al.*, 1993) has involved cooperation through different agencies viz. AID, the Rockefeller Foundation, CIMMYT, FAO of the UN, and JICA, besides that of many visiting scientists.

Table 3. Quantity and value of Thai fresh baby corn exports, 1988-1995.

Year	Quantity t	Value (million Baht)
1988	2,220	38.6
1989	1,476	33.4
1990	1,785	43.5
1991	1,666	41.1
1992	1,929	47.9
1993	2,066	25.1
1994	2,522	36.7
1995 (Jan.-Apr.)	1,107	19.5

Source: Dept. of Export Promotion, Min. of Commerce, Thailand.

Table 4. Maize seed production (kg) of the National Corn and Sorghum Research Center (Suwan Farm) of Kasetsart University, 1985-94.

Year	OPV's	Hybrids	Total
1985	351,544	29,113	380,657
1986	328,613	24,610	353,223
1987	408,852	10,656	419,508
1988	614,181	25,277	639,458
1989	586,450	9,890	596,340
1990	471,197	6,349	477,546
1991	157,092	9,990	167,082
1992	98,670	36,080	134,750
1993	140,850	52,230	193,080
1994	53,250	50,000	103,250

Participation in international programs.

International Research and Development (R & D) efforts in which Thailand has participated include the following:

i). The Inter-Asian Maize Program (IACP), initiated in 1964, conducted meetings on R & D activities every year in different Asian countries for a period of 12 years, during 1964-75.

ii). The Asian Regional Maize Program. The termination of the Rockefeller Foundation program led to CIMMYT's initiative with this program. The purpose is similar to IACP and its meetings are held every three years.

iii). The Tropical Asian Maize Network (TAMNET), has been initiated with mutual agreement by the participants of the First South-East Asian Maize Workshop, CIMMYT, and FAO at the Asian Institute of Technology (AIT), on January 12-15, 1993.

iv). The Asian Regional Maize Planning and Coordination Meeting. This is a collaboration between national programs from countries with similar research problems, and includes assignment of responsibilities and identification of resources for implementation of identified projects (Chutkaew, *et al.*, 1994).

v). The International Training Program in Field Corn Breeding and Production for 12 maize scientists from six countries. This training for Bhutan's maize scientists was held at KU in 1993 with support from the Bhutan German Seed Project. Another training for 10 maize scientists of five nations with FAO and KU support was financed by France, and held in 1994.

vi). The International training program in Baby Corn Production and Processing for 15 maize scientists from 15 countries for two weeks, June 26 to July 7, 1995. The program was held at KU with FAO support.

Table 5. Open-pollinated maize seed (t) produced by the Department of Agriculture (DOA), and Department of Agricultural Extension (DOAE), Ministry of Agriculture and Cooperatives (MOAC), 1987-1994.

Year	DOA	DOAE	Total
1987	96.4	-	96.4
1988	94.9	-	94.9
1989	100.6	1,710	1,810.6
1990	90.8	2,223	2,313.8
1991	95.0	2,650	2,745.0
1992	110.0	2,439	2,549.0
1993	108.2	554	662.2
1994	100.0	287	387.0

Table 6. Open-pollinated and hybrid maize seed (t) produced by public and private sectors, 1981-1994.

Year	KU (OPV's & Hybrids)	DOA & DOAE (OPV's)	Private Sector Hybrid	Total
1981	-	-		
1982	-	-		
1983	-	-		
1984	-	-		
1985	380.7	-	1,740	
1986	353.2	-	1,810	
1987	419.5	96.4	1,368	1,883.9
1988	639.4	94.9	1,700	2,434.3
1989	596.3	1,810.6	3,600	6,006.9
1990	477.5	2,313.8	5,050	7,841.3
1991	167.1	2,745.0	6,700	9,612.1
1992	134.7	2,549.0	7,700	10,383.7
1993	193.1	662.2	9,000	9,855.3
1994	103.2	387.0	12,000	12,490.2

Table 7. Hybrid maize seed use, 1981-1994.

Year	Quantity (t)	Percent requirement net	Planted area (,000 rai)
1981	40	0.10	2.08
1982	145	0.36	7.68
1983	449	1.12	24.00
1984	897	2.24	47.84
1985	1,740	4.35	92.80
1986	1,810	4.53	96.48
1987	1,368	3.42	72.96
1988	1,700	4.25	90.72
1989	3,600	9.00	192.00
1990	5,050	12.63	269.28
1991	6,700	16.75	357.28
1992	7,700	19.25	410.00
1993	9,000	22.50	480.00
1994	12,000	30.00	640.00

Source: Dept. of Agric. Extension (DOAE)
Note: Demand for maize seed is approx. 40,000 t/year and the planting rate is 18.75 kg/ha.

vii). The five month long International training program on maize crop management July-November 1995, at Suwan Farm, Thailand. Cosponsored by ADB, CIMMYT, KU, DOA, DETEC, and NARS, there were 17 participants from 15 nations undergoing this training.
viii). The International Hybrid Maize Training Program was held for one week at Nakhonsawan Field Crops Res. Center, Thailand, on September 18-22, 1995.
ix). Maize Quality Improvement Center. Established with aid from JICA and the Dept. of Agric., Min. of Agric. and Cooperatives in 1988. Co-sponsored by CIMMYT and DOA, there were 14 trainees from 8 countries.

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NEW DEVELOPMENTS IN MAIZE RESEARCH AND PRODUCTION IN VIETNAM

Tran Hong Uy [1] and Pham Van Bien [2]

Food Production in Vietnam, 1985-95

The strategy of food production by the year 2000 A.D. in Vietnam aims at achieving a target of 30 million tons, comprising 26 million tons rice, 3 million tons maize, and 1 million tons of other food crops such as sweet potato, potato, and cassava. The objective is to satisfy food demands of its population (expected to reach 80 million by 2000 A.D.), as well as taking part in the Asian export market. To achieve the stated targets, a broad 3-point program of Govt.-controlled measures, as indicated below, has been initiated.

1. Investment in domestic research to develop new technologies, and introduction of selected technologies from other countries. Investment in extension work to transfer appropriate technology to farmers, including organizing technology training courses for farmers. Wider publicity of improved maize production demonstration models is included in this exercise through use of all available communication channels.
2. Policy initiatives for rapid adoption of new technologies such as making farmers owners of land in the long term, reducing the agricultural tax, subsidizing the new seed and irrigation prices, and providing loans at low interest rates etc.
3. Making available the market mechanism for farmers to sell their produce, thus leading to quick recuperation of capital involved.

Thanks to these three measures, the food output in Vietnam has increased during this decade. Data in **Table 1** indicates the production status of two cereal crops in Vietnam during 1985-95.

During the last three years, maize area has negligibly increased, but yield and production have quickly increased by use of highly productive hybrids and the application of new agronomic practices, such as use of more fertilizer. This was possible because the government allowed the price of maize grain to go up, encouraging farmers to spend more on inputs of seed and fertilizer to increase yields per unit area. New open pollinated high yielding varieties, such as CV-1, CV-2, VN-1, HL-36, and MSB-49B have been released and cultivated in the high mountain areas and other difficult ecosystems. The use of both non-conventional and conventional maize hybrids has quickly expanded in fertile soil areas with irrigation and intensive farming. In 1995 25% of the total maize cultivated in the country was hybrid maize. This was achieved in only 6 years, starting with hybrid demonstrations in 1990. Presently, the average national maize yield is more than 2 t/ha. Hybrid maize average yields are more than 5 t/ha, with yields up to 11 t/ha in fertile soil areas.

The coming years will witness adoption of hybrid maize at a much faster rate, with expansion of cultivation of non-conventional maize hybrids in difficult ecosystems, and of conventional hybrids, especially single cross hybrids, in fertile soil areas. By 2000 A.D., the area under maize cultivation is targeted at one million hectares, of which 40-50 per cent will be under hybrids.

Efforts in research and production must be strengthened since demand for maize is increasing at a fast rate. For example, maize grain requirement as animal feed alone will be 2 million tons in 1996. While Vietnam could export 50-10000 tons grain per annum in the past, the country had to import 40000 tons of maize grain in 1994-95, even with domestic production at 1.2 million tons.

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Research Efforts in Maize Breeding and Agronomy.

i) The OPV breeding program.

Since 1973 many OPV's have been developed (**Table 2**). VN-1 and CV-1 are new drought and saline-acid tolerant varieties. TSB-1, CV-1 and VN-1 are downy mildew resistant varieties. Most OPV's originated from CIMMYT germplasm. VM-1 and VN-1 have yield potentials approaching that of hybrids.

Table 1. Total output and sown area of rice, maize, and all food crops.

	Production (1,000 t)			Sown area (1,000 ha)		
Year	Rice	Maize	All Food Crops	Rice	Maize	All Food Crops
1985	15,874.8	587.1	18,200	5,703.9	397.3	6,833.6
1986	16,002.9	569.8	18,379.1	5,688.6	400.9	6,812.3
1987	15,102.6	561	17,562.6	5,588.5	405.6	6,709.9
1988	17,000	841.8	19,583.1	5,726.4	510.5	6,697.8
1989	18,996.3	837.9	21,515.6	5,895.8	509.4	7,089.6
1990	19,225.2	671	21,488.5	6,027.7	431.8	7,110.9
1991	19,621.9	672	21,989.5	6,302.7	447.6	7,448.0
1992	21,500	707	24,000	6,442.8	457.4	7,614.6
1993	22,836	900	26,000	6,559.0	500.2	-
1994	23,528	1,000	27,000	6,598.0	511.3	-
1995	24,000	1,200	-	6,600.0	520.0	-

Table 2. Characteristics of OPV's.

Variety	Maturity	Yield potential	Special characteristics
TSB-2	Early	3-5 t/ha	
MSB-49	"	"	
MSB-49B (VIEMYT)	"	"	
HLS	"	"	
TSB-1	Medium	3-6 t/ha	Downy mildew resistant
TH-2A	"	"	
TH-2B	"	"	
CV-1	"	"	Tolerant to drought, downy mildew, and saline-acid soils
VN-1	"	"	Tolerant to drought, downy mildew, and saline-acid soils
LH-36	Late	5-7 t/ha	
VM-1	"	"	

ii) The hybrid maize program (HMP).

This program was initiated in 1973. In 1988, some single crosses and double crosses were tested. In 1991, the initial hybrid sown testing area was about 500 hectares, comprising hybrids developed by NMRI, and imported from Pacific Seed Ltd. Co., CP Group, Bioseed Genetics Vietnam Joint Venture Ltd., Ciba Geigy, Uniseed Ltd. Co, Cargill and Pioneer.

During 1992-95, NMRI released many non-conventional hybrids (designated LS). LS-3 to LS-5 are early maturity, yielding 4-6 t/ha; LS-6 is medium maturity, yielding 5-6 t/ha; and LS-7 and LS-8 are late maturity, yielding 5-7 t/ha. The farmers happily accept these hybrids because they can easily get yields up to 5 t/ha. Also, these hybrids cost only 1/3 to 1/4 of imported double crosses. In adverse areas, the yield of non-conventional hybrids is higher than the yield of conventional hybrids.

Since 1990, the conventional hybrid (designated LVN) program has been strengthened, particularly to meet the requirement of the intensive farming areas such as Mekong River Delta, North Eastern area, and Central Plateau. Thanks to these conventional hybrids, yields and total maize production have sharply increased in these areas. NMRI's conventional hybrids (see **Table 3**) are being increasingly accepted by the farmers.

Table 3. Characteristics of conventional hybrids.

Convention hybrid	Maturity	Yield potential
LVN-1	Early	5-9 t/ha
LVN-2	"	"
LVN-4	"	"
LVN-20	"	"
LVN-5	Medium	6-10 t/ha
LVN-9	"	"
LVN-11	"	"
LVN-12	"	"
LVN-10	Late	7-13 t/ha
LVN-16	"	"
LVN-19	"	"

Researches related to maize agronomy include efforts in promoting maize and legume crops as important components of spring crops in the Mekong River Delta and Central Coastal areas, which generally cultivate three rice crops in a year. Also, the use of early maturity drought and cold tolerant cultivars as an additional crop in north mountain areas is encouraged. Planting maize and soybean as inter-crops with zero-tillage after two rice crops in the Red River Delta in north Vietnam is a new research thrust.

Production and Supply of Maize Seed

Annual hybrid maize seed production in the country is about 1,200 tons, of which 60% is of non-conventional maize hybrids. In recent years, about 920 t of hybrid seed has been imported. The production of seed of OPV's, which is done by provincial seed companies, amounts to 1,500 t. There is considerable price difference between different types of hybrid seed sold within the country. The ratio domestic seed price:grain price varies from 2.26 for OPV's, to 10.71 for single cross hybrids. For imported hybrids, the range in ratios was 8.57-23.3. In 1996, the country is expected to cultivate hybrid maize on about 180,000-200,000 hectares, which will continue to increase in future. The Government's main emphasis remains to boost production of the two must important cereal crops (rice and maize), with efforts to expand hybrids in both.

Comments/questions:
Sarasutha, Indonesia. You told that the constraints to develop hybrid seed utilization in Vietnam come from farmers' weakness such as lack of capital, etc. I think, this is also our problem in Indonesia. How will the Vietnam government solve the problem to develop hybrid seed utilization at farmers level?

Answer: 1) Extension. 2) Seed subsidy. 3) Local government investment.

INAUGURAL SESSION

Chairman: Dr. A.S. Khehra, Vice-Chancellor, PAU, Ludhiana, India.
Chief Guest: Lt. Gen. (Rtd.) B.K.N. Chhibber, His Excellency, the Governor of Punjab.

Dr. K.S. Aulakh, Director of Research, PAU, Ludhiana welcomed the delegates from India and other Asian countries of the region. While welcoming the delegates, he remarked that maize is an important cereal crop of Asian region. Accordingly, the varieties must be developed for higher yield with disease and pest resistance. Dr. Delbert Hess, Director, Maize Program, CIMMYT, Mexico in his remarks stressed for quality seed production to maximize maize production in the Asian region, as seed is the basic input to maximize production and productivity. Dr. E.A. Siddiq, Deputy Director-General, ICAR remarked that maize production and productivity in India have almost doubled, but the area remained the same over the years. He emphasized on increasing productivity in the states of Rajasthan, MP, UP and Gujarat. He also laid emphasis on *rabi* cultivation of maize as it can produce as much or higher than 6 t/ha of grain. In his strategy to increase productivity, he laid emphasis on use of early composites and single cross hybrids, use of temperate germplasm, resistance to important diseases and insects, and post-harvest losses. He also emphasized on alternative uses of maize to diversity production for oil, starch, breakfast foods and many other products of commercial and industrial value. He further underlined for the exchange of germplasm and collaborative research programs to solve specific problems related to maize production in India and elsewhere in Asian region.

Dr. Carlos De Leon, Maize Specialist, CIMMYT, Bangkok, highlighted the workshop's planning and technical program. He emphasized that the workshop was oriented towards understanding the status of quality seed production in the Asian region by the public and private sectors, and other problems and their solution in the region in the form of panel discussions. Dr. A.S. Khehra, Vice Chancellor, PAU, Ludhiana in his remarks said that the workshop has gathered 100 participants, of which 46 were from 15 other Asian countries. His remarks focused on the launching of the then first All India Coordinated Research Project on Maize (now, Directorate of Maize Research) in 1957 in India. He said that over the years, maize productivity increased more than 200%. He emphasized on the use of germplasm from CIMMYT and elsewhere, and on the use of composites and hybrids. He pointed out the use of Tuxpeno cycle 7 germplasm in developing heterotic pools along with the locals - and extracting inbreds and their use in the development of single cross hybrids. He also emphasized on tailoring plant types as per need of the region.

Lt. Gen. (Rtd.) B.K.N. Chhibber, His Excellency, the Governor of Punjab, highlighted that production of food grains in India increased 7-fold; from 3.2 to 21.8 million metric tons, over the years. He remarked that Punjab is the food basket of the country, which has been possible with the help of ICAR, CIMMYT and other International Institutes. He pointed out that maize has wide industrial uses apart from its use as food, feed and fodder. He said that further emphasis must be laid to diversify its uses as pop corn, sweet corn, baby corn, oil, starch, breakfast foods and others. He further emphasized on the use of diverse germplasm from CIMMYT for further improvements in maize production. He said that the international institutes are going to play a greater role in further boosting food production and therefore, full advantage must be taken by different countries. Dr. N.N. Singh, Project Director (Maize), India, proposed a vote of thanks for one and all on behalf of ICAR, PAU, ARMP and CIMMYT. He specially thanked the Governor, Lt. Gen. (Rtd.) B.K.N. Chhibber, the Vice-Chancellor Dr. A.S. Khehra, and the CIMMYT scientists - Drs. Delbert Hess, S. K. Vasal, Shivaji Pandey, Carlos De Leon and James Lothrop for their presence in the Asian Regional Maize Workshop.

Session I - Status of the seed situation in Asia

Moderator & overviewer: Dr. Mogens Lemonius.
Panelists: China, India, Philippines, Thailand, Vietnam.

After an overview given by Dr. Lemonius, five country reports viz. China, India, Philippines, Thailand and Vietnam were presented. In his overview, Dr. Lemonius emphasized that performance of the region's seed sector should be seen in view of an increasingly tight cereal supply situation which was threatening food security. There was thus an urgent need to increase productivity in cereal production. The need for more maize production was further emphasized by increasing demand for feed, and changes in Asian diets. Among the country reports presented, the impressions gained were as follows.

Data available from CIMMYT and FAO illustrate that maize productivity is closely related to the availability of quality seed and other inputs. Countries which have been able to supply substantial quantities of quality seed with a high proportion of the seed being hybrid seed, such as China and Thailand, have considerably higher maize yields than countries in which the supply of quality seed was limited, such as India and Philippines. China now has 21 m ha under maize, of which more than 95% is planted with hybrid seed, predominantly single crosses. As a result of this, China reached an average yield level in 1992 of 4.5 t/ha and continued to increase yields, with 5 provinces in the Chinese 'maize belt' in the Northern part of the country being the main suppliers of hybrid seed. China is introducing measures to improve both genetic stability and purity of the hybrids, as well as the germination of the seed. Steps were also taken to secure a more stable seed supply, which would better reflect the demand in the market. It was expected that some Chinese companies would be able to invest in their own varietal development programs. Others might collaborate with research institutions. China has already invited outside seed companies to invest in seed production.

In India, it was assessed that the current maize area of 6 m ha would require 120,000 t of seed. However, only 15,000 t were produced and distributed, of which 60% was hybrids. Most of India's maize area (60%) was in difficult ecologies, where the tendency to grow widely adaptable composites and farmers to save their own seed will continue. The national average yield level was around 1.7 t/ha. Research efforts were needed to improve seed viability and control seed borne diseases, and policies should be developed to further encourage private sector seed supply. Provided the necessary collaboration could be established between public and private parties, a yield level of 2 t/ha in the difficult areas, and 3.5 t/ha in the more favorable areas, should be possible within the next 5-10 years.

Philippines has half of its cereal area under maize, and planted 3 m ha in 1994 with an average yield of 1.5 t/ha. In the same year, the utilization of certified seed was 7,600 t of hybrids and 5, 000 t of OPV's, resulting in a relatively low replacement rate. The report identified the low utilization of quality maize seed as the main obstacle to efficient maize farming in Philippines. The situation was influenced by inadequate seed production and supply facilities, farmers' low purchasing power, transportation problems and lack of farmers' appreciation of the value of good seed. A cereal enhancement program had been introduced and was expected to increase the use of good seed.

Maize area in Thailand was close to 1.2 m ha in 1994 with a yield level around 3.0 t/ha. The country has a well developed private maize seed sector which supplies about 12,000 t of hybrid seed annually. This is being supplemented with less than 500 t seed of hybrids and OPV's from government departments and Kasetsart University. The government's seed program has a clear policy of not supplying maize seed as long as the private sector is performing well. To complement research work done by the private sector, Kasetsart University has developed a number of good hybrids which are available for royalties. A special demand of the seed industry is the need for good baby corn varieties to support Thailand's annual export of canned and fresh baby corn of almost 50,000 t in 1994.

In Vietnam, maize production has been increased dramatically, reaching 500,000 ha area in 1994, of which 100,000 ha were under hybrids, compared to 500 ha with hybrids in 1991. The national average yield in 1994 was 1.8 t/ha. The government will continue to emphasize maize production with the aim to reach one million hectares by the year 2000, with 40-50% under hybrids. Since 1973, a number of OPV's have been introduced to meet the requirements of diverse growing conditions. Since 1992, a number of non-conventional hybrids were released. Vietnam needs to research the introduction of maize in rice areas along the Mekong river, and to develop ways of growing spring maize in the Northern mountainous areas. In recent years, a substantial number of private companies have introduced their hybrids in Vietnam.

Session II - Problems & prospects of seed production in Asia.

Moderator & overviewer: Dr. Zhang Shihuang, China.
Panelists: Bangladesh, Indonesia, Laos P.D.R., Myanmar, Nepal and Sri Lanka.

In Bangladesh, maize area and production has started showing a positive trend with integrated efforts of different agencies including non-government organizations. The marketing of maize grains has been easier with rapid expansion of poultry and dairy industries, with special preference for yellow flint grain. Hybrid cultivars are becoming more popular due to higher yield, but the hybrid seeds are expensive and use is limited to only big farms. It is felt that supply of quality seeds at reasonable prices can help further boost area and production. It was reported that hybrid seeds cost TK 120.00/kg as compared to TK 10.00 for the local OPV's. It is felt that future hybrids and OPV's need to be early and tolerant to drought. Also, participation of national/multinational seed companies is required.

For Indonesia, it was reported that due to increasing demand of maize for food and feed, maize seed has to be imported from other countries. These imports have aided Indonesia to increase production through a maize production intensification program. One of the main reasons for low yields is non-availability of quality seeds in adequate amounts at the right time at an acceptable price. It was reported that there is a big gap between seed and grain prices. Also, the amount of commercial seed produced by the private sector and the state seed company is only 4.03% of the total seed requirement. The data from Indonesia indicated that there is great opportunity to produce quality seeds of improved varieties in areas other than East Java.

Laos, being a small country, grows maize on an area of approximately 37,500 ha. The country uses maize primarily as food, feed and baby corn. It was reported that hybrids from China are giving good results. However, there is a general lack of seed of good varieties, technical personnel and extension workers.

In Myanmar, maize is the second most important cereal crop after rice, giving a national average yield of 1.7 t/ha. Most of the maize grain is utilized as livestock feed, and less than 20% is used as food. There is a decrease in exportable surplus due to increased demand for domestic consumption, particularly for livestock and poultry feed.

In Nepal, maize seed production and distribution is directly controlled by the public sector. During 1993-94, maize area under quality seed in Nepal was 54%. Agro-ecological zone specific varieties, especially for hills, are needed for increasing maize production. Additional resources are needed to undertake hybrid research, and collaboration with private seed companies for seed marketing in potential and accessible areas of Nepal is desired.

In Sri Lanka, low yields (1.39 t/ha) are due to a low seed replacement rate. For boosting production, hybrids are required along with private seed enterprises. A modern seed policy that allows rapid commercialization of the seed is needed.

Session III - Seed situation in Asia (Private-Public Sector).

Moderator: W. L. Trevisan

Some countries like Thailand with very open policy for seed business accomplished in 10 years what took 70 years to be accomplished in the developed world, or 50 years for countries like Brazil or Argentina. The progress from OPV's to double crosses; from double cross to three ways; and from three ways to single crosses in just 10 years is a remarkable accomplishment.

Some strengths and weaknesses of each country that favor progress or represent some challenges for full progress of the seed business in Asia were presented. Country - wise, these are reported below:

Thailand.

- The biggest task for the seed industry was to achieve in 6-8 years what took 70 years to be accomplished in the developed world.
- Climate is not helpful, and most companies still have some problems to find enough good/safe areas to produce seeds.
- Turn-over of hybrids is very fast. Marketing needs to be also fast and very creative.
- The country is still in the early stage of learning how to produce quality single cross seed in large amounts to adequately meet requirements of the Thai market.
- The continuous supply of competitive lines by Suwan farm represents a strong help to the Thai (and other Asian countries) seed companies.

Philippines.

- Very hot/humid condition almost all year around.
- Very difficult to manage harvest, drying and transportation of seed.
- Very difficult to keep high germination standards in the distribution channel.
- Geography of the country and localization of the markets make seed distribution very difficult.

India.

- The *kharif* and *rabi* workable seasons and the huge continental dimensions of the country makes it easy to find good places to produce seeds.
- A tremendous potential to export seeds to other countries in Asia, but needs to resolve the following:

1. Problems in the seed certification process - In general, seed companies do not apply for such certification with the present regulations, which require deposit of parental lines. Certification is a prerequisite for export in India.
2. Seed quality issues - Much needs to be done by the local seed companies to improve the purity and germination standards presently delivered to the Indian farmers.
3. Seed importation for research is a big problem - The local system doesn't respect property rights. Seeds may lose germination before reaching the seed companies. It takes 6 weeks to 4 months to be cleared. Most of the time seed is stored at room temperature.
4. Transportation system makes harvesting/shelling/drying processes very difficult.
5. Small land holders make it more difficult to produce larger amounts of seeds.

Indonesia.

- Small land holdings.
- Hot/humid conditions makes more difficult the harvest/drying/germination maintenance processes.
- Use of F_2 seed of hybrids as seed.
- Advantages are: plentiful irrigated areas, adequate export/import regulations, and high yielding conditions.

Session IV - Researchable issues in seed production of maize.

Chairman: Dr. S. K. Vasal

While discussing the researchable issues involved in maize seed production, Dr. S. K. Vasal, Maize Breeder, CIMMYT mentioned that breeders generally detect the problems only when the hybrids are released for cultivation. He suggested that they should use only good potential lines in a hybrid development program from the initial stages. Consequently, problems faced would be much less in producing good amounts of seed. He invited Dr. N.N. Singh, Project Director (Maize) of India to present various researchable issues.

Dr. Singh pointed out the following issues for producing the quality seed under Indian conditions:

1. Presently 80% of the seed production in India is confined to the states of AP and Karnataka and, therefore, may pose problems of diseases and pests. Identification of alternative areas of seed production for augmentation of quantum of seed produced in India and also to take care of the ecological problem of crop vulnerability to diseases and insect pests was considered a critical requirement. Seed production research in other areas in winter season with assured irrigation in north Bihar and eastern Uttar Pradesh, and in dry regions of Rajasthan, Gujarat, Haryana, western Punjab, western UP, MP, Orissa and West Bengal are necessary.
2. Integrated pest management schedules should be developed to control diseases and insect pests of economic importance region-wise, where seed production program is undertaken. This is necessary as some of the parents may cause problems in seed production.
3. The effect of chemicals on seed viability and in controlling seed borne diseases has to be studied to recommend fungicidal schedules for seed treatment.
4. Studies on effect of aging on seed vigor and viability are necessary for purposes of revalidation of seed lots.
5. Studies are needed on the effect of late sowing in winter season on seed germination, crop vigor and seed yield for enhancing seed productivity.
6. Need for establishing physiological indicators for seed harvesting.
7. Comparison of hand detasseling vs. use of chemical hybridizing agents is needed for economical quality seed production.
8. Study of use of commercial cold seed storages for maintenance of germinability.
9. Seed lots produced in coastal areas have invariably shown poor germinability. So, methods to prolong storability of such seeds also need to be worked out.
10. Characterization of released materials should be done in the manner of meeting international requirements of registrations and intellectual property rights.
11. Need to develop agronomic package of practices and uses of micro-nutrients for higher and economical seed production, especially in the case of single cross hybrids.

He informed the house that in the Hybrid Project, initiated in India since 1989, parents of new experimental hybrids which are in advanced stages of evaluation, are planted at at 2-3 selected locations. Observations are taken by the monitoring team to detect seed production problems, if any. These recommendations also go to the committee at the time of releases, as well as suggestions to develop agronomic packages of seed production of new hybrids, especially of single cross hybrids, before release. For issues like nicking problem, time isolation, male-female ratio, use of male sterility, moisture at harvest, drying after shelling, use of seed dressing chemicals, etc. specific recommendations should be worked out. While producing quality seed, it should be kept in mind that the farmers must get high return. For this, the female parent must have good potential to produce enough seed, and the male should have good pollen dispersal capacity. Selection of seed production areas for producing seed environmentally, and its timely transportation to the farmers are also important.

Session V - Integrating public and private institutions and NGOs involved in agriculture for maize production in Asia.

Chairman: Delbert C. Hess
Moderator: Mangala Rai

Substantiating with statistics on human population attributes, their socio-economic status and maize production in the Asian Region, and comparing it with the situation in the developed world, eastern Europe and undivided USSR, it was clearly brought out by the Moderator that the agricultural requirements and problems of the Asian region are certainly different and distinct compared to the rest of the world. Critical constraints like small-size land holdings, very meager resources at command of the farmer producer and large maize areas in difficult agro-ecologies were found unique to the Asian Region resulting in yawning demand-supply imbalances. Thus, to cater to the larger requirements, the need for integrating efforts by the public-private institutions and NGOs to collectively address the basic problems was considered absolutely necessary. Several positive points peculiar to maize crop viz. its multipurpose nature, unprecedented productivity increase in the last decade in the region in some of the Asian countries, the still available tremendous productivity potential, wider adaptability of the crop, enhanced hybrid maize culture and consequently the greater interest of the private sector, etc. were specifically mentioned to make a strong case for witnessing effective linkages between different types of institutions. Availability of quality seed was projected as the most critical requirement to play the catalytic role in making other agro-production-protection technologies successful in the actual situations. The importance of open-pollinated varieties in maize, which contributed significantly in increasing maize productivity in the region, was mentioned in view of the poor vertical seed replacement rates (average of once in six years) peculiar to the region. The dominating presence of the public sector with only a small beginning of interest evinced by the private sector in the region was especially mentioned to make a case for its continuity and growth in the integrated set up being envisaged in the session. The floor was then allowed for presentations by the panelists and discussion by the audience for subsequently crystallizing issues to develop linkages and modalities by the Moderator at the end.

Dr. Walter Trevisan began by highlighting the critical problem of decreasing budgets in public sector and international organizations like CIMMYT, and the changing trend towards increased usage of biotechnological tools to point towards the greater role of private sector in future in strengthening public-private sector relationship. The shift in CIMMYT's strategy towards development of heterotic pools for hybrid development was appreciated for increased usage of CIMMYT's germplasm in future by the seed industry. Certain mechanisms to promote integration efforts like joint research projects (totally or partially financed), commercialization of developed lines for enhancing their usage, working on a coordinated concept for common targets and customer-oriented training opportunities were proposed by him. Dr. Ester Lopez extensively discussed the advantages and weaknesses of both public and private sector, and highlighted the role played by the NGOs in Philippines in maintaining the local seed production and supply system and in conserving genetic diversity. Dr. J.S. Sandhu, in realization of the general absence of well-established R&D system in private sector companies in India, expect a few (only 12 out of 147 private seed companies), and continuity of greater role of public sector ever since organized agricultural R&D started in India, emphasized for a complementary and supplementary public-private sector relationship. He particularly mentioned the recent thinking and developments in the Indian Council of Agricultural Research for a greater public-private partnership. Dr. P.V. Bien explained the national agricultural research and production system in Vietnam, and made a mention of the constraints faced in increasing maize production, including the constraints in developing effective collaborative programs. From the learned audience, many useful issues and points emerged. The need for public-private collaborative programs particularly for catering to the requirements of difficult ecosystems was highlighted by Dr. N.N. Singh in view of the large maize areas exposed to vagaries of weather.

With this background, the floor was again handed over to the Moderator by the Chairman. In his concluding presentation, Dr. Mangala Rai, the moderator, summed up the session, beginning with outlining the two kind of views emerging from the discussions. One view was to have a supportive role of the public sector, whereas the other moderate view was for a greater complementary, supplementary and augmenting role for the public sector. It was emphasized that a supportive role for the public sector goes with the stage of development of a country and for specific need-based areas, which is appropriate for the developed economies. For the developing countries, public sector should continue to play a leading role. It was indicated that maize cannot be looked at in isolation and much broader guidelines are needed for effecting the needed linkages. All kinds of linkages, whether among and between the public sector institutions, or with private sector companies and NGOs, would be possible only after developing a proper policy framework and followed by result-oriented mechanisms and modalities. A brief mention of the initiative taken in India, the acceptance of Johl Committee Recommendations on public-private partnership, resource generation, contract research, incentive-reward system, etc. by the Governing Body of the Indian Council of Agricultural Research, was made to underscore the need for specifically identifying a few items to make a beginning for effective time-bound public-private collaborative programs. The need for developing issue papers for collaboration was considered critical for addressing to the agri-business research. A clear identification of role of each of the organizations viz. CIMMYT, FAO-RAPA, National Agricultural Research Systems, the private sector and NGOs was considered necessary for making any headway in integrating the efforts of different sectors of involved agencies for ultimately increasing maize production in Asia. Subsequently, Dr. Mangala Rai identified the following specific points and issues for effective integration efforts.

1. A tremendous scope for collaboration between public sector, private sector, NGOs and Farmers' Associations does exist both at the national and regional level. The need is to identify specific research, development and policy issues and specific partners on case to case basis, and wherein there is also a scope for collaboration for both within public sector and with private sector. For the purpose, there should be an apex body at the national level.
2. A fairly good number of initiatives are already on the ground at the regional level. These could be brought under one umbrella, which may be named as CAMP (Cooperative Asian Maize Program), and which can have one establishment office with the endeavor of realizing effective partnerships between important and interesting agencies. Here, the greater role of national program leaders, international institutions, including Asia-Pacific Seed Association should be ensured. The office should address to the requirements of market intelligence and human resource development, and formulate specific programs as a harmonized system to harness the potential. A committee could be formed to formulate the scope, modalities, detailed program, etc.
3. For harnessing higher productivity levels in the Asian Region, the great scope for germplasm enhancement for biotic and abiotic stresses was specifically identified to start with. For this critical requirement, funding system should be explored jointly by NARS, regional and international organizations and lead function of identified centers in the Region be delineated.
4. One country may be given the leadership role to prepare the background paper, which may be approved by CAMP and taken as document for identifying funding and other support.

Session V. Comments/questions:

B. S. Dhillon, Ludhiana, India.
Comments: We can discuss the collaboration of Public and Private Sectors and NGOs at three levels.

1. Sharing knowledge.
2. Sharing germplasm.
3. Providing finances to Public Sector by Private Sector. These can be for research, human resource development (fellowships to students, setting up of chairs, etc.), and for infra-structure development.

Let us deliberate on these issues and identify areas of collaboration.

Sain Dass and V.P. Ahuya, Attar Singh, India.
Comment/question:

It was admitted by the private sector that they are using the public sector bred inbred lines. Is the Private sector thinking to finance the public sector as in the Philippines line development program, for better integration?

Geekay Bhatie, Pioneer Overseas Corporation.
Comment:

Establishment of Agri-business cell in key universities and ICAR system for single window entry.

Research collaborative program on speciality corn.

Germplasm enhancement is related to release of diverse hybrids by different countries, which is increasing over years.

Shivaji Pandey, CIMMYT-Colombia.
Comment:

National maize research programs and selected representatives of private sector should periodically but regularly get together in each country to explore areas of collaboration.

S. K. Bhalla, H.P, India.
Comment:

The agroclimatic conditions in hilly areas differ drastically in different zones and also even in different farming situations existing within a zone. Any hybrid developed by a private company needs to be tested extensively in different farming situations before seed distribution. Since it may not be possible for private seed companies to test their hybrids on their own, it can be done effectively in collaboration with SAU's. Some mechanism needs to be established for collaboration between private and public sector in this regard.

Dayanand, India.
Comment/question:

What kind of interaction is anticipated between Private and Public sector so far meeting the demand of seed of the nation? Is this the collaboration only to exchange the genetic material? If by exchange of genetic material or by their own efforts evolve some good crop variety by any private sector or viz. a viz. by public sector, would all the agencies together produce the seed in order to cater the needs of the nation? If this is not done, there is very little benefit to farmers/users. Government agency should take some measure to take some firm decision to produce the seed material of any good material developed by A or B. If the seed production of good material is not jointly taken care by all the agencies, the purpose of this seminar will be defeated. I strongly feel the seed production of good varieties is important to meet the needs of farmers.

S. N. Singh, India.

Asian region farmers are mostly poor and the soils are showing deficiency of nutrients particularly for nitrogen, since maize is a heavy feeder crop. Nowadays costs of nutrients are going high, thereby increasing the cost of production. Under such circumstances, a project for screening of germplasm for low fertility status should be taken up in collaborative way and should be strengthened by CIMMYT. This would help the poor farmers and boost the maize production in the region.

L. B. Choudhary, India.

Eastern region of the country with special reference to Bihar, there is problem of high moisture stress. There should be a center as on the lines of Pantnagar to advocate for this technology to boost yield.

D. Hess, CIMMYT-Mexico.

My comment relates to a project that has been developed largely based on discussions that took place two years ago in Vietnam. The project is still being circulated among donors with the hope that it will be funded in the near future. The project proposes that a steering committee be formed to guide the research activities, and that one staff member (breeder/agronomist) be added to the CIMMYT-ARMP staff to assist in the execution of the project.

Session VI - Integrating traditional plant breeding with biochemical and biotechnological techniques for increasing maize production in Asia.

Moderator: R. B. Singh

In his opening remarks, Prof. Singh reiterated that conventional plant breeding will remain the center of attention in crop improvement efforts and molecular biology and biotechnology should support the breeding efforts. Biotechnology offers new opportunities such as creation of novel genotypes and pyramiding of genes and the breeders should not remain aloof in making use of this new technology. Thus, there is an urgent need for integration of traditional plant breeding with the fast emerging field of biotechnology for reaching the targets in a more precise manner and with greater speed.

Prof. Singh also reviewed the Asian scenario of high population and food shortages, and the role the maize crop should play in alleviating the problems. He listed some of areas like maturity, temperatization of tropical maize, tolerance to biotic and abiotic stresses, quality aspects, etc., where biotechnology can help.

The panelists reviewed the latest developments in the field of molecular biology and tissue culture, particularly those concerning maize, and surveyed the areas where biotechnology working in concert with conventional breeding can be effective in bringing about rapid improvements. However, the panelists pointed out that this is only an emerging technology and should be viewed as such. Too much can not be expected too soon, and good results are expected only through an integration of biotechnology and breeding efforts. Considering the cost-intensive nature of this new technology, caution was expressed regarding its practice in the developing countries. It was felt that each problem is to be assessed carefully and priority areas decided on the basis of non-availability of solutions through conventional approaches.

The following recommendations finally emerged:

1. There is an urgent need to increase the productivity of maize in the Asian region through solving some of the outstanding problems. Biotechnology has already shown some success. But its potential has to be assessed.

2. Biotechnology and conventional plant breeding should be synergistic and biotechnology should not work in isolation.

3. National priorities as to the use of biotechnology in problem solving are to be set realistically based on the constraints and prospects and not on the basis of the novelty of a technique. The following are the priority areas where biotechnology can supplement the breeding efforts:

   i. Resistance to *Chilo*, stalk rots and *Rhizoctonia*.
   ii. Tolerance to moisture stress (excess water and drought) and cold.
   iii. Quality aspects towards industrial uses.

   The following strategic biotechnology research areas should receive high priority:

   i. Male sterility system.
   ii. Development of homozygous lines through haploidy route.
   iii. Regeneration and transformation ability.

4. The role of the private sector should be positive. There should be openness and truthfulness in reporting results, particularly the failures and limitations of an approach, for proper assessment of the technology.

5. CIMMYT may devolve some of its biotechnological activities to the national maize research and development programs.

6. A Cooperative Asian Maize Program may be established to orchestrate the activities in the region based on commonalties of the problems and prospects and also keeping in mind the on going initiatives and willingness of the cooperators.

Session VI. Comments/questions:

B. S. Dhillon, India.

Integrating biotechnology with plant breeding.

1. Insect resistance. *Chilo* is a serious pest in this region. We should take it as No. 1 priority.
2. Stalk rots. It is a stalk rot complex. We should identify one disease.
3. Drought tolerance and early maturity. CIMMYT is working on drought tolerance. Conventional methods are effective with respect to earliness. Thus, these areas may be left out for the moment.

Vipan Kalis, India.

Has any works been done on resistance against *Erwinia* stalk rot?

J.K.S. Sachan, India.

Comment:

Erwinia stalk rot (ESR) resistance has been observed in several collections of wild *Coix, (Coix spp.). Chionachne koengci* has also shown resistance to ESR. Both *Coix* and *Chionachne* are crossable with maize. Seed development has been observed up to 15-20 days. After 20 days seed collapses, through embryo rescue hybrid plants can be obtained.

K. A. Nayeem, Parbham, India.

Let us congratulate all the molecular biologists for commendable work for Maize Molecular genetics. There are priority areas in maize, and this august gathering decide for the following requirements.

1. Male sterility.
2. DM resistance.
3. Low moisture ear.
4. Short duration.
5. Drought resistance.

Use of computer with molecular probes/markers for identification best combiners and hybrid.

Is there any break down for Bt gene, in case of cotton in USA, it is reported, then what are reasons?

D. A. Dayanand, India.

Comment/question:

1. No one from the private sector has affirmed the area of collaboration in clear cut terms.
2. Private sector is in general working and developing the business for best potential areas. There is need to work for the major 70% area lying in states of Rajasthan, U.P., M.P., and Gujarat for rapid development.
3. What kind of sharing of resources between the two sectors will take place?

A. H. Banday, Srinagar, India.

Material needs to be identified which bears some sort of cold tolerance at the seedling stage and particularly towards the maturity.

D. Hess, CIMMYT-Mexico.

Comment:

At CIMMYT there is significant work going on in both biotechnology and maize breeding. With this effort, CIMMYT should be able to develop effective uses of biotechnology in maize.

However, after much work we are to date not able to identify any techniques than can be transferred to conventional breeders to enhance this work. We now have a staff member working full time on evaluating transgenic plantlets and transferring transformed traits to elite germplasm.

David Bergvison, CIMMYT-Mexico.

1. Bt hybrids released in the U.S. may suffer yield losses as these lines have to be taken out of the conventional breeding program to be transformed. Once incorporated back into the hybrid program two or three seasons of selection will be lost and the associated yield gains.
2. Tranformation projects are expensive and would not be practical for all national programs. Transformants should be generated by a central research organization and the desired gene introduced into locally adapted material through a back crossing program.

Tawatchai Prasatsrisupab, Thailand.

In 1996, Ciba Seeds U.S.A. are going to sell and market in USA with introductory quantity a Bt hybrid corn, namely Maximizer, hybrid corn with knockout built in European corn borer control. It means that the Bt hybrid has been approved by the Environmental Protection Agency (USA). Maximizer hybrid corn showed an average yield improvement of 14.3 bushels per acre when compared to conventional hybrids under exposure to European corn borer infestation.

Sangam Lal, India.

Question:

Whether any work on resistance breeding is done on *Erwinia* stalk rot of maize?

Answer: *Erwinia* stalk rot of maize incited by *Erwinia chrysanthemi pethover zeae* has been a major disease since inception of the All India Coordinated Maize Improvement Project (now, Directorate of Maize Research). We had a project on it since beginning through the financial assistance of PL-480. Almost all the maize genotypes from various indigenous and exotic sources were evaluated through a well standardized technique using syringe method of inoculation. Most of the materials were observed susceptible except few. One of the promising materials noted during early evaluations was Rudrapur Local i.e. CM600, which was used in a released hybrid, Ganga Safed 2. Later, a couple of lines were identified, where some tolerance/resistance was noted at Pantnagar, then considered a hot spot location. Currently, work has been intensified at Dhaula Kuan Maize Center located in Himachal Pradesh (India) on this disease, and a few materials have been identified having good promise. These are being used to incorporate resistance.

Session VII - Future of maize in Asia.

Moderator: Mangala Rai

Important recommendation were as follows:

1. In the likely growth driven dimension, socio-economic analysis keeping maize in the center regionally and globally with competing crops/commodities needs to be worked out with probable alternate scenarios.
2. A technology paper keeping technology in hand and in the pipeline in maize vis-à-vis competing crops needs to be developed.
3. Diversification of maize is needed for meeting the needs of various users. An exact perspective research strategy needs to be devised, considering food, feed, baby corn, pop corn, and oil industry usage of maize. A working group involving researchers, development officials, policy planners, industry, etc. would be important.
4. To realize the worth of technology in hand, greater awareness particularly about hybrids needs to be created, for which on-farm demonstrations by public and private sector need to be initiated.
5. Accelerated single cross hybrid development, with greater tolerance to biotic and abiotic stresses should receive utmost attention.
6. Human resource development, particularly in the frontier areas of technology, was considered important. CIMMYT in association with NARS can devise a strategy and explore this possibility within and outside the region.
7. Pricing policy and effective market intervention system need to be deliberated.
8. Linkages with delineation of areas of responsibility at least in certain specific areas could be thought of.
9. "Maize in Perspective", should be discussed at greater length in the 7th Asian Workshop involving economists, sociologists, researchers and development officials cutting across crops, commodities, disciplines, sectors and sub-sectors. For this, a working paper should be prepared in the next six months and circulated to different institutions/systems/centers/leaders.

Session VII. Comments/questions:

B. S. Dhillon, India.
Comments :

Future of maize in India.

1. Improved varieties must possess stable performance over years.
2. Maize is grown during rainy season. Rains may be less or more. Therefore, improved varieties must possess drought tolerance and excess-water stress tolerance.

Dayonand, India.

1. Dr. Carlos made a mention of re-investigation of agronomic practices for maize with respect to state of Bihar during winter season. I being a component of national program of maize shall feel concerned if the area of agronomic work is pinpointed to take up the work in future.
2. Maize is not a crop for water logged condition. The area may be shifted to water logged crop.
3. I still emphasize there is need to work for 80% dry area.

S. Pandey, CIMMYT-Colombia.
Comment:

Suggest a more thorough discussion on Future of Maize in Asia at next meetings, and include technology, policy, sustainability, comparative advantages, etc. in the discussions.

S. K. Bhalla, H.P, India.

1. In future, no doubt stress should be on hybrids, but since more than 70% area particularly under stress environment where existing hybrids are not likely to do well, the development and

improvement program of OPV's should be given equal importance, in order to sustain and improve yield of maize.
2. Maize production is more than consumption, and as a result farmers are not getting remunerative prices. Therefore in order to provide stimulus to farmers for higher production, there is need to set up industrial concerns.
3. The cost of hybrid seed being distributed by private seed companies is prohibitive i.e. Rs. 60/kg. In order to encourage farmers to grown hybrids, the cost of hybrid seed needs to be controlled.

K. A. Nayeem, Parbhari, India.

Maize area is increasing fastly in the non-traditional areas. The yield potential is high. This will be again high due to use of heterotic pools, single hybrids etc. There is a need to give importance for setting up of Industrial units for different products, so that farmers could get remunerative prices, and propose use of high maize production in future.

The germplasm exchange between public to private. This is very freely being been carried out since more than a decade. At this juncture, it is possible that most of the private organizations have their own germplasm, and derived germplasm. Hence, there should be exchange of germplasm from private to public in future.

S. A. Akhtar, India.

Future of maize should be diverse use as a raw material. Approach for this direction is needed.

L. B. Chaudhari, India.

Future of maize depends on proven technology and its adoption. Since maize cultivation in most of the Asian countries is done under rainfed situation, what action is proposed on the following in future to raise production?

1. Development of early and medium maturity varieties.
2. Varieties for higher moisture content situations.
3. Genotypes for varied cropping systems.
4. Diversification of uses and stability of prices.

Manuel L. Logono, Philippines.

The future of maize in Asian hinges a lot on many issues that we have discussed so far. Technology wise, I think the direction is clear, that is, Asian countries should vigorously engage in hybrid research and promote its adoption among the farmers. But I think there was little discussion on two major issues: 1) Government policy; for example, as farmlands in Asia are rapidly converted into other purposes such as housing, industries, etc. This development does not point to a bright prospect unless appropriate policies are instituted. 2) In the light of the WTO-GATT, the name of the game now is competition. The farmers should be taught how to increase productivity in order to survive in the intense competition. Increasing productivity is not only a function of yield per unit area but also includes other inputs such as irrigation and post-harvest facilities. Unless we address these problems, I am not really very optimistic about the future of maize in Asia.

Rinju Baruah Saikia, India.

There is large area under maize cultivation in high altitude either in India or in Asia. So far as India is concerned there are few high yielding OPV's/hybrids. For a better future of maize in Asia we must develop high yielding OPV's/hybrids for this region.

L.M.L. Mathur, India.

With the ever increasing number of indigenous maize lines in India, there is a strong need to strengthen quality protein (QPM) laboratory at the head quarters to analyze various components of maize, especially oil protein, starch etc. to fulfill the demand of the industry. Maybe, the project could be transferred to India as suggested by Dr. Chamnan.

Sain Dass and V.P. Ahuja, India.
Comment/question: to R. C. Sharma.

1. The isolates of Rhizoctonia should be restricted to the respective countries. The apprehension is that during their handling in laboratories, if some recombinations take place, it may produce super races. The same applies to other diseases also.
2. Do you have any information on the level of performance (yield) of the inbred lines which you have stated as moderately resistant in your finding? If your answer is yes, please comment about the performance. We will like to know further whether you have maintained them in this year or you will supply seeds from the stored remnant seed.

Walter Trevisan, Brazil.

I am glad to see that you are screening for the key diseases for corn production in Asia. I would like to suggest/ask we think about the next step where we would put all these resistance or tolerances into a "multi-disease" resistant tolerant cultivar or line.

Second, we as seed company, would like to have chance to participate in these screenings. We are willing to pay for our entries if the group here decides so. This objective is in line with what we have discussed during this meeting of having joint cooperation to bring the farmers in Asia more stable hybrids/cultivars. And in Asia stability to produce any corn starts with disease resistance.

Thank you, Mr Moderator, for this opportunity.

Question: to R. P. Singh
From : Sarasutha, Indonesia.

1. Talking about price, it usually depends on supply-demand. But you think that in the future of maize in India, higher prices realization?
2. In Indonesia, the price of maize will go down lower than floor price arranged by government at harvest time because of more supply than demand (over production). If farmer wish to store the product, they have not enough money because of high cost of grain/seed store.
3. Would you like to inform me what did you think about higher price realization?
4. Do you advocate to produce maize which has longer storability?

Answers:

1. Yes, till demand is more than supply, the price is going to be higher side. In India, the demand of maize will remain higher than supply due to higher and higher demand for feed and industrial uses, besides for food.
2. If there is situation when supply is more than demand, maize uses need to be diversified and emphasis needs to be given for export. Export can only take when you are competitive to international prices for that too there is need to reduce cost of production per unit of land. This means higher production per unit of land and other inputs.
3. Realization of higher price makes sense only relative to prices in other crops.
4. Higher support price is not good for stable growth in any particular crop, and maize is not an exception. Hence increase is productivity is the answer for stable growth in maize production.

Concluding Session

With the active participation of maize scientists from the public as well as the private sector, the Sixth Asian Regional Maize Workshop thoroughly discussed the maize seed production issues and situation in Asia and concluded to recognize the following major concerns that need critical attention;

1. The quality of maize seed made available to farmers in the region remains to be a priority. Many seed production difficulties have to be solved to increase the quality of maize seed produced, achieve higher efficiency of seed recovery, better seed processing procedures and to maximize seed yields. New areas that will be highly suitable for seed production of maize in each country in the region must be expressed pinpointed. Efforts should be devoted to plan well seed production programs to achieve these objectives specially under situation of small land holdings of farmers selected for seed production.

2. To safeguard genetic purity and germinability of seed products sold, consciousness of each country seed standards is underscored. It is noted that the standards for these are already in place in most of the countries but the successful compliance to such standards should be the joint responsibility of both the seed industry players and the government. In this area of concern, mutual trust and self regulation must be cultivated to be able to deliver best seed products to the farmers.

3. Seed distribution system for maize currently in place in each country must be re-examined to look for areas for further improvement. While geographic location and infrastructures lessen flexibility to enhance better distribution system, careful selection of alternative seed production areas may help to solve the problem. Again, the expected benefits in moving towards this direction must be weighed against increased investment cost, added transport, manpower and other costs.

4. Much of the problems in seed production specially for hybrids can be traced to the issue of the producibility of the hybrids. Characteristics of seed parents such as vigor, ear qualities, nicking, line *per se* performance and reaction to diseases must be emphasized early in the line development stages of the breeding program. Conscious efforts must be exercised utilize inbreeding tolerant maize germplasm sources to sustain progress in this area of concern.

5. In many countries of this region, including those where the seed industry, is already very active the availability of quality maize seed still remains a major issue in maize production programs. In this area the workshop recognizes the strengths and expertise of the private sector in developing markets for their products. Private sector presence and participation in the seed industry should be welcome and where they are already present, growth of the business should be enhanced to gain a wider area of coverage, deliver better products, adherence to fair marketing practices thereby making available quality seed at prices affordable to the maize farmers.

6. The issue of open market policy on maize seed specifically germplasm materials whether proprietary or otherwise was brought up during the workshop. Import or export regulations including quarantine procedures should be reassessed by each country in the light of the benefits that new germplasm products can contribute in broadening the genetic base of materials used for maize breeding research activities. Of particular importance are the sources of resistance to endemic pests and diseases for which new sources have to be introduced. A very restrictive situation and unwarrantedly long quarantine procedures without safeguards is still seen as counterproductive and not conducive to a freer exchange of materials even for research purposes.

7. Once in a while outstanding hybrid products that perform exceptionally well across several environments are released for commercial production in the country of origin. With further testing such materials may also perform very well in other countries. To capitalize on this breakthrough there should be a mechanism for these products to become available to a wider client farmers by allowing other players of the seed industry (smaller seed companies) to produce and market the same outstanding products under

some kind of contract or licensing agreements. Again, the view to an exclusivity clause of use to a product must be re-examined if this thrust is to gain a foothold in the market place.

8. Greater complementary between private - public plant breeding efforts to pursue joint research projects was also underscored. Private plant breeding research efforts are rationally staffed and adequately funded but more often the complementing expertise such as plant pathology, entomology and biotechnology are lacking. Therefore the development of joint research projects to utilize such expertise must be explored. A possible area for joint collaboration is on germplasm enhancement to meet the long term objectives of maize breeding needs.

9. Improved open pollinated varieties (OPV's) continue to be used by maize farmers located in less productive and more marginal areas of maize cultivation in many countries in the region. Given the limits imposed by such environments, the use of OPV's will still bring about benefits to these farmers. Low replacement rates of released OPV's is a major concern that should be overcome by a concerted program of extension and seed replacement at regular interval of 2 to 3 years. And to support such efforts, maize breeding research activities must not shift away completely from developing and continually improving outstanding breeding populations. Hybrid oriented plant breeding initiatives are most welcome but a good balance should be made to serve the needs for improved open pollinated varieties in the marginal areas as well.

10. In the past several years maize breeding work on specialty maize types has received only little attention. But in a few countries work is still going on and some good germplasm products are available. Several countries have expressed desire to develop various types of specialty maize and their collaborative effort in this area should be examined and some action plan be discussed in the next workshop.

11. Research on the application of biotechnology to maize breeding in the region has been receiving a good deal of attention recently. The possible areas for a collaborative work in this regard will be following; a) breeding for resistance to *Chilo partellus*, b) disease resistance to stalk rot complexes, c) abiotic stresses such as drought and excess water and d) breeding for quality aspects such as high oil or high quality protein and other novel characters for industrial uses.

12. A proposal for Cooperative Asian Maize Program was put forward during this workshop with the objective to further strengthen regional collaboration in maize research. However, the emerging consensus was to strengthen the already existing network such as TAMNET rather than replacing it with another. Network that is already in place offer several advantages in terms of organizational structure, operating cost, facilitation of communication work and implementation including access to test locations. All that may have to be done to make the network really achieve its objectives is for everyone to make the network work.

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