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## **Transitioning Maize Seed Industry in India: Sectoral Dimensions**

**R.P. Singh, Ranjit Kumar and N.P. Singh\***

### INTRODUCTION

The maize sector in India has undergone dramatic changes in recent years with the emergence of private seed industry. Maize seed companies, once uncommon, have sprung up in many important maize-producing states and offer farmers a wide range of improved open pollinated varieties (OPVs) and hybrids of different characteristics. Private companies have captured the lion's share of the national maize seed market, and are poised for a big leap in future. The upsurge of the private maize seed industry has important implications for public institutions, hitherto entrusted with the sole task of developing improved production technologies for millions of maize farmers. Public institutions have by and large tried to maintain a synergy between efficiency goals by serving the needs of large-scale, commercial farmers and equity goals by addressing the needs of small-scale, semi-subsistence farmers. The policy reforms introduced in the late eighties gave an impetus to the private seed industries, which made substantial investment in maize research and development (R & D) and provided a wide range of improved cultivars benefiting many maize growers. This helped in realising an impressive annual growth of 3.62 per cent in maize production during the nineties (Singh, 2000).

However, the impressive performance of private seed companies has raised many eyebrows over the efficiency and effectiveness of public sector seed agencies in producing and distributing high quality maize seeds to farmers in a timely and cost-effective manner. Even though the market for maize seed has grown rapidly, the long-term economic viability of many private seed companies are unrealistic. The profit driven private companies must pay attention to the bottom line, whereas public agencies continue to receive government directives to maintain relatively lower seed prices that undermines their incentives to operate efficiently. On the other hand, it would be a dangerous proposition that the public sector no longer has a role to play. The private seed companies have demonstrated the ability to perform some of the functions formerly assigned to public organisations, but they are unlikely to assume those functions in future, which cannot easily be exploited for commercial profit. Therefore, there will always be a need for public-sector participation in the maize seed industry (Singh *et al.*, 1995). However, a perfect synergistic/complementary

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\* Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi -110012 (India).

relationship between the two sectors has to perpetuate to make the maize seed industry economically viable and farmers friendly.

Today, there is a need to take a fresh look at erstwhile complacent public sector seed industry in India about their outstanding past records. But under changed scenario, the administrators of public research institutions are finding it very difficult to maintain the vibrancy in the sector and secondly, their most of the decisions increasingly being influenced by the strategies of ever growing private seed companies. This is not necessarily an undesirable development. For policy makers and research administrators, deciding an appropriate strategy for the future is complicated by the lack of appropriate information about the public and private seed industries. This paper is an attempt to examine the organisation and performance of India's maize seed industry and address the question of where the on-going liberalisation process is likely to lead this industry. The specific objectives are: (i) to examine the changes in seed policy, (ii) strengths and weaknesses of the public and private seed industries and (iii) policy perspectives, making maize seed industry more dynamic, efficient and responsive.

#### EVOLUTION OF SEED INDUSTRY POLICY

With the promulgation of the Central Seed Act in 1966, the legal foundation was laid for India's present-day seed industry, which provides legislative framework for regulation of quality of seeds produced and distributed in the country. In addition, the Central Seed Act prescribed certification standards of seeds and assigned responsibility for their enforcement to the state governments. The Central Seed Committee (CSC) and its various sub-committees and the Central Seed Certification Board (CSCB) are apex agencies set up under the Act to deal with all matters pertaining to quality seed production and distribution.

A unique feature of the Central Seed Act was to maintain effective control over seed of most staple food crops firmly in the hands of government organisations. Although private companies gradually came to dominate certain segments of the market (e.g., vegetables and flowers), seed production and distribution functions for socially and politically important cereals such as rice, wheat, sorghum, and maize were actively pursued through state agencies and parastatals, marginalising the share of private companies.

Policy reforms introduced during the late 1980s, in an attempt to scale back the direct state participation in the Indian economy led to a series of changes that were having far reaching implications for the seed industry. The reforms gained momentum in 1988 with the passage of the New Policy for Seed Development, a landmark piece of legislation that further opened up the vistas for foreign participation. The New Policy for Seed Development permitted imports of seed of coarse grains were also permitted, but with a premise that the Indian company importing the seed will negotiate a technical co-operation agreement with the foreign supplier stipulating that parent lines, breeder seed, and seed production technology

would be ceded to the Indian company within a period of two years. Import duties on seed and seed processing equipment were also lowered from 100 per cent to 15 per cent.

The policy reforms introduced in the late eighties had a noticeable implication for the maize sector especially, as many of India's most important crops (such as rice, wheat and pulses) are based on non-hybrid seed and private participation for the development of non-hybrid seed has been modest. However, by lowering barriers to entry and loosening restrictions on certain types of previously prescribed behaviour, the Government paved the smoother way for increased participation by private companies which led to opening up of new companies producing maize seed and selling in direct competition with the government seed agencies. Further, the proposed Seed Act, 2001 will also give a new impetus to the transitioning maize sector in India.

#### MAIZE PRODUCTION PERFORMANCE

The area of maize crop in India increased from about 3.36 million hectares during triennium ending (TE) 1952 to 6.32 million hectares during TE 2000. However, expansion in maize area declined in the early 1970s and remained virtually unchanged for two decades. A significant shift occurred later in 1990 when winter (*rabi*) maize cultivation expanded rapidly, particularly in the states of Bihar, Andhra Pradesh, Karnataka and part of Rajasthan.

The spread of maize cultivars and crop management practices helped in maintaining a continuous growth of average maize yield since 1950s. Rising yield coupled with steady expansion in area led to a rapid growth of 5.95 per cent in maize production during the period 1950-1966 (Singh and Kumar, 2000). However, there was a significant deceleration (-1.43 per cent per annum) in its growth during the period 1966-1986, the era of Green Revolution as attention shifted to rice and wheat cultivation. After a noticeable decline, the growth in maize production, fuelled by significantly high-yield growth, averaged at 3.62 per cent per annum during 1986-2000, the period of post policy reform. This may be due to increased availability and adoptability of a wide range of modern maize cultivars. However, the performance is dismal in several pockets of BIMARU states comprising largely Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh, owing to the usage of traditional cultivars. Among the top ten major maize growing states, only few states like Maharashtra and Karnataka have performed consistently in all the periods. Andhra Pradesh and Bihar registered a higher yield growth rate during the last decade due to large-scale adoption of improved cultivars. However, maize has been pushed to marginal and resource scarce lands in the states of Uttar Pradesh and Madhya Pradesh, thereby realising a downfall in the yield growth rate from 4.99 to 0.32 per cent and 3.92 to 1.42 per cent respectively (Table 1).

TABLE 1. PERFORMANCE OF MAJOR MAIZE GROWING STATES IN INDIA

States (1)	Compound growth rate (per cent)							
	1998-2000		1980-90			1990-2000		
	Area (per cent share) (2)	Yield (kg/ha) (3)	Area (4)	Product- ion (5)	Yield (6)	Area (7)	Product- ion (8)	Yield (9)
States with higher than national average yield								
Andhra Pradesh	6.51	3,128	-1.47	-4.15	-2.71	3.65	8.39	4.74
Bihar	11.71	2,003	-3.10	-3.33	-6.43	1.23	3.62	2.38
Himachal Pradesh	4.84	2,154	0.96	1.47	0.51	-0.47	0.52	0.99
Karnataka	8.87	2,910	6.02	6.57	0.53	9.85	10.46	0.59
States with lower than national average yield								
Madhya Pradesh	13.55	1,450	1.20	5.12	3.92	-0.62	0.80	1.42
Rajasthan	15.09	1,131	0.02	0.95	0.94	-0.20	0.58	0.79
Uttar Pradesh	15.90	1,328	0.06	4.87	4.99	-1.27	-0.85	0.32
All-India (million ha)	100.00 (6.32)	1,764	-0.18	1.90	2.08	1.01	3.25	2.24

Maize in India is virtually utilised domestically for food, feed and industrial use. Direct consumption of maize has however declined over time, while feed and industrial use has risen due to increased demand for poultry and starch in recent years. Rising household income has led to increased meat consumption, particularly of poultry, in turn accelerating feed demand for maize (Mohanty *et al.*, 1998). Increased industrial demand for maize comes primarily from the starch industry. While international trade in maize is still negligible, export (as grain or as livestock feed ingredient) is expected to increase with increased maize productivity. A marked shift has been observed in the seasonality of maize production in various states during the period 1996-2000. A significant increase in maize area was observed in both the seasons in Andhra Pradesh while in the case of Bihar, area under winter maize (*rabi*) has stagnated but declined in *kharif* season (Appendix). However, the area under summer maize in Bihar had increased, may be due to non-availability of other crops that can withstand the hardy situations.

## SEED SECTOR IN INDIA

## (a) Organisation of Public Sector Seed Industry

In India, public institutions engaged in seed sector is largely confined in the hands of Central as well as State Governments. The government through its network of seed corporations and allied institutions is playing a major role in seed production and distribution. However, this upsurge in seed demand has constrained the public sector seed institutions to cope with the demand for seed especially hybrid and OPVs. The gap between demand and supply is continuously on the rise and with dwindling resource crunch, the private sector seed industry is emerging at a faster rate and the synergy between these two sectors is aptly meeting the demand for maize seed industry in India.

### *(b) Organisation of Private Sector Seed Industry*

With the passage of new policy for seed development in 1988, a major boost came in the private sector seed industry. However, there are only a few players comprising multinational and Indian companies. The seed production is also in the hands of small companies, who cater to the local needs. These companies operate on a small scale and do not afford to invest on R & D support from the public sector. The maize seed industry which attained an all time high seed production of approximately 35,000 metric tonnes in 1998 is still hovering around the same level in spite of the presence of large transnational seed companies (IARI-CIMMYT survey, 1999 and personal communication from Industry). The industry is finding difficulty to break this threshold and hence is constrained to increase their production capacity.

#### MAIZE RESEARCH AND DEVELOPMENT

##### *Public Sector Research*

The Indian Council of Agricultural Research (ICAR) through its network of the Directorate of Maize Research (DMR) earlier, All India Co-ordinated Maize Improvement Project, which was established in 1957, is involved in promoting and co-ordinating maize research and development throughout India. The DMR's responsibilities, implemented through 27 commodity-specific maize research programmes located all over the country, include undertaking basic and strategic research for genetic improvements, conducting multi-locational testing of germplasm, developing efficient package of practices for increasing maize production, and generating technologies tailored for maize specific end uses. Many of the research programmes co-ordinated by the DMR are located at state agricultural universities, where in addition to participating in the national research effort, also work on issues of local and/or regional importance. Several other government research organisations, as well as general (i.e., non-agricultural) universities, also undertake research work directly or indirectly related to maize.

Over the years, public investment in maize research has been substantial. However, it is difficult to delineate the precise budget expenditure done in the maize research in the absence of such information released by ICAR. Though, the level of public investment can be assessed indirectly by considering the numbers of maize researchers working in the national programme. In 1997, the 30 maize research programmes co-ordinated by DMR employed 102 full-time equivalent scientists at the senior level (Table 2). Most of these (76 per cent) were involved in plant breeding or in activities that directly support plant breeding (e.g., physiology, pathology, entomology). A further 16 per cent were engaged in crop management research and 8 per cent in other research and extension tasks.

TABLE 2. ANNUAL INVESTMENT AND PERSONS INVOLVED IN MAIZE RESEARCH, 1999

Particulars (1)	Public sector research (2)	Private sector maize research		
		National companies (3)	Multinational companies (4)	Total private sector (5)
Number of research programmes	30	18	5	23
Maize research personnel				
Senior-level scientists	33	42	8.5	50.5
Intermediate-level scientists	69	29	7.5	36.5
Total scientific staff	102	71	16	87
Technical staff	240	225	24	249
Total staff	342	296	40	336
Scientists per million ha of maize	16.5	-	-	14.1
Researchers engaged in (per cent)				
Germplasm improvement	78	95	96	95
Crop management research	17	5	4	5
Other/unknown	5	0	0	0
Annual budget (Rs. million)	42.3	27.1	37.5	64.6

Source: Singh (2000).

### *Private Sector Research*

After the seed policy reform during the late eighties, many private companies plunged into maize research. Initially, many private companies started to produce and sell maize seed in India, and relatively few were conducting research. Not surprisingly, private sector maize research has focused almost exclusively on plant breeding. Because the industry is experiencing a period of persistent change, the number of companies with maize breeding programmes fluctuated constantly. Currently, about 20 Indian-owned companies and five transnationals are actively engaged in maize breeding research. Many of India's private maize breeding programmes are still in its infancy; approximately half have been launched since the seed policy reforms were introduced during late 1980s.

Like public sector research investment, to measure the exact amount of private investment in maize research is also difficult due to lack of detailed financial data. Therefore, private investment in maize research measured in terms of number of scientists indicate that in 1997, private sector employed 87 full-time equivalent maize scientists at the senior level in research activities, indicating that the number of maize researchers working for private seed companies is close to the number employed in public breeding programmes (Table 2). This represents a significant change from earlier years, when ICAR and state agricultural universities carried out virtually all maize research. As in the public sector, the emphasis is heavily biased towards germplasm improvement activities, particularly hybrid development activities (e.g., generation and maintenance of inbred lines, test-crossing) to determine combining ability.

### Research Products

How successful have been India's maize researchers? The performance of the public breeding programmes can be evaluated by examining germplasm products. An analysis of 238 maize varieties and hybrids developed in India from 1961 to 1997 reveals a number of interesting patterns. To begin with, the relative importance of public and private breeding programmes has changed over time (Table 3). During the 1960s, improved materials (varieties as well as hybrids) came exclusively from public breeding programmes. Proprietary hybrids first appeared in small numbers in the mid-1970s and increased in importance during the 1980s and early 1990s following the appearance on the scene of the transnational companies. Today, private companies are producing new materials at nearly the same rate as all of the public breeding programmes combined.

TABLE 3. VARIETAL DEVELOPMENT IN MAIZE, 1961-99

Particulars	Public agencies	Private companies		
		National	Multinational	All companies
(1)	(2)	(3)	(4)	(5)
Type of cultivars (number)				
Improved OPVs	79	0	0	0
Hybrids	41	101	17	118
All improved materials	120	101	17	118
Maturity				
Extra early (<100 days)	7	3	1	4
Early (100-110 days)	33	40	1	41
Intermediate (110-120 days)	36	46	3	49
Late (120 days and above)	44	12	12	24

Source: Singh (2000).

Not only the origins, but also the types of materials released have changed. Although varieties and hybrids were released by public breeding programmes in almost equal numbers during the 1960s, over the following two decades the proportion of varieties increased. The shift in emphasis from producing hybrids to varietal improvement appears to have been stimulated by two beliefs: (a) hybrid and (b) successful adoption of hybrids requires annual seed purchases and therefore cannot succeed without the support of a well developed seed industry. During the mid-1980s, attention shifted back to hybrids. In part, this reflected the growing importance of private sector breeding programmes, which were working exclusively on hybrids. However, the interest in hybrids extended even to public breeding programmes, where researchers had become convinced that hybrids perform well under a wide range of production conditions and can be profitably adopted by small-



scale farmers. This re-thinking was reflected in the increase in the relative proportionate development of hybrids.

Overall, the characteristics of materials developed by public breeding programmes and private companies have differed. Public breeding programmes have produced relatively more materials featuring the hard, flinty grain type preferred by small-scale farmers. Public breeding programmes also have produced relatively more special trait germplasm targeted at specific production niches (e.g., materials adapted to rainfed production conditions, materials recommended for early sowing). In contrast, private breeding programmes have concentrated on commercial materials, developing mostly full-season dent or semi-dent hybrids suitable for irrigated production conditions.

Use of breeding materials developed by publicly funded organisations has been extensive in the past but over the years the phenomenon has undergone a transformation and currently a two-way symbiotic relationship is prevailing in breeding activities. Nearly one-third of the hybrids were found containing ICAR germplasm, indicating that materials developed by the national maize programme are successfully finding their way into commercial releases. Use of breeding materials distributed by the International Maize and Wheat Improvement Centre (CIMMYT) has also been extensive, with about 35 per cent of all public sector releases and 25 per cent of all private sector releases containing CIMMYT germplasm (Singh *et al.*, 1995).

#### MAIZE SEED PRODUCTION

##### *Public Sector Seed Production*

Both the Central Government (through the National Seeds Corporation, or NSC) and some State Governments (through various State Seeds Corporations or SSCs) produce maize seed on a commercial basis. These agencies do not actually produce seed themselves; instead, they employ contract growers, who are supplied with parent seed obtained from ICAR research stations or agricultural universities. The contract growers operate under the supervision of NSC or SSC technical staff. Commercial seed produced by contract growers is transported to centrally located conditioning plants for drying, cleaning, grading and packaging. All stages of seed production and processing are monitored by inspectors from the government seed certification agencies. After meeting the stringent quality standards, the certification labels are affixed before the seed actually goes to the market.

##### *Private Sector Seed Production*

Private sector seed production operations are concentrated in Andhra Pradesh, Karnataka and Maharashtra. These states are preferred because of conducive climate permitting two crops per year (an important consideration in producing hybrid seed).

Like the public seed agencies, large seed companies work with contract growers, who produce commercial seed under close supervision of company representatives.

Not all maize seed produced by the private sector in India originates from large seed companies. A significant proportion (between 10 to 35 per cent in most years) is produced by small seed companies. These companies do not have their own research programmes and produce seed of private as well as public bred varieties and hybrids. Small-scale seed production is economically viable because it requires little investment beyond that needed for ordinary maize grain production. The costs involved in selecting, grading and conditioning seed are modest, so small companies comply (more or less) with seed production requirements and try to sell their crop as seed rather than as ordinary grain, in the hope of capturing an attractive price premium. Due to the recent explosive growth in national seed production capacity, in most years only a portion of their capacity can be sold as seed owing to the fact that farmers tend to retain their own grain for the seed purpose as per requirement and marketable surplus. Thus the seed volumes attained by the companies are still hovering at the levels attained a couple of years back.

However, the low-cost seed production by small seed companies are plagued by poor technical expertise and/or state-of-the-art processing and storage facilities, thereby they could hardly maintain the stringent quality standards being set for seed production. This problem is compounded by the ineffectiveness of the official certification system. Seed companies that market their own proprietary hybrids clearly have an interest in ensuring that seed sold under their brand name meets high quality standards, but the same is hardly true for small companies selling seed of public materials. Because the main interest of small companies is in minimising production costs, much of the 'certified' seed produced by small companies is not really certified at all. Under current law, certified seed is exempted from sales tax. This means that the companies have an incentive to 'certify' their seed simply by purchasing certification labels from corrupt inspectors or by printing counterfeit labels; it is in their interest to pay any amount up to the value of the sales tax. Many seed company representatives admitted off the record that these practices are widespread.

Even if the quality of their seed is unreliable, small companies perform several important functions. To begin with, small companies often operate in marginal areas of low production potential - areas that have largely been bypassed by the larger seed companies. Furthermore, small companies frequently provide a supply buffer. Because the area planted to maize varies greatly from year to year, the industry frequently has difficulty forecasting demand for seed. In years when demand exceeds supply, small-scale producers stand ready to step forward with additional supplies. Although this seed may be of variable quality, it is probably better than no seed at all.

## MAIZE SEED DISTRIBUTION

*Public Sector Distribution*

Maize seed produced by the NSC and SSCs is sold directly from government warehouses or through dealers located in major population centers. The public seed agencies invest little in promotion and advertising because the public varieties and hybrids they sell are well known to farmers. Although selling prices are low, the lack of rural distributors represents an inconvenience for farmers. Sales can be good in years when there are general shortages of maize seed, but in years of abundant supply, seed produced by the NSC and SSCs often remains unsold.

*Private Sector Distribution*

After leaving the conditioning plant, seed produced by private companies is delivered by truck to local distributors. Most seed companies work not only with wholesale distributors (who supply small shops), but also with retail distributors (who sell directly to farmers). Seed is usually advanced to distributors on credit, with the seed company receiving payment only after it is sold. Surplus inventory is returned by the distributors to the seed company for storage until the following season or for sale as grain.

Seed companies have learnt the hard way that it is not enough to develop good hybrids and produce high quality seed; it is also necessary to know how to sell that seed in the notoriously challenging Indian market. By now, most companies realise that distribution requires specialised skills, and many have formed separate marketing divisions to handle distribution functions. Indian-owned companies have generally built up their own distribution networks; in contrast, most of the transnationals have opted to form alliances with local companies having established distribution networks.

Since seed policy reforms were introduced in the late 1980s, the area planted to improved OPVs and hybrids has grown rapidly, and thereby adoption of improved germplasm in most of the regions has stimulated important changes in farmers crop management practices (Singh and Morris, 1997). However, despite the considerable gains that have been made in meeting the needs of commercial farmers, many poor farmers have yet to realise the dividends of ambitious seed policy (Pray, 1990). Efforts by seed companies to develop brand awareness have met with mixed success. Brand name awareness is strongest in zones where the market leaders' seed production operations are concentrated. On the other hand, even those farmers who know the names of different seed companies often have trouble definitively identifying seed of a particular company because of the presence of many competing products sold under similar names with similar packaging.

Outside the commercial production zones in which the seed companies have concentrated their promotional efforts, farmers hardly remain aware of seed company names and product names. Consequently, for most farmers the choice of maize seed

depends little on brand name recognition; what is most important is the recommendation made by the distributor from whom the seed is being purchased. As a result, competition in the Indian maize seed industry plays itself out in an intense battle for the allegiance of distributors. Seed companies know that in order to move product, they must establish a network of loyal distributors who will recommend their brand before all others. Seed companies therefore invest considerable effort into getting and keeping the allegiance of distributors, offering them price discounts, favourable credit terms and other inducements. In return, the seed companies try to persuade distributors to commit to handling exclusively their brand, a requirement that they sometimes attempt to enforce through periodic surprise visits to distributors' shops. Distributors of course recognise the value of their services and are adept at playing off the seed companies against one another.

### *Seed Sales*

Published data on maize seed sales in India are unreliable. This is not surprising, as public seed agency and private companies both have reasons to conceal the truth about their sales. The public seed agencies have been sharply criticised in recent years for being inefficient; given the hostile environment in which they operate, they are understandably reluctant to release detailed information that might provide additional fuel for their critics. In the case of private companies, information about sales can provide a competitive advantage to rivals, whose marketing strategies may be influenced by the knowledge of how the rest of the industry is doing. Another reason for concealing information about seed sales, seldom mentioned by seed company representatives, is that the information could be used as a basis for tax assessment.

Table 4 clearly shows the status of seed sales by various agencies and institutions. Public seed agencies generally maintain the records of their sales but on the contrary private sector agencies are conservative and conspicuous in detailing

TABLE 4. MAIZE SEED SALES BY SECTORS IN INDIA

Particulars (1)	(tonnes)			
	1981-83 (2)	1985-87 (3)	1990-92 (4)	1997-99 (5)
Public sector organisation				
OPVs	167	811	658	388
Hybrids	4,675	2,436	2,326	1,322
Private seed companies				
OPVs	0	193	485	608
Hybrids	378	705	6,267	32,295
Total public plus private sales				
OPVs	167	1,004	1,144	996
Hybrids	5,053	3,141	8,593	34,247
Total	5,220	4,145	9,737	35,243
Market share of private sector (per cent)				
OPVs	0	20	58	61
Hybrids	7	23	73	93

Source: Singh (2000).

their volumes. Despite these shortcomings, three important trends are evident. First, the market share controlled by private companies has grown rapidly to the point that private companies now dominate the market. Second, sales of hybrid seed have grown rapidly, while sales of varietal seed have declined, raising questions about long-term prospects for OPVs. Third, growth in the volume of seed of proprietary hybrids has been much more rapid than growth in the volume of seed of public hybrids, indicating that private companies are more effective at getting their materials to farmers.

Some transnational seed companies felt the strong need of easing out of stringent quarantine regulations for the import of seed. But in reality, the exotic maize varieties and hybrids generally perform poorly under Indian production environments. Furthermore, there is little economic incentive to import commercial seed.

#### CONCLUSIONS

In the pre-nineties era, seed sector in India happens to be the exclusive domain of public institutions but with the emergence of private seed industry in the recent past, the maize sector in India has undergone several iterative changes. The private sector with its latest know-how and aggressive marketing strategies have captured a larger chunk in the seed sector. However, this upsurge in the number as well as volume of business of private seed companies have put a serious question mark on their efficiency, effectiveness and equity considerations. These indicators can easily be met with the holistic synergy between private and public sector institutions in the true form, thereby making the industry farmer-friendly and economically viable in the long run.

The policy reforms introduced in the late eighties had a noticeable implication for maize sector especially, as many of the India's most important crops are based on non-hybrid seed and private participation for the development of non-hybrid seed has been the modest. But with relaxation in certain provisions, the proactive participation from the private sector has increased, even then the public sector with its vast network continues to provide leadership role in the seed sector. The researches endeared in the private and public domain has effectively made an indelible impression on the production performance of maize in several parts of India. However, with the dwindling resources in the public sector, the private sector researches will add to the research capabilities in providing the best to the farmers. This transitioning will require a perfect complementarity between these two sectors. The public sector research with its edge in germplasm and basic and strategic research for genetic improvement will have to work in tandem with the private sector research institutions. However, in the past the characteristics of the material developed by the private and public sectors have differed in view of the commercial orientation of the private sector. This has to be backed up with the equity considerations in future.

APPENDIX  
SEASONWISE STATUS OF MAIZE PRODUCTION IN MAJOR GROWING STATES OF INDIA

	1996-97				2000-01			
	Kharif (2)	Rabi (3)	Summer (4)	Total (5)	Kharif (6)	Rabi (7)	Summer (8)	Total (9)
<b>Andhra Pradesh</b>								
Area ('000 ha)	274	87	-	361	416.8	106.5	-	523.3
Production ('000 tonnes)	820	370	-	1,190	1,057.8	369.4	-	1,427.2
Yield (kg/ha)	2,993	4,253	-	3,296	2,538	3,469	-	2,727
<b>Bihar</b>								
Area ('000 ha)	437.4	197.6	145.4	780.4	287.3	191.5	160.3	639.1
Production ('000 tonnes)	683.5	654.8	332	1,670.3	503.3	602.5	354.2	1,460
Yield (kg/ha)	1,563	3,314	2,283	2,140	1,752	3,146	2,210	2,284
<b>Himachal Pradesh</b>								
Area ('000 ha)	307.3	-	-	307.3	298.1	-	-	298.1
Production ('000 tonnes)	589.4	-	-	589.4	683.6	-	-	683.6
Yield (kg/ha)	1,918	-	-	1,918	2,293	-	-	2,293
<b>Karnataka</b>								
Area ('000 ha)	389.2	46.4	10	445.6	600	58	11	669
Production ('000 tonnes)	1,245.4	109.8	30	1,385.2	1,948	140	24	2,112
	3,200	2,366	3,000	3,109	3,247	2,414	2,182	3,157
<b>Madhya Pradesh</b>								
Area ('000 ha)	847.4	-	-	847.4	817.1	-	-	8,17.1
Production ('000 tonnes)	946	-	-	946	1,199.5	-	-	1,199.5
Yield (kg/ha)	1,116	-	-	1,116	1,468	-	-	1,468
<b>Rajasthan</b>								
Area ('000 ha)	927.9	-	-	927.9	969.2	-	-	969.2
Production ('000 tonnes)	1,028.6	-	-	1,028.6	1,014.7	-	-	1,014.7
Yield (kg/ha)	1,109	-	-	1,109	1,047	-	-	1,047
<b>Uttar Pradesh</b>								
Area ('000 ha)	1,065.5	-	-	1,065.5	913.9	-	-	913.9
Production ('000 tonnes)	1,535.9	-	-	1,535.9	1,491.2	-	-	1,491.2
Yield (kg/ha)	1,441	-	-	1,441	1,632	-	-	1,632
<b>All-India</b>								
Area ('000 ha)	5,713.4	547	-	6,260.4	5,969.3	587.4	-	6,556.7
Production ('000 tonnes)	9,179.4	1,589.4	-	10,768.8	10,478.6	1,589.3	-	12,067.9
Yield (kg/ha)	1,607	2,906	-	1,720	1,755	2,706	-	1,841

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