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Private Sector Research and Technology Transfer in Pakistan

by

Carl E. Pray

Department of Agricultural Economics
Cook College, Rutgers University
New Brunswick, New Jersey 08903

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Executive Summary

This survey is part of a University of Minnesota/Rutgers University study financed by AID/Washington on private sector research in the Third World. The purpose of this survey is to (1) find out how much and what kind of research is being conducted by the private sector, (2) identify the policy constraints and incentives to private research and technology transfer, and (3) identify major impacts of private research and technology transfer on farmers.

The Pakistan survey was conducted in February 1986. Representatives of fourteen agribusiness companies were interviewed. This sample included almost all the major private sector agricultural research programs in Pakistan and representatives of both Pakistani and multinational companies. In addition, we interviewed officials of the Pakistan government, AID and CIMMYT. We also drew on a number of recent studies on agribusiness in Pakistan.

The survey found that there was a small amount of private research being conducted by the private sector. The total current expenditure on research by the private sector in Pakistan is about Rs. 13 million or US $800,000. There are at least 40 scientists, including 8 to 10 PhDs working in the private sector. this is a conservative estimate. If the companies' maximum estimates and guesses for the other firms are used, the total could easily by Rs. 20 million. About half of this expenditure is by pesticide companies. There is also research by the seed industry, the tobacco industry, and the sugar industry.

The private sector has also played an important role transferring tech-

nology into the country and spreading technology to farmers. Private pesticide, tobacco, fertilizer and tractor companies sell inputs which embody technology and provide management information through their dealers and technicians. The tobacco companies and sugarmills have their own extension services.

Private research has not had a major impact on agricultural production in Pakistan. There have been some successes, however. Research has had an important impact on tobacco productivity and quality, and more corn is produced because of private research.

Government policy has played an important role in determining the amount of private research. Government ownership or regulation of the input supply industries has crowded out much private business and, thus, the possibility of private research. Although many of these industries were privatized in the late 1970's, regulations and the threat of nationalization may restrict their investments in research. Government regulations have restricted the returns to research in some industries. For example, companies have not been able to get approval for the sale of private hybrid corn varieties in spite of an explicit policy of encouraging the private seed industry.

The government has done some things that have encouraged private research. The most important is the training of scientists. Almost all of the scientists in private sector got their training through government scholarships and their experience in government research programs. Cooperative research and trials by companies and the Tobacco Board seems to have encouraged innovation in the tobacco industry.

The policy implications of this analysis are that there should be more (1)

privatization, (2) deregulation, (3) public investments in higher education, and (4) effective government research which works with private agribusiness. AID should assist in the process of policy change through analysis of the impact of science and technology policies and policy dialogue based on this analysis. It should also continue to support higher education, public research, and the international agricultural research centers. It should attempt to use its support for public research to push for more communication and cooperation between the public and private sector. Finally, it should experiment with vays of directly encouraging firms to innovate.

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1 Introduction

This survey is part of a University of Minnesota/Rutgers University study financed by AID/Washington on private sector research in the Third World. This paper is part of the second phase of this study which consists of a survey of private agricultural research and technology transfer in six countries in South and South East Asia - the Philippines, Indonesia, Thailand, India, Pakistan and Bangladesh. The purpose of these surveys is to (1) find out how much and what kind of research is being conducted by the private sector, (2) identify the policy constraints and incentives to private research and technology transfer, and (3) identify major impacts of private research and technology on farmers. In addition, we have made some preliminary recommendations of programs and policies that AID should support. In a third phase of this project, we plan to quantify the impacts identified in this phase and measure how policies influence these impacts.

The Pakistan survey was conducted in February 1986. Representatives of fourteen agribusiness companies were interviewed. This sample included almost all the major private sector agricultural research programs in Pakistan and representatives of both Pakistani and multinational companies that were doing research. In addition, we interviewed officials of the Pakistan government, AID and CIMMYT. We also drew on a number of recent studies on agribusiness in Pakistan.

2 Overview of Agricultural Table Sector

2.1 General Performance

In the last two years (1984/85 and 1985/86) crop production in Pakistan has grown very rapidly (see Table 1). During the last decade as a whole, growth rates in agricultural production have been quite high - around 3 percent annually. In the livestock sector, there has been moderate growth in red meat and milk production. The segment of the livestock sector that has grown rapidly is commercial broiler and egg production which doubled between 1980 and 1985.

Inputs have also grown quite rapidly with the exception of land. Cropped area increased only about 10 percent in the last decade. Total population grew about 3 percent annually, but the rural labor force grew somewhat less rapidly because of urbanization and migration to the Middle East.

The consumption of modern inputs grew very rapidly as Table 1 shows. Fertilizer consumption almost tripled between 1976 and 1985. Tractor imports almost tripled which meant the actual number in use increased even more rapidly. The distribution of improved seed doubled. Pesticide consumption has grown rapidly in the last three years after the adjustments to privatization and the elimination of most subsidies. The number of tubewells installed each year has declined, but total water availability has increased by about 20 percent over the decade.

Table 1: Basic Data on Agriculture.

	Index of Agricultural Production (a)				Cropped Area (Million Hectares)	Improved Seed Distribution (000 Tonnes)	Water Availability (MAF)	Fertilizer Off-take (000 N/T)	Credit Disbursed (Rs mln)	Tubewells Installed (Nos)	Tractors Imported (Nos)	Production of Meat (000/ Tonnes)	Milk Production (000 Tonnes)	Fish Production (000 Tonnes)	Total Forest Production (000 cu. metres)
	All Crops	Food Crops	Fibre Crops	Other Crops											
1947-48	74	81	68	52	11.63	.	..	..	4.70	..	..	.	..	43.3	623
1948-49	86	99	59	61	12.34	.	..	..	15.70	..	..	..	..	45.6	759
1949-50	87	97	76	65	12.48	.	..	..	3.50	..	..	..	..	48.6	1,034
1950-51	90	100	86	57	12.88	.	..	..	7.20	..	..	..	..	51.5	835
1951-52	74	76	85	58	12.24	.	..	..	2.60	..	..	..	..	56.3	765
1952-53	72	68	109	61	12.09	.	..	1.00	4.28	..	..	..	..	60.0	985
1953-54	91	96	87	78	13.26	.	..	14.80	23.26	..	..	..	..	61.0	912
1954-55	88	86	97	91	13.28		.	14.10	4.90	..	..	..	..	62.0	866
1955-56	90	90	102	80	13.39	.	..	6.60	32.84	..	..	..	..	66.0	793
1956-57	94	95	105	84	14.16	.	..	9.00	36.55	..	..	..	..	65.8	1,124
1957-58	96	92	104	102	13.93	.	..	16.00	45.61	..	..	..	..	67.3	950
1958-59	102	99	97	112	14.33	.	..	18.00	55.15	..	..	..	..	62.7	756
1959-60	100	100	100	100	14.89	.	..	19.10	87.58	..	..	..	..	72.5	631
1960-61	100	98	103	103	14.86	.	..	31.40	103.78	..	..	..	..	91.5	682
1961-62	109	105	111	122	15.25	.	..	37.50	147.81	..	..	..	..	85.3	501
1962-63	119	108	128	151	15.47	.	..	40.20	133.33	..	..	..	..	90.9	513
1963-64	118	108	144	124	15.13	.	..	68.70	129.04	..	..	..	..	99.0	530
1964-65	128	120	130	162	16.25	.	..	87.20	127.54	..	..	..	..	110.2	784
1965-66	127	117	142	181	15.54	.	63.87	70.49	132.42	..	..	..	..	120.3	688
1966-67	135	114	156	189	16.41	.	67.54	111.83	195.15	..	4,113	..	..	153.3	705
1967-68	157	150	171	170	16.94	.	68.54	190.43	178.66	..	2,182	..	..	151.8	101
1968-69	168	160	161	184	16.24	.	72.79	244.64	141.68	..	4,411	..	..	157.6	787
1969-70	186	177	185	214	16.77	.	75.50	307.70	155.35	7,727	5,696	..	..	173.6	864
1970-71	174	164	188	195	16.62	.	69.95	283.20	158.38	8,627	3,879	..	..	172.8	762
1971-72	183	170	245	169	16.60	22.54	71.10	379.20	128.00	10,344	4,224	568	7,800	155.3	878
1972-73	188	181	243	163	16.93	18.10	81.17	436.20	106.75	10,260	1,847	592	7,899	191.2	730
1973-74	196	190	228	188	18.28	27.77	80.06	402.90	913.30	8,477	5,216	623	8,044	214.2	493
1974-75	187	183	220	171	17.37	26.31	77.02	425.50	1,010.07	8,863	7,190	641	8,193	169.1	505
1975-76	199	207	176	193	18.02	43.16	85.95	550.60	1,457.79	8,847	10,809	684	8,348	174.1	493
1976-77	203	212	149	224	18.21	93.55	84.57	631.80	1,716.50	8,767	15,554	715	8.524	210.7	787
1977-78	209	208	197	223	18.49	48.42	89.44	713.60	2,048.28	8,820	11,902	749	8,704	267.9	589
1978-79	219	238	162	212	19.30	48.96	87.39	879.80	2,299.51	8,642	15,178	783	8,888	293.0	805
1979-80	239	245	250	210	19.22	60.89	91.14	1,044.30	2,970.10	8,783	19,313	819	9,075	300.0	662
1980-81	249	254	245	236	19.33	73.41	97.79	1,079.50	3,999.21	6,160	16,137	856	9,267	297.3	628
1981-82	258	257	257	261	19.78	79.48	86.45	1,080.00	5,269.11	6,200	19,293	894	9,462	317.8	693
1982-83	270	277	283	235	20.13	70.30	101.40	1,243.60	5,936.28	4,383	22,913	947	9,662	330.0	686
1983-84	237	253	170	248	20.06	75.49	103.69	1,202.66	8,141.08	4,240	27,840	1,010	10,242	350.0	724
1984-85	275	265	346	239	20.10	88.02	102.81	1,253.26	10,315.84	5,422	24,746	1,079	10,902	365.0	769
1985-86 (E)	294	287	415	207	..	92.52	103.36	1,483.71	11,174.00	5,573	28,500	1,153	11,500	387.0	826

- not available.
. not applicable.
E: Estimated.
MAF: million acre feet.
N/T : nutrient tonnes.
(a) Base 1959-60=100.

Sources:
1. Federal Bureau of Statistics.
2. Ministry of Food, Agriculture and Cooperatives.
3. Planning & Development Division.

The growth rates of total factor productivity have been calculated only up to 1979 (Wizarat, 1981). That analysis indicated only one period of rapid productivity growth - during the late 1960's. After this burst of productivity, there was no productivity growth during the 1970's. Yield per acre - a partial productivity measure - is the only readily available measure of productivity growth. Among the four major crops - wheat, rice, cotton and sugarcane - only wheat has shown a steady upward trend in yield per acre over the last decade. The others have stagnated or declined. Therefore, it appears that most of the growth has been due to increased inputs or increases among the minor crops.

2.2 Specific Industries

The supply of modern seed varieties has been a responsibility of the government since the British period. The government developed improved seed varieties which were then multiplied on government farms and sold to farmers. These seeds never made up more than a small proportion of the total seed sold. There were also some important private seed multiplication programs like the British Cotton Growers Association farm in Khanewal. For the period between 1947 and 1960, the system continued as it was in the British period.

In the early 1960's, the supply of modern inputs was made the responsibility of a semi independent corporation called the Agricultural Development Corporation. In the 1970's, the seed part of this Corporation was separated to become the provincial seed supply corporations in Punjab and Sind. Some other government organizations also sell seed, i.e., the Ghee

Corporation imports and sells the seeds of oilseeds.

The private seed industry is just getting started in Pakistan. The first private company to start a modern seed business was Rafhan Maize which went into operation in the mid 1960's manufacturing starch from corn. It needed a supply of corn during the spring season and so it set up a system of contract growers and provided them with hybrid seed. The government has restricted its sales of seed to its contract growers. In the last few years, it has marketed its hybrid corn and hybrid sorghum-sudan grass to some noncontract farmers who were will to sign a paper absolving Rafhan of responsibility if there is a problem with the seed.

Cargill entered the seed business in Pakistan in 1984. It is currently selling sunflower hybrids and a small amount of corn and sorghum-sudan grass hybrids. They are testing hybrids and varieties of a number of other crops which they hope to sell in the future. They also have applied to produce orange juice concentrate for export and are thinking of expanding into other areas such as vegetable oil production and feedmills. Cargill also owns Shaver, a large Canadian poultry breeder which was one of the ioneers of the poultry industry in Pakistan. Pia-Shaver which is 30 percent owned by Cargill is one of the leading hatcheries in Pakistan today.

Jaffer Brothers started working on producing seed potatoes in 1982. They import foundation seed from Holland on behalf of their contract farmers in Swat Valley. This year they had more than a thousand contract farmers. They provide the foundation seed, fertilizer, and other inputs to the farmers on credit. They agree to buy the seed potatoes at a fixed price and provide the farmers with technical assistance through the season. At the end of the season they buy the seed and subtract the cost of the inputs.

The potatoes are shipped to Lahore where they are sorted and packaged and the distributed to farmers through Jaffer Brothers' network of input dealers. This year they sold about 67,000 bags of seed.

Jaffer Brothers are expanding in two directions. First, they are starting to produce basic seed in Hunza. Second, they are trying to produce seeds of some other crops like berseem.

An important fact is that none of these companies considers seeds as their main business. Rafhan is primarily a starch and now high fructose sugar producer. Cargill's goals include concentrated orange juice, oilmills and feedmills. Jaffer Brothers' income is mainly from the sales of pesticides.

The pesticide market in Pakistan is a large market - $100 to 120 million a year in sales. About 90 percent of total pesticides sold are cotton insecticides. Table 2 shows the growth in pesticide application which is a good indication of the quantity of pesticide consumption. There is no production of active ingredients in Pakistan. Two firms do the bulk of the formulation although three others have the capacity to formulate and do some formulation. The industry is quite competitive with a large number of firms as Table 3 shows. Additional evidence of competition is that the shares have shifted greatly over time with the market leader of a few years ago now reduced to less than 5 percent of the market.

Firms expect the cotton insecticide market to continue to expand. The largest expansion at the moment is in the synthetic pyrethroids. Companies are also starting to look at some of the smaller markets. Several think that wheat herbicides is a market which will expand in the near future.

The farm machinery industry is composed of both private and public sector producers and importers. Tractors have been mainly supplied

Table 2: Plant Protection Coverage, Spray Acres in Million Acres.

Year	Aerial	Ground
1975-76	4.56	4.05
1976-77	5.49	6.21
1977-78	3.29	6.45
1978-79	2.22	5.29
1979-80	.95	5.37
1980-81	.62	2.13
1981-82	.45	4.65
1982-83	.68	6.71
1983-84	.62	10.47
1984-85	.86	14.00*

*Estimate.

Source: Pakistan, 1985.

Table 3: Pesticides' Sales, 1985, by Company.

	Name of Companies	Value (RS.M.)
1.	Granulars Limited	519.550
2.	CIBA-GEIGY (Pakistan) Limited	475.224
3.	Hoechst Pakistan Limited	214.434
4.	Agro Chemicals Limited	193.261
5.	Bapco (Bayer)	130.985
6.	Pakistan Burmah Shell Limited	119.199
7.	United Distributors Limited (Dow)	114.834
8.	Sandoz (Pakistan) Limited	87.823
9.	Jaffer Brothers Limited	62.790
10.	I.C.I. Pakistan Limited	57.928
11.	Agricides Limited	51.334
12.	Alintco Limited	39.931
13.	R. B. Avari and Company Limited	31.305
14.	AGMEC Limited	26.703
15.	ZIMCON Limited	25.747
16.	Farm Services Syndicate	21.384
17.	Ittehad Pesticides	12.919
18.	May and Baker Limited	0.384
	Total	2,185.600

Source: Pakistan Agricultural Pesticides Association.

through imports. Table 1 shows the rapid growth of annual imports during the 1970's. The net population of tractors was expected to be 111,000 in the 1982-83 period. Until 1972, these imports were by the private sector. In 1972, tractor imports and manufacturing were nationalized.

The small amount of local manufacturing of tractors stopped from 1972 until the late 1970's when the Millat Company, which is primarily owned by the government, started producing Massey Ferguson tractors. In 1981, the government ended the public sector monopoly on tractor imports and manufacturing and allowed the private and public sector to import tractors. It tied imports to progressive local manufacture schemes. Millat and IMT Associates achieved 40 and 30 percent local content by late 1983 (USDA/USAID, 1983).

Commercial poultry was started in 1964 by PIA-Shaver. This was a joint venture between the government owned airline and the Canadian poultry breeder. Arbor Acres, the American based company, entered the market the next year. Now, almost all of the major U.S. and European breeders have franchises or subsidiaries in Pakistan.

Production of eggs and broilers by commercial operators has expanded rapidly ever since the mid 1960's. Commercial poultry meat production went from 10,000 mt in 1977 to 47,000 mt in 1984 and commercial egg production grew from .73 billion to 1.71 billion in the same period of time (OICD/USDA, 1984, and Frasch, 1985). The breeding industry went through a bad time in the years 1982 to 1984 due to very rapid expansion of hatcheries which greatly reduced the price of chicks and reduced hatcheries' profits.

The feedmill business is expanding in response to growing demand by

the poultry industry. One businessman who is planning to set up a feedmill for dairy cattle in Karachi estimated that at least 20 new feedmills were being set up around the country. He had visited one producer of feedmill equipment in Punjab who was producing equipment for eight new mills.

Virginia tobacco production and the cigarette industry were established almost immediately after Independence in 1947. Pakistan Tobacco Company, a subsidiary of British American Tobacco (ABAT), founded the industry in Pakistan and brought in varieties from their Indian subsidiary and elsewhere. Premier Tobacco Company, a subsidiary of Phillip Morris entered the market in the 1950's. In the 1960's, several local companies were also established.

The structure of the companies was based on the structure of BAT in India. The companies have contract growers to whom they provide subsidized inputs and credit and also extension advice. These contract growers cure the leaves and then sell them to the company for a price which is determined, in part, by the quality of the leaf. The companies then produce cigarettes using primarily local tobacco and a small amount of imported tobacco for flavor.

After a period of rapid growth in the 1950's and 1960's tobacco production seems to have levelled off in the 1970's and 1980's. However, companies report that the yield per acre of Virginia tobacco in their contract area has increased considerably in the last decade.

The sugar industry is divided into two parts: (1) the refined or white sugar industry which is mainly large scale factories, and (2) the desi ghee industry is locally owned and primarily in the private sector. The sugarmills have a system of contract growers who are provided with technical advice

and assistance in getting subsidized inputs from the government.

Sugar is produced almost entirely from sugarcane. Production of sugarcane has increased in the last decade, but the increase has primarily been due to increased acreage rather than increased yield per acre.

3 Research by the Private Sector

The total current expenditure on research by the private sector in Pakistan is is about Rs. 13 million or US$800,000. There are at least 40 scientists including 8 to 10 PhDs working in the private sector. These figures are based on the statements of the companies interviewed plus some extrapolation to three other firms that are also known to be doing some research. This is a conservative estimate because when companies gave me a range of figures, the lowest figure was chosen. Also, several other pesticide firms that were known to be doing some research could not be included in the survey. Using the companies' maximum estimates and guesses for the other firms, the total could easily be Rs 20 million.

About half of this expenditure is by pesticide companies and this is probably an underestimate. There is some debate about whether their activities should be called research and development. I have included it as R&D for two reasons. First, at least some of the reearch is developing new knowledge and new technology. ICI, Sandoz and Mitsubishi are trying out different formulations of pheronomes and combinations of pheronomes and pesticides for control of pink bollworm. Second, Ciba-Geigy and ICI are trying new types of small application equipment which will be much safer and more effective for the small farmer. In addition, most of the companies are testing the effectiveness of new chemicals for the control of insect pests in cotton, although some do not use scientific tests. Some of the companies are now testing herbicides for wheat and rice and plant growth regulators for a variety of crops.

The other input supply industry that is doing some research is the seed

industry. Rafhan Maize has had a corn breeding program for 20 years. They continue to do breeding to increase yields and reduce farmers' costs of production. They use a combination of public lines from the U.S. lines that they got from Funk and lines developed from hybrids that they test from time to time for other U.S. complanies. They are also doing some trials of sorghum-sudan grass. In recent years, they have been trying strawberry, raspberry and rhubarb varieties from Switzerland in Swat. They are also doing some work with popcorn in Swat. Their program has been an important training ground for private sector scientists. Key scientists in both Jaffer Brothers and Cargill worked at Rafhan before hired to work in these new companies.

Jaffer Brothers has been doing research on the production and processing of seed potatoes. They have had to identify disease free areas and work out a system of producing disease free seed potatoes. Now they are developing their capacity to produce foundation seed instead of importing it from the Netherlands.

Cargill is currently testing hybrids and varieties of sunflower, corn, sorghum-sudan grass, safflower, wheat, rice, rape and soybeans. They are just starting a program to breed crops in Pakistan.

Some companies in the fertilizer industry have conducted research in the past. For example, Exxon started research in Pakistan in 1966. They had experiments to find out the response curves of improved wheat, rice, maize and surgarcane varieties. They worked with the government to develop the best cultural practices for the new wheat and rice varieties. In the 1970's, they cooperated with the government scientists and the University of Hawaii on a program to determine the most effective way to apply urea in

rice. Since the early 1980's, Exxon has not done any research. It does make research grants to government institutions that are doing research which is of interest to Exxon. It is not clear whether any private companies are doing research. Exxon staff did not think any others were, but some government scientists thought that Fauji Fertilizers might have a small program. I was not able to visit Fauji to confirm this.

The incentive for the private sector to do research was reduced by the restrictions on fertilizer sales by private companies in the 1970's which meant they could not profit by doing more research. The other reason for reduced research was the perception that the local research program had greatly improved between the mid 1960's and 1980 and that the government could and should do this kind of research.

The other category of firms that is investing in research is the processing industry. In Pakistan, companies in the cigarette and the sugar industries are doing research.

Pakistan Tobacco Company (PTC) pioneered the production of Virginia tobacco in Pakistan in the late 1940's and early 1950's. At first they borrowed technology developed by Indian Tobacco Company, their predecessor and sister company. In 1956, they established their own research program to test tobacco varieties for for yield and quality and to improve management and cultural practices. They imported seed from India and elsewhere for testing and developed fertilizer requirements and pesticide application methods. Now new technology comes from BAT Industries' branches around the world and is channelled through their headquarters in England. In 1964, Premier Tobacco Company also set up a small research program. Its program was similar to PTC's. However, now it is primarily

working on Burley varietal research. They get their germplasm from Coker seeds which has a tobacco program in Spain because Philip Morris (Premier's parent company) cannot send tobacco seed directly from the U.S. Philip Morris does provide technical assistance from their subsidiaries in the Philippines and Malaysia.

In the mid-1970's, the Pakistan Tobacco Board established a research program with its main station near Mardan. The companies now run their varietal trials jointly with the board.

Shakkarganj Research Institute was established in 1983 to do sugarcane research. The head is a retired plant breeder from the government. The company is making a major investment in laboratories, equipment and land for research. The purpose of this program is to increase the yield per acre and the sucrose content of the cane. They are building a photoperiod chamber so that they can breed cane varieties. At the same time, they are planning to import varieties from Brazil and Barbados for selection and crossing with local varieties. They are also doing some work on mechanization of cultivation. They have imported equipment from Australia and elsewhere for trial under Pakistan conditions.

I was not able to visit the Sind Sugar Research Institute in Hyderabad but collected some information about them at Shakkarganj. They have been in operation since the mid-1970's. They primarily do trials of different sugarcane varieties, work on fertilizer recommendations and develop pest control programs. The research staff is made up almost entirely of retired government scientists and administrators. Their research is funded jointly by six sugarmills in the Sind.

There is a considerabsle amount of innovation that goes on through

informal R&D in the private sector. There have been substantial improvements in the design of agricultural machinery. Child and Kaneda have documented the innovations in irrigation pumps in the 1960's. To study the innovation process in this industry would take much more time than was available for my survey. It would be a very worthwhile sstudy and possibly should be taken up in the next phase of this project.

3.1 Impact of Research

The impact of private research appears to have been relatively limited as yet. The major impacts of private research have so far been in the tobacco and corn industries. Improved varieties and management practices have doubled the yields of Virginia tobacco from 1000 to 2000 kg/ha. Improved furnaces have reduced the cost of flue curing tobacco and improved implements are starting to reduce the cost of cultivation. In the corn industry, hybrids have enabled farmers to get good yields in the spring season. They have developed high yielding hybrids for the main season and also developed control measures for corn borers which are the main corn pest. The pesticide research done in Pakistan may have developed safer, more effective ways of using pesticides. It has speeded the introduction of more modern pesticides which are not as dangerous as the chlorinated hydrocarbons that they replaced.

4 Technology Transfer by the Private Sector

4.1 Technology Transfer into Pakistan

Most of the companies that do research also transfer some technology into Pakistan without modification. Their research progsram has tried the technology and found that it fits conditions in Pakistan. There are also some companies with no research that transfer technology directly.

A lot of technology is being transferred by processors or end users of a crop rather than input supply people. Lever Brothers imported sunflower varieties in an unsuccessful attempt to get that crop going. Arbor Acres brought in corn seed from Brazil in the early 1970's and is now importing U.S. soybean varieties, hybrid corn and drying and storage equipment. The sugarmills and tobacco companies are bringing in crop varieties and farm machinery for testing.

Input suppliers have also been very big transferers of technology. The pesticide industry transfers to Pakistan chemical plant protection methods developed elsewhere. Foreign poultry breeding companies and their local affiliates have transferred the genetic stock pharmaceuticals and management technology that made the commercial poultry industry possible in Pakistan. The tractor industry has imported all of their technology. The basic designs of much of the farm equipment used also was imported from Western or other Asian countries. However, there have been important small changes made to the basic design by local artisans.

4.2 Diffusion of Technology Within Pakistan

Although this is not the primary focus of this study, it is important to note the important role of the private sector in this area. The cigarette and sugar industries have networks of buyers who also act as technical advisors. Their operations have been described in some detail in Tabor and Morgan (1983). Some companies in the pesticide and fertilizer industries also have well trained technical staffs and distributors.

Private companies in the fertilizer industry at certain times have played an important role in the diffusion of technology. In the early days of the Green Revolution, Exxon was very active in supporting demonstrations of new varieties and their responsiveness to fertilizer. They provided training courses for government extension agents on the application of fertilizer. They provided technical training to their dealers and held farmers meetings to teach modern farm management practices to farmers. Dawood-Hercules and Jaffer Brothers provided similar services.

Today these private companies plus Fauji fertilizers are providing training to dealers and farmers. Exxon also finances demonstrations and field days which are put on by government research institutions. This year they financed demonstrations of new rice varieties from the government research institutions at Kala Shah Kaku and Dokri; no-till wheat, fertilizer and planting date trials at Faisalabad and Tandojam and sugarcane trials at Tandojam.

5 Government Policies and Programs That Affect Private Research and Technology Transfer

Six types of government policies and programs affect private sector research and technology transfer in Pakistan. First, government regulates the prices of many products. Second, governments determine what products can be sold by which companies through licensing and import policies. Third, government corporations supply many inputs and buy some of the outputs. Fourth, taxation provides incentives and disincentives to research. Fifth, the patents and monopoly power can provide incentives for private research and technology transfer. Sixth, government research sometimes cooperates with private sector research programs. The first three types of policies could be grouped under the category of industrial policy while the last three could be called technology and research policy.

5.1 Industrial Policy

The negative impact of government regulatory policy is probably most clearly seen in the case of the seed industry. The government has an explicit policy to encourage seed production by the private sector. Since the early 1980's, the government has eliminated income and sales taxes on the seed industry and they allow the import of seed processing equipment duty free. The implementation of government seed laws, however, has substantially restricted the amount of private research and seed sales.

The government seed laws went into effect in the last 10 years. The gov-

ernment established a seed board that is supposed to approve all varieties before they are sold. However, the government did not allow private hybrids in their trials at first. Recently, they have allowed some varieties into their trials, but none of them have even been approved for sale to farmers.

Most of the major multinational seed companies have looked at the possibility of setting up subsidiaries in Pakistan. Pioneer tried for a year in 1969 and gave up. However, they continue to test hybrids in Pakistan every year. Exxon tried some Northrup-King sorghum and maize hybrids in the early 1970's but decided a seed industry would not be profitable. Ciba-Geigy and Rafhan almost went into a joint venture to produce maize in the early 1980's, but local conditions and global strategy caused Ciba-Geigy to pull out after several years of planning. DeKalb sells a limited amount of hybrid corn and soybean seed to the local representative of Arbor Acres.

After selling seed to the Ghee Corporation for a number of years, Cargill decided to go into business for themselves. In 1984, salesmen of Cargill sunflower hybrids were jailed for selling unregistered seed while the agents of the government owned Ghee Corporation were allowed to sell the same hybrids. Eventually, the courts decided that if the government corporation could sell an unregistered hybrid so can Cargill. Government activity of this type reduces profits and makes companies very wary of investing in Pakistan.

A number of companies are watching the fate of Rafhan and Cargill. If it appears that these companies will be able to operate profitable seed businesses, a number of other companies might well open up operations in Pakistan.

The commercial poultry industry is an example of successful tax policies

but unsuccessful technology and research policies. The Pakistan government had a number of tax incentives and subsidies during the 1970's that encouraged the development of the commercial poultry industry. These included: (1) income and sales tax exemptions on poultry farming, breeding and processing; (2) duty free importing of all breeding stock and poultry equipment; (3) providing land on a lease basis to set up poultry estates; and (4) relatively easy credit for poultry operations. These incentives led a large number of middle class, urban individuals to invest in the poultry industry. Many of these incentives are still in place today.

Unfortunately, the government has not been able to provide an effective veterinary system and a research program on disease control to back up veterinarians. The leaders of the poultry industry list this as one of the major constraints to further growth.

The main factors affecting private research and technology transfer by the private sector have been nationalization and import policies. The nationalization of tractor imports and production from the early 1970's until 1981 meant no private research on tractor production or the tractor itself. Since then, companies have been primarily trying to start up production rather than improve the machines they produce. There is also government pressure to increase local content of tractors.

Improvements of irrigation equipment have been made by local manufacturers over time. This was documented by Child and Kaneda in 197?. However, attempts by the government to encourage this type of small scale industry may have discouraged other, more important changes. One study stated:

> In order to protect small scale manufacturers of oil engines, the government had instituted a ban on imports of all diesel engines below 20 hp size. In reality, this policy in many ways stagnated the small diesel engine industry as it did not permit the market development of modern, light-weight, high speed diesel engines. Because of the lack of high speed diesel engines, small scale farm mechanization and irrigation could not be developed in Pakistan. (USAID/USDA, 1983.)

The cigarette industry is very heavily taxed. About 75 percent of the market price of a cigarette goes to the government. It also appears to be closely regulated by the government through the Pakistan Tobacco Board which sets minimum prices, fixes the content of contracts with growers, conducts research and determines which technologies to recommend. These issues are determined by the Board on which consists of representatives of the govsernment, industry and the farmers. The cigarette industry operates as a regulated oligopoly. This limits the amount of competition and allows the firms to capture gains to research. Thus, in this case, government regulation may actually lead to research.

The government has intervened in the sugar industry by regulating imports and exports so that prices have generally been well above the price of sugar in the world market. It sets a price at which the sugarmills are required to purchase cane from their contract growers. The government has set up mill zones around easch white sugar mill. Within these zones, farmers are supposed to sell 80 percent of their cane to that mill. The government has also provided input subsidies. The net affect of these poli-

cies has been to keep sugar more profitable than it would have been world prices. Without these profits, companies probably would not have done the small amount of research that they did do.

5.2 Technology and Research Policy

Although there are a number of area in which private and public sector researchers do not work well with each other, there are a number of cases where there seems to be rather close cooperation. Some of these might serve as examples for other commodities or disciplines. Perhaps the closest cooperation is the tobacco industry. The two private research programs conduct their variety trials jointly with the Tobacco Research Institute of the government's Tobacco Development Board. The Board is financed by a tax on tobacco production, and the companies are represented on the Board. The companies felt that they had considerable influence on the research program of the Institute. Sometimes the industry provides the Institute with special funds for important project or equipment that is needed. Several years ago when the Institute was working on improving the efficiesncy of flue curing, the industry provided furnaces and equipment to make special briquettes.

There are two other areas where there has been some cooperation between public and private research programs. One is between Jaffer Brothers' potato program, the government research program and the International Potato Center (CIP). They are trying to reduce Pakistan dependence on seed potatoes from Holland. PARC, CIMMYT and Oregon State cooperated with representatives of the pesticide industry to train researchers

and extension agents in weed management in wheat production.

There are some cases of industry assistance to public sector research. The tobacco industry provides special funds to the Tobacco Research Institute. when needed. Exxon provided money for fertilizer and varietal demonstrations. The Poultry Association of Pakistan has provided money to the Poultry Research Institute in Karachi for nutrition at research projects. The Association also provided the layers and feed, sold the eggs and then put the earnings back into a rotating fund for research.

6 Potential Policy Changes and AID Activ ity

6.1 General Economic Policies

The general privatization of the economy and a return to market forces for setting prices could pay substantial dividends for Pakistan. There is the danger, however, of substituting private monopolies for public monopolies. Pakistan has moved gradually in the direction or privatization. The pesticide, fertilizer and tractor industries are important examples of privatization since 1977.

There has been less progress in moving away from government determination of prices of agricultural inputs, outputs and goods made from agricultural products. This is where progress is required in the future.

6.2 Technology Policies

The current seed certification process is a major constraint to private sector research to develop new hybrids and varieties. The process appears to be a lengthy one. So far, no corn hybrids or varieties produced by private companies have ever been approved. Several varieties have been tested for two years and are still awaiting approval. This has clearly limited the activity of the private seed industry in Pakistan. The potential benefit of this law may be to prevent seed susceptability to certain diseases from being imported. The government has released varieties that have disease problems and so it is not clear that the government system is always effective in eliminating varieties with problems. An objective system of quarantine for imported varieties and an unbiased, voluntary system of certification would

seem to be the most appropriate goal for the Pakistan system.

The government can play an important role in testing technology developed or imported by the private sector to provide farmers with information about which technology works best under certain conditions. For example, in the early 1980's, PARC was planning to test the performance of imported poultry varieties. They would ask the hatcheries to voluntarily submit birds for testing. The results would be published regularly but there would be no restrictions on selling a variety if it did not do so well in a trial. The results would help commercial poultry operations decide on what birds to choose. There are two dangers in such a scheme: first, if the government does the trial poorly, they would be providing mistaken information and second, the government of Pakistan has an almost irresistable urge to regulate. This might soon become a required testing program and then be used to prevent some varieties of poultry from being used.

Regulation of the pesticide industry is also clearly needed. The current system seems fairly effective in identifying pesticides that are effective. Companies also seem satisfied that they have effective patent protection.

6.3 Research Policy

PARC and AID should try to expand the areas in which private companies who do research and technology transfer work with public research. The tobacco and potato case seem to be the best examples of fruitful cooperation at the moment.

The poultry producers had a strong desire for greater cooperation. The poultry producers in Karachi would particularly like to have an active re-

search institute in the Sind. Their number one constraint is disease problems which is something none of them can work on as individual companies. They can set up diagnostic labs and are doing so, but the study of disease problems is something they feel the government should do. At the moment they feel that they are getting nothing out of the Poultry Research Institute in Karachi. Part of the reason is the chronic lack of funds of the Institute. The Institute's board discussed turning it over to the Poultry Association, but this was turned down by the Sind government. Now the Poultry Association is in favor of shifting it to PARC so that it would at least have sufficient budget to so some work.

Shakkarganj Research Institute is exploring the possibility of having scientists from the government of Punjab work at Shakkarganj for six months and then return to the government. They would then come back from time to time as consultants or for further research.

Some reordering of priorities in the plant protection research appears necessary. More resources need to be devoted to government research on IPM and biological control. At the moment, scientists at the Pakistan Central Cotton Committee have little time for it. The Commonwealth Institute for Biological Control does not have sufficient resources to survey the pests and predators of the cotton crop.

PARC also could encourage interaction of public research with private agribusiness. The private sector can help to diffuse public sector research more rapidly. In Thailand and Indonesia, the most important agents in diffusing government corn varieties are Chareon Pokphand and Cargill. Both companies are important seed producers, but their feed business is even more important. They have been promoting corn varieties even though

varieties are potentially less profitable than hybrid corn.

6.4 Future AID Activities

AID should continue to encourage privatization of agribusiness through policy dialogue and projects. AID has been one of the few forces in Pakistan consistently pushing for a larger private sector. It has used policy studies to show the inefficiency of the public sector and available leverage to push the results of these studies.

AID should support for education in the agricultural sciences and for agribusiness education at institutions like the Lahore University of Management Sciences. In Pakistan, there is a very clear pattern of retired government scientists leading the private research programs. Most of these scientists were trained in the U.S. with USAID scholarships. These AID investments in higher education are now paying off in the development of private sector research in Pakistan.

AID should encourage more interaction of public and private research through AID's MART project and other projects. There are a few examples of public and private research interaction. Two examples involved CIMMYT's work with wheat herbicides and CIAT's work on seed potatoes. Both of these centers receive funds from AID. PARC has recently established an agribusiness advisory council and the MART project is financing a survey of private sector research. These linkages should be built upon.

More research is needed in the area of integrated pest management, biological control and safe ways of using pesticides. In the plant protection area, the primary issues seem to be how to achieve a better balance between

chemical and more integrated forms of control of cotton pests. This means that the private sector and government researchers have to work together more closely. The MART project might try to organize more public-private research cooperation around this problem. Pesticide companies might be willing to provide resources for research on natural predators.

There are two types of policy studies that could be valuable for Pakistan. The first would focus on policies that influence technology development and adoption. AID is proposing to finance a number of studies on agribusiness which should deal with the general policies affecting the profitability of the companies and, hence, their ability to finance research. However, the issue of intellectual property rights - primarily patents - and their role in providing incentives for transferring technology or developing new technology needs to be examined. The second type of study would focus on innovation in a specific industry. Agricultural machinery is one candidate for further study and plant protection might be another.

The agricultural machinery industry presents a puzzle. Studies have documented the inventiveness of small machine shops in Pakistan and elsewhere in Asia. At the same time, observers from PARC and CIMMYT report unmet needs for the mechanization of certain operations. The IRRI rice mechanization program that met with some success in the Philippines and Thailand was tried for a number of years here but apparently failed. Government machinery research also appears to have failed to produce anything very useful. A study needs to be done to find out (1) whether informal agricultural machinery research is widespread in Pakistan, (2) what type improvements are being made, (3) what impact these improvements have had, (4) what factors, including policies and property rights, determine

companies innovative activities, and (5) what is the companies' relationship to public research? (especially did they work with the IRRI project? and what was their assessment of that?). Another useful study might be the role of agribusiness in diffusing technology. Many businesses have extension people who frequently double as salesmen to the input firms or buyers for processing firms.

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Pakistan: List of Meetings

Saturday, February 1	**Islamabad**
	Alan Haukins, USAID
	Dick Goldman, USAID
	Larry Morgan, Chemonics
	Peter Hobbs,CIMMYT
Sunday, February 2	Barry Primm, USAID
	Derek Byerlee, CIMMYT
	Joe Brooks, USAID
	John Stevens, CIMMYT
	M. Afzal Khan, Arbor Acres Pak Ltd.
Monday, February 3	**NWFP**
	M. Mohsin, Premier Tobacco Industries, Ltd.
	Md. Niaz Khan, Pakistan Tobacco Co., Ltd.
	Islamabad
	Khalil Sattar, K&N Poultry (Karachi)
	Derek Byerlee, CIMMYT

Tuesday, February 4	Dr. Khan Bahadur, Rafhan Maize Products (Faisalabad)
	Lahore
	Mohammad Amin, Cargill Pakistan, Ltd.
	Asim H. Qadri, Farm Aids, Ltd.
Wednesday, February 5	**Faisalabad**
	Malik Mohammad Anwar, Rafhan Maize Products
	Sarfraz Ahmad Khan, Rafhan Maize Products
	S. A. Qureshi, Shakkarganj Research Institute (Jhang)
Thursday, February 6	Mohammed Naim, Feedmill (Karachi)
	Karachi
	Jost Frei, Ciba Geigy
Friday, February 7	Holiday
Saturday, February 8	C. B. Porter, Imperial Chemical Industries
	M. Tahreem Malik, Imperial Chemical Industries
	John A. Chandler, Jaffer Brothers, Ltd.
	Mansoor Ahmed, Jaffer Brothers, Ltd.
	Shaikh Suliaman, Jaffer Brothers, Ltd.
	Abdur Rafay, Agro Chemicals, Ltd. and President, Pakistan Agricultural Pesticides Association
Sunday, February 9	S. M. Zaki, Exxon Chemical Pak.
	M. I. Samee, Exxon Chemical Pak.