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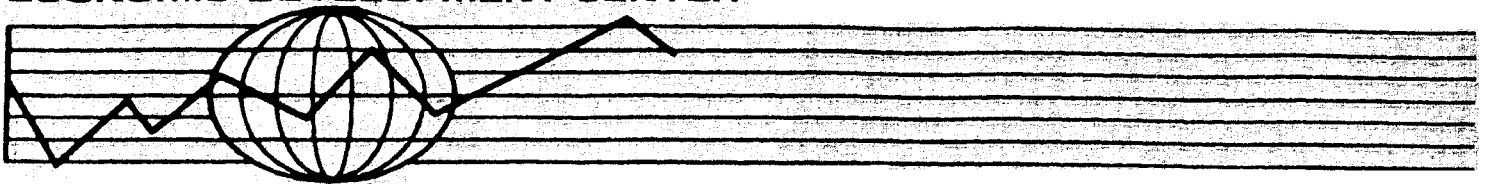

AGRICULTURAL RESEARCH AND TECHNOLOGY TRANSFER BY THE PRIVATE SECTOR IN THE PHILIPPINES

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EXECUTIVE SUMMARY

This paper is one of six country studies in Phase II of a research project on private sector research and technology transfer funded by the Policy Planning and Coordination Bureau of AID/Washington. The other five countries are Bangladesh, India, Indonesia, Pakistan and Thailand.

This paper reports the results of an April, 1985 survey of 24 Filipino firms supplemented by published information and information from a brief visit to the Philippines in March, 1986. This survey attempted to do three things: (1) find out how much research was being done by the private sector, (2) identify government constraints and incentives to private research and (3) identify commodities and regions where impacts of research and technology transfer have been large and couild be studied in the next phase of this project.

The commercialization of agriculture in the Philippines was a major factor inducing private agricultural research. Agricultural input industries and the plantation sector grew rapidly until the early 1980s due to a combination of new technology from public research and government policies that made agriculture more profitable.

Agricultural research by the private sector is now between 32 and 40 percent of the total research conducted in the Philippines. However, it is still small compared to the value of agriculture - only 0.1% of the value of agricultural GDP. Private research grew rapidly in the 1970s, but then levelled off or perhaps declined in the mid 1980s. The seed industry, pesticide industry, and plantation and processing industries had the largest research programs. There was also research in livestock feeds and shrimp

production but the quantity is unknown. There is a considerable amount of innovative activity in the agricultural machinery industry but most of it is informal R and D.

The growth of private sector research in the Philippines was due to the growing profitability of the input industries and plantation sector plus some government activities that specifically effected the profitability of investments in research. The most important public sector activity was agricultural research by the government and International Agricultural Research Centers. Research by the government, IRRI, CIMMYT and Rockefeller Foundation led to methods for controlling downy mildew in hybrid corn and methods for producing hybrid rice which led to private breeding programs in these crops. The presence of IRRI and UPLB has led four companies to establish Asian regonal research programs in Los Banos. A second important activity was the training agricultural scientists which enabled companies to use local staff rather than expatriots. Third, policies that allowed the concentration of economic power resulted in some firms which were large enough to capture substantial benefits from research. Fourth, policies that allowed research oriented foreign firms 100 percent ownership in local subsidiaries helped induce some companies to locate research facilities in the Philippines, Fifth, utility patents seem to have stimulated innovative activity in the agricultural machinery industry.

The major impact of private technology transfer and research has been in the poultry and swine sector and the plantation sector. Poultry and swine technology were imported from outside and have been modified by formal and informal research to be more productive in Philippine conditions. Plantation

research reduced the cost production of bananas and pineapples and increased yield per ha of sugarcane. Pesticides introduced by the private sector have increased the yields of rice, vegetables and bananas. Pesticide research has identified some new compounds for use as herbicides and plant growth regulators. Plant breeding is beginning to have some impact with 50,000 ha under hybrid corn. Innovations in agricultural machinery have reduced the imports of foreign machinery and parts and increased the efficiency of local machinery.

AID has indirectly supported the development of private research through its support for government research programs, agricultural universities and international agricultural research centers. The current weakness of the government research and university programs suggests that an important way of strengthening private research in the future will be to invest in public sector research. Some of this support could be targetted at programs which would be particularly useful to the private sector - i.e. the development of white inbreds of corn or nobelization of cane and releasing the early generations to the private sector for their cane breeding programs. AID might consider supporting a competitive grants program that private and public research institutions would be eligible for. AID might also strengthen private research and technology transfer by supporting policy conferences on science and technology policy which bring together the public and private sector and by supporting research by Filipino social scientists on science and technology policy.

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OVERVIEW OF AGRICULTURAL DEVELOPMENT

General

The agricultural sector grew at a rate of about 4.0 percent annually during the period 1955 to 1980. This growth is broken down into different sectors in Table 1. During the 1970's, growth was led by the crop sector which grew by almost 8 percent in the first half of the decade and by 6.5 percent in the last half. By 1980, crops made by 65 percent of the gross value of agricultural output. Rice, coconuts, corn and sugarcane are historically the most important crops. Table 2 shows their growth rates. Rice production grew rapidly due to modern varieties of seed, fertilizer, irrigation and pest control. The growth in corn production was due to growth in demand for corn for human consumption and livestock feed and to government policies which raised the price of yellow corn. There was a small increase in average yield per acre, but most of the increase was due to increased acreage. The changes in sugarcane and coconut production were largely due to changes in acreage rather than productivity changes.

The changes in agricultural exports are shown in Table 3. This shows the rapid increase in coconut and sugar exports. An additional thing to note is the rapid rise in fruits and vegetables category. This is due to the rapid increase in banana and pineapple production and exports from almost nothing in 1965 to around $200 million in 1979.

Table 1. Sector Growth Rates of Value Added in the Philippines, 1955 - 1980.

	1956-1961[a]	1961-1966	1966-1971	1971-1976	1976-1979	1956-1979
			(Percent)			
Industry	4.7	5.8	5.2	6.9	6.8	5.2
Manufacturing	6.3	5.2	5.6	7.1	5.8	6.0
Services	4.3	4.4	4.6	5.2	4.8	4.8
Agriculture	3.6	4.3	3.5	4.2	4.7	4.0
Forestry	9.8	5.9	4.0	-4.6[b]	-1.0[b]	2.8[b]
Fishery	2.9	4.9	7.7	4.6	3.3	4.8
Livestock and Poultry	-2.6	6.8	1.9	1.7	4.2	2.1
Crops	4.6	3.3	5.0	7.7	6.5	5.3

[a]End years are three year averages centered at the year shown.

[b]This low growth rate was due in part to underreporting of log exports (Power and Tomaneng).

Source: David, 1983.

Table 2. Annual Growth Rates of Major Agricultural Cops in the Philippines, 1955-1980.

	1956-1961[a]	1961-1966	1966-1971	1971-1976	1976-1979	1956-1979
Rice	2.9	1.4	5.2	3.1	5.7	3.5
Corn	7.2	2.8	2.7	2.6	5.1	5.8
Sugar	8.0	1.7	6.7	3.1	-2.5	4.4
Coconuts	-0.2	5.3	1.9	13.9	8.9	5.6

[a]End years are three year averages centered at the year shown.

Source: David, 1983.

Table 3. Value of Philippine Agricultural Exports By Leading Commodities, 1955-1980.

	1965[a]	1966	1971	1976	1979
	(FOB million US$)				
Agricultural exports	369.2	680.4	800.2	1,681.6	2,259.3
Coconut Products	167.0 (45.2)[b]	217.7 (32.0)	230.3 (28.8)	589.0 (35.0)	919.0 (40.7)
Sugar Products	102.0 (27.6)	146.7 (21.6)	211.3 (26.4)	535.7 (31.9)	359.7 (15.9)
Forestry Products	48.3 (13.1)	228.0 (33.5)	264.7 (33.1)	311.3 (18.5)	475.3 (21.)
Fruits and Vegetables	8.7 (2.4)	13.7 (2.0)	42.3 (5.3)	141.0 (8.4)	214.0 (9.5)
Abaca	35.7 (9.7)	21.7 (3.2)	16.0 (2.0)	26.0 (1.5)	35.7 (1.6)
Tobacco	4.7 (1.3)	38.0 (5.6)	16.0 (2.0)	31.0 (1.8)	31.0 (1.4)
Fish	0.1 (0.03)	0.5 (0.1)	5.6 (0.7)	28.5 (1.7)	98.5 (4.4)
Others	2.7 (0.7)	14.1 (2.1)	14.0 (1.7)	19.1 (1.1)	126.1 (5.6)
Total Exports	428.3	806.0	1,101.2	2,673.0	4,604.6
% of Agricultural to Total Exports	86.2	84.4	72.7	62.9	49.1

[a]Three year averages centered on the year shown.

[b]Figures in parenthesis are percentage of agricultural exports.

Source: David, 1983.

Livestock, including poultry, contributes about 15 percent of of the gross value added in agriculture. Figure 1 shows the rapid growth in meat production since 1955. The growth rate of pork, poultry meat and eggs accelerated rapidly during the 1970's and grew even more rapidly in the early 1980's.

Specific Industries

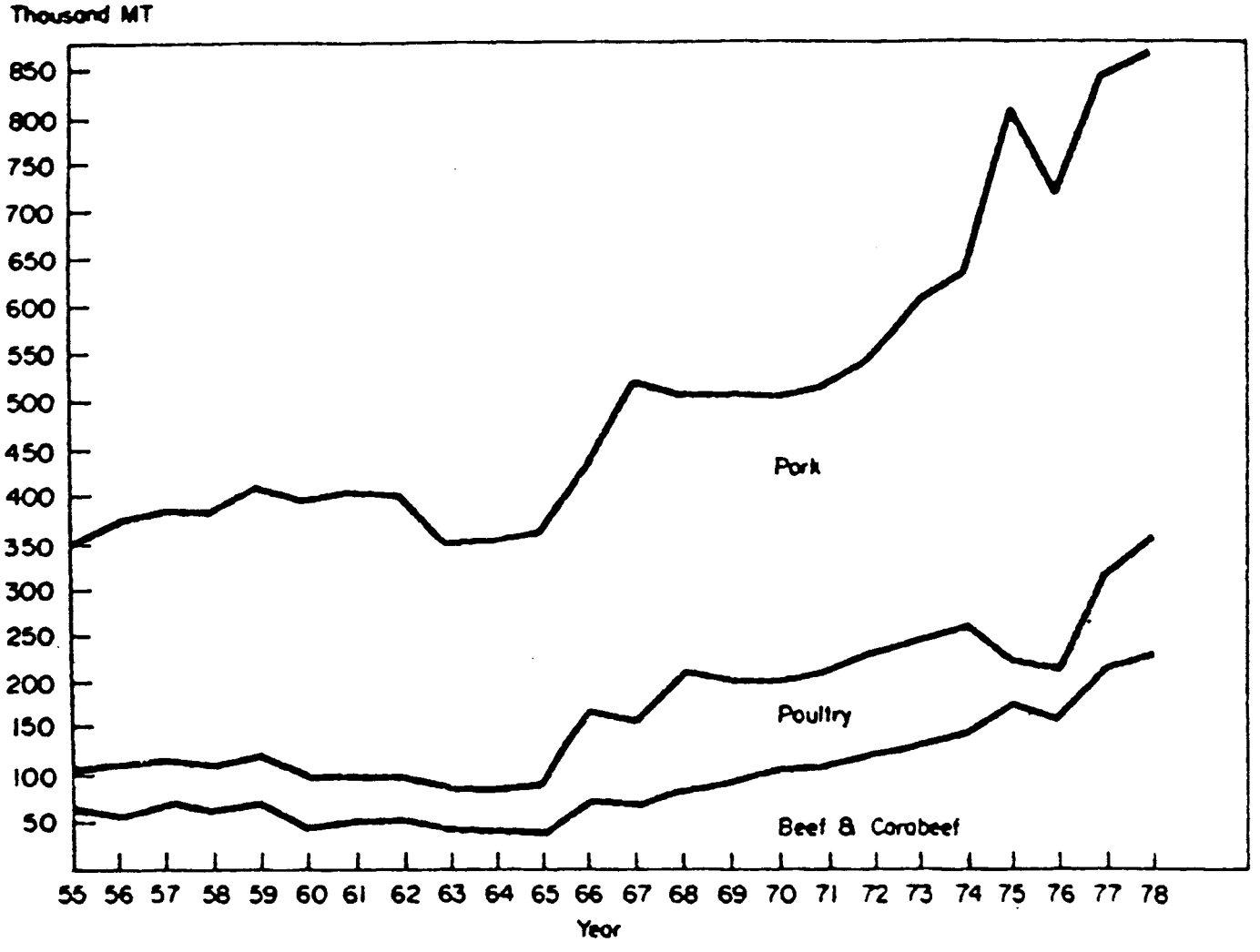
The large-scale, private seed industry consists primarily of the hybrid corn industry. The first hybrid corn seed was marketed in 1979. Sales peaked in 1983 when the market was about 1300 metric tons. In 1984, sales were down. This year (1985), several companies are predicting that sales will reach the 1983 levels again.

The structure of the corn seed industry in 1985 was relatively simple. Pioneer, a wholly owned subsidiary of Pioneer Overseas Corporation, and Pacific Seeds, a joint venture with a multinational, breed new hybrids, import hybrids and produce foundation seed. The seed is then multiplied and distributed exclusively by a local company in each case. The two other companies, San Miguel Corporation and Cargill, have their own research, seed production and distribution system.

The government has assisted the private seed industry in a number of ways. Government research and international agricultural research developed downy mildew resistant varieties which were essential for the successful development of hybrids.

Government policies have occasionally slowed the growth of the hybrid seed industry by controlling prices. For a period in the early 1980's, prices were held below the level at which companies could make a profit.

Figure 1. Trends in Meat Production, 1955-1980.



Source: Cabanilla, 1983.

Only one seed company appears to have been able to take advantage of the agricultural incentives act. The others are too big or otherwise disqualified. A proposed law will provide incentives to companies that are not foreign owned. The government did allow two seed companies to be 100 percent foreign owned which is unusual. This was permitted because they were bringing in new technology which the country needed.

The key factor in the demand for hybrid corn has been the government corn production programs - specifically, the Maisagana program. Several companies developed their research and seed production programs on the expectation that Maisagana would be successfully implemented. It required farmers to use approved hybrids or varieties and provided the fertilizer and pesticides needed through highly subsidized credit programs. Unfortunately, the program rarely succeeded in getting credit to the farmers on time and so inputs were not purchased. Now, the government does not have enough money to run these programs (although money for this may be forthcoming from donors), and Planters Products, which distributed most of the inputs and some seed corn, is on the brink of bankruptcy. The seed companies are currently going after markets in which these subsidies are not needed.

The second key factor in the demand for hybrid seed is that the price of yellow corn is considerably above the world market price (David, 1983). This is due to a combination of government support prices and internal procurement and import duties.

Fertilizer has been a very important input into rice, sugarcane and banana production. These three crops accounted for 86 percent of the fertilizer used in 1983 (FADINAP, 1985). Consumption grew quite rapidly until

1980 and then levelled off at about 850,000 mt. Around 20 percent of fertilizer consumed is produced in the Philippines, the rest is imported. Most of it is imported, produced and distributed by the private sector. The main distributor is Planters Products, Inc. which controls about 66 percent of the market (FADINAP, 1985).

The government has subsidized the use of fertilizers by providing it through rice production programs like Maisagana 99, the Iloilo project and the maize production program MaiSagana.

Pesticide use was very limited in the Philippines until recently. Figure 2 shows the growth in pesticide imports. This gives a general picture of pesticide use because all of the active ingredients of pesticides except some 2,4-D and a large portion of the formulated products are imported.

Table 4 indicates the type of pesticide sold, and the next table (5) shows the use of pesticides by crop. The major factors in the growth of insecticides are related to the rice production. The growth in the demand for insecticides appears to be due to a combination of factors: the intensification of cropping patterns due to increased irrigation and fast maturing varieties; the susceptibility of some of the new rice varieties to insect pests; increased availability of pesticides; and subsidized credit for insecticides. The subsidized credit was provided to farmers for the purchase of specific pesticides in intensive rice production schemes like Maisagana 99 and corn programs like Maisagana. The first period of rapid growth in insecticide utilization took place between 1971 and 1978. This is the period during which the Maisagana 99 had the most impact.

Table 4. APIP Stock Sales of Pesticides at Net Distribution Price, 1977-1981.

(1,000 U.S. $)

Item	1977	1978	1979	1980	1981
Insecticide	18,131	24,078	28,456	28,495	31,792
Herbicide	5,427	6,872	8,081	8,081	10,392
Fungicide	8,354	9,077	8,148	8,081	10,907
Rodenticide	112	115	79	79	75
Nematocide	--	--	--	---	2,279
Fumigants	536	987	195	1,280	1,162
Other (hormones, Miticide, etc.)	1,085	1,200	1,829	1,883	2,137
Total	33,645	42,329	47,319	47,966	58,744

Source: APIP.

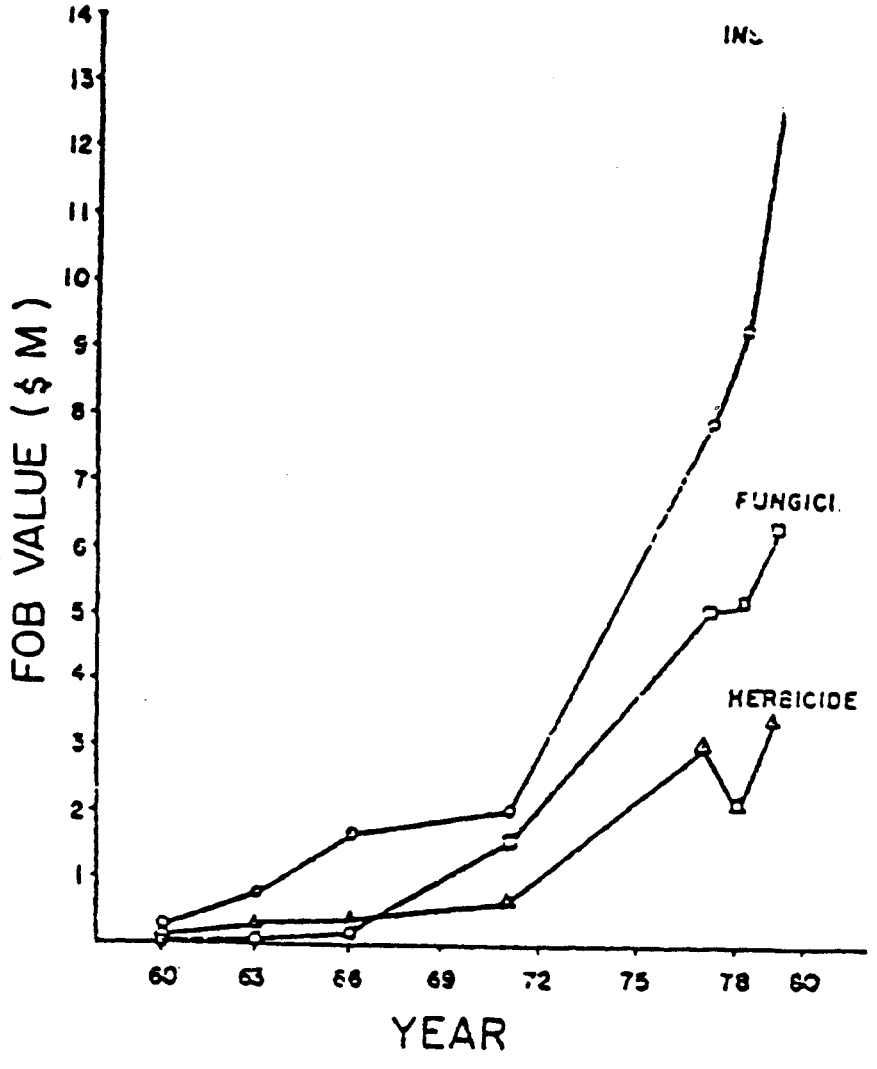
Table 5. Estimated Usage of Pesticide by Major Crops: 1980

	Percent of Total Sales				
	Insecticide	Herbicide	Fungicide	Rodenticide	Fumigant
Rice	54	54	-	84	-
Fruits	23	-	8	-	-
Vegetables	16	5	30	-	-
Corn	2	2	2	-	-
Cotton	2	-	-	-	-
Tobacco	2	-	-	-	-
Sugar	1	18	-	16	-
Banana	-	21	60	-	-
Total	100	100	100	100	100

Source: APIP.

Rice, bananas and sugarcane account for almost all of the herbicide use in the Philippines. Most of the herbicide used in rice production is in upland rice areas where farmers are using short duration rice varieties and increasing the intensity of production by growing two rice crops a year. Banana and sugarcane plantations are the other big users of herbicides.

Figure 2. Philippine Pesticide Importation.



Source: Fertilizer and Pesticide Authority.

Banana production accounts for all of the fumigants, which are nematicides, and 60 percent of the fungicides, which are used to protect the crop from sigatoka. Thus, as banana production rises or falls, the use of these pesticides rises or declines.

A number of government policies affected both the supply and demand for pesticides. On the supply side, strong government policies on patents and trademarks encourages foreign companies to sell in the Philippines. The absence of regulation before 1977 and the relatively inexpensive registration and labeling procedure at present is also an incentive to invest. There are also specific tax incentives for investments in local formulation facilities. However, tariffs and other taxes are high enough to be a constraint to sales according to several companies interviewed. David (1983) found that the implicit tariff on pesticides was 23 percent and so pesticides were at least that much more expensive than on the world market. Restrictions on foreign exchange are sometimes restrictions to imports and sales by some companies.

Another set of government activities influenced the demand for pesticides. Research by UPLB, BPI and IRRI was the basis of the new rice varieties that encouraged intensification of cultivation and increased profitability of pesticide use. Government investments in irrigation also intensified cultivation and led to increased pesticide use. Other research decreased the need for pesticides. Breeding crops for pest resistance has been a major success of government and IRRI research programs.

Pesticides for rice and corn have been available through major crop production programs of the 1970's and 1980's like Maysagana-99 and Maysagana Mais. Approved pesticides can be purchased with low interest (actually

negative real interest rates) government backed loans. In some cases, the government subsidized the price of the pesticides sold in these programs. It should also be noted that one of the chemical companies helped develop and then supported the pilot program which then became the Maisagana-99 program. The government has tried to control the prices of pesticides at certain times. At present, however, prices are not controlled directly.

Government policies to assist the banana industry have also been important to pesticide demand since banana plantations require intensive pesticide applications. These policies are described below in the section on the plantation industry.

Before 1970, agricultural mechanization in the Philippines was primarily four wheeled tractors that were used on the sugarcane plantations. There were also some large rice threshers in use. Cultivation by small two wheeled tractors started in the early 1960's. These machines were imported from Japan and the United Kingdom. The demand for these machines really took off after 1966 due to increased income from the green revolution rice varieties and the availability of credit from the Central Bank and IBRD (Mikkelson, 1984).

Local production of machinery was limited to assembling four wheeled tractors from imported parts before 1970. Domestic production of two wheeled tractors started in the early 1970's. "An important factor in stimulating domestic production was the release in 1972 of a simple hand tractor design developed by engineers at the International Rice Research Institute (IRRI) in the Philippines... Annual sales growth of domestic hand tractors averaged a phenomenal 112.7 percent of this period [1972-78]. IRRI-designed machines

accounted for 45.6 percent of 1975 production and 41.7 percent in 1976." (Mikkelson, 1984). The industry also produced a number of other new products including small scale threshers for rice and other crops, irrigation pumps and grain driers.

About 75 firms were producing agricultural machinery of some type in 1981. The industry is fairly concentrated. Five of the the 49 firms reporting in Mikkelson's survey had 62 percent of sales (Mikkelson, 1984).

The most dynamic sectors of the livestock industry are commercial poultry and swine production. Commercial poultry accounted for about half the poultry meat production in 1983. The growth in poultry production was initiated by the import of improved birds from U.S. and Canadian poultry breeders, the import of feed technology from the U.S. and Europe and of veterinary pharmaceuticals from the U.S. and Europe. The industry has grown rapidly through integration of hatcheries, feedmills, contract growers and retail outlets. There is some concentration in that SMC has 40 percent of the market of broiler chicks, half of the feed market and a large chunk of the retail poultry market.

The government has provided protection against imports - the main threat being Thailand. The effective protection rate is over 200 percent for commercial broiler operations but almost nothing for eggs (Cabanilla, 1983).

The commercial swine industry has built on the success of poultry. About 10 to 15 years ago, when poultry production became more competitive and less profitable, some of commercial poultry producers shifted to pork production. The feedmills shifted easily into swine feed production and the pharmaceutical companies that supplied poultry pharmaceuticals also provided

swine products. The varieties of swine come primarily from Europe. About 25 percent of the pork is produced in large commercial farms. There is little or no effective protection for swine.

The main plantation crops in the Philippines are sugarcane, bananas, pineapple, coffee and rubber. There are now some cocoa plantations also.

Sugarcane plantations date back to Spanish colonial days. Most of the technology for sugarcane production has been imported from other Asian countries like Taiwan and Indonesia. In recent years, Australia has also been an important source of technology. There is now both private and public sugarcane research, but much of the technology continues to be imported. The demand for sugar has been determined largely by the interaction of U.S. sugar policy and the policies of the Philippine government. Before 1974, it was allowed into the U.S. duty free. Since then it has had to compete with other producers for that market and sales and income have declined drastically. In recent years, it has suffered from the glut of sugar on the world market. A useful review of these policies is found in Nelson and Agcaoili (1983).

In the past a major constraint to the development of large scale plantations by foreign companies was a law that restricted the size of lands that could be owned or leased. There was also the constitutional article that limited ownership of agricultural land to Filipino citizens or corporations that were at least 60 percent Filipino owned.

The growth in plantations other than sugar depended on changing these laws or getting around them. The banana companies accomplished this by three different means in the late 1960's: farm lease and management contracts with small-scale landowners; a plantation development agreement with the Bureau of

Prisons; and small-scale growers contracts. The other crucial factor in the development of the banana plantations was reduction of Japanese import restrictions on bananas in 1963. (Centre, 1981)

Rubber production was started in the 1940's, but it grew slowly until about 1969. In the next ten years, production tripled. Technology was imported from Malaysia by Goodyear, Goodrich and Firestone. The University of Southern Mindinao may also have imported and transferred some technology to small farmers. Large estates account for 22 percent of the rubber acreage and a much higher percent of production. The other 78 percent is held by small holders who average 2 ha. of rubber a piece.

The production of Virginia tobacco dates back to the period immediately after the Second World War. At that time, a small American company introduced Virginia tobacco production to local farmers and bought back their leaf tobacco. This really took off in the 1950's. In the 1960's, the government took over the buying and marketing of Virginia tobacco while private companies continued to make the cigarettes. The original Virginia tobacco company went out of business. In recent years, the government has handed some of the marketing back to the private sector. For the past eight or ten years, the private sector has started doing some applied research in tobacco production. At the same time, the government has established quite a successful research institute on Virginia tobacco. Tobacco is unique among the cash crops in that it is almost entirely grown by small holders.

INVESTMENT IN RESEARCH

There are two sources of information on private sector expenditure on research and number of scientists. The main source is a survey of twenty-five agribusiness firms conducted by the author in the Philippines in April and May 1985 and two other firms that were interviewed in April, 1986. Seven other firms which were reportedly doing research and development including one chemical firm, two seed companies, several feed mills/animal and shrimp production units and three agricultural processing companies could not be interviewed. The data on the firms interviewed are in column 2 of Table 6.

This was supplemented by expenditure data from two earlier surveys conducted in 1979/80 and 1981/82 by Mikkelsen and his associates (Mikkelsen, 1984). The 1979/80 survey contains R and D data on six agribusiness firms - including two firms which were not interviewed in the 1985/86 survey. The 1981/82 survey is just on the agricultural machinery industry. In addition, estimates of R and D expenditure of two other firms from knowledgeable competitors were used. The estimates in column 4 were calculated with the addition of these data. I regard this as the most accurate estimate of private agricultural research. However, it is still an underestimate because it does not include expenditure by several major livestock and food processing companies; a major plantation company which reportedly has nine expatriot scientists and several pesticide companies.

The total expenditure of $3.3 to $4.6 million is more than previous estimates. Government research on agriculture and natural resources in 1985 was around $7 million. Thus, private sector research is at least one-third of the total agricultural research expenditure in the Philippines. Table 7

Table 6. Private Sector Expenditures and Research Personnel.

	Research Expenditures				Personnel					
	Interviews		Interviews +		Interviews			Interviews +		
	No. Cos. (1)	R & D Exp. ($ 000s) (2)	No. Cos. (3)	R & D Exp. ($ 000s) (4)	No. Cos. (5)	PhDs (6)	Total Scientists (BA+) (7)	No. Cos. (8)	PhDs (9)	Total Scientists (BA+) (10)
Seeds	4	1583	4	1583	4	4	46	4	4	46
Pesticides	6	954	8	1170	8	6	47	8	6	47
Agricultural Machinery			22	215				22		31*
Animal Husbandry and Nutrition	2	106	6	500	5	2	36	5	2	36
Plantation and Processing	5	631	7	1137	6	13	59	8	28	94
Totals	17	3374	45	4605	23	25	188	47	40	253
Government Research 1984				7062					205	2762

Notes

1985 $s using ₱18.55=$1.00.

* This includes people without BAs.

Sources: Survey; Government expenditure, Sardido; Government personnel, Gomez, 1985.

shows estimates of private agricultural research from various government surveys. In 1970/71 private research was estimated to be 6.2 million pesos or just under one million U.S. dollars (NARSS, 1971). This had grown to at least 20 million pesos a decade later. If we include research by the food, beverages and tobacco industry, plus half of the chemical industry's research to account for pesticide and fertilizer research, the figure is P 30 million. It is not clear whether any of the research expenditure in the two manufacturing categories is included in the earlier data or not. Some of it is included in the current survey. This survey estimates prviate expenditure on agricultural research in 1985 to be P 67 to P85 million.

More than half of the research is carried about by multinationals (Table 8, column 2). This survey indicates that about P30 million or $1.6 million was done by local firms. Local firms did all of the research in the agricultural machinery and livestock industries and about a third of the seed and plantation research. Multinationals did almost all of the pesticide research and two-thirds of the seed and plantation research.

The next table 9, presents some rough estimates of the allocation of private and public research by crop. The private sector estimates should be treated as very preliminary. The rice research by companies is primarily pesticide research and agricultural machinery research. Corn research is mainly by the seed industry with some pest control work. The fruits and vegetables research is primarily banana and pineapple research. It is interesting to note the dominance of the private sector in corn and fruits and vegetables. Rice is more evenly divided, but if you include IRRI in the public sector, the public sector is dominant. In all other commodities, the public sector is dominant.

Table 7. Research Expenditure - Government Sources.

	1970-71	1981	1982
PRIVATE SECTOR			
Ag., Fish & Forestry	6,179 (13%)*	20,481 (13%)	18,323 (13%)
Manufacturing			
Food, Beverages & Tobacco		8,266	8,739
Chemicals		1,438	1,636
Total Ag. Related	6,179 (13%)*	30,185 (19%)*	28,698 (21%)
PUBLIC SECTOR			
Ag. & Nat. Resources	46,906	161,800	136,900

Sources: 1970-71 from NARSS 1971; 1981 and 1982 private expenditure from NSTA, 1984; and 1981 and 1982 government from Gomez 1985.

*Numbers in parentheses are private expenditure as a percent of public expenditure.

Table 8. Philippines Private Sector Research, 1985.

	Total Research Expenditure (million pesos)	Research by Philippine Cos. (million pesos)
Seeds	30.4	10.0
Pesticides	21.7	.5
Ag. Machines	4.0	4.0
Plantation processing	21.0	9.7
Livestock	5.0	5.0
Total	85.1	29.2
Government research	131	

Sources: Private research - survey + Mikkelsen for agricultural machinery. Government expenditure Sardido, 1986. Government personnel Gomez 1985.

Table 9. Philippines Private and Public Research by Commodity.

	Private (1985)	Public (1984)
Rice	20	15
Corn	30	6
Sugarcane	3	29
Coconut	2	11
Tobacco	2	19
Fruits and vegetables	19	3
Other crops	3	27*
Livestock and poultry	5	17

Sources: Private from survey; public from Sardido.

*Half of this is root crop research.

The second part of Table 6 contains data on the number of scientists in the private sector. More firms provided data on research personnel than research expenditure. These numbers also include personnel of three firms based on competitors' estimates and personnel who are doing research in the agricultural machinery industry even though a number of them do not have their bachelor's degree (columns 9 and 10). These numbers are the last column in Table 10 which also provides other estimates of country's research scientists. The first two estimates of private sector research personnel are much too low. Some of the current private research programs were already in operation in 1971 and the 1971 data also include IRRI.

The trend in private sector research and development generally seems to be upward. Research expenditure and personnel appear to have grown although the samples are sufficiently different that real research expenditure could have declined. Interviews with companies support the upwards trends in Tables 7 and 10. Private research in seeds and pesticide experiment stations in the Philippines did not start until the 1970's. They are now substantial research programs. Hybrid seed research has apparently levelled off or declined in the last two years with two of the four major research programs reducing the size of their programs. The processing industries appear to have grown until about 1980 and then declined. The banana company with the most extensive laboratory and research facilities closed its operations in the Philippines including a laboratory and extensive field research. Research in the livestock and feed industry also seems to have started in the 1970's and was growing rapidly, at least until last year.

Is this enough private sector research or should the private sector be

Table 10. Number of Agricultural Research Staff - Public and Private Sector.

	1971	1983	1985
Private			
PhDs.	24*	1	41
Total	151*	15	282
Government			
PhDs.	157	205	
Total	1875	2762	

Sources: 1971 NARSS; 1983 Gomez 1985; 1985 this survey.
*Includes 17 PhDs. and at least 100 scientists from IRRI.

investing more? There really is no international standard for private research. The United States spends about 1.5 to 2.0 percent of the value added in agriculture on private research. Evenson has suggested that .5 to .75 percent of agricultural value added might be appropriate for the Philippines. Private companies are currently spending about .1 percent of value added on agricultural research in the Philippines. Thus, there is some evidence that the Philippine private sector should be spending more on agricultural research.

Research Activities and Goals By Industry

Seeds

Most of the research on seeds by private companies is concentrated on hybrid corn. At least four companies have research programs in which some breeding is taking place. Several other companies are testing hybrids in the Philippines. Most of the research so far has been devoted to yellow corn which is used for livestock feed and makes up about 20 percent of the total crop. In recent years, most of the companies are working on or have developed white hybrids as well, but companies are still concentrating on yellow hybrids.

The companies which are attached to foreign firms brought in lines from their tropical research programs in Brazil, Jamaica, Australia and elsewhere. San Miguel uses exotic material collected from universities in the United States, CIMMYT and elsewhere. In most cases, the exotic lines were then crossed with local material or the Suwan varieties from Thailand to incorporate downy mildew resistance. Now that seed treatment can control downy

mildew, some companies are relying on chemicals rather than trying to increase genetic resistance.

The early hybrids of most of these companies had problems with diseases or pests other than downy mildew. Two of the companies seem to have overcome these problems and control most of the market at present. The other two companies are trying to eliminate the problems with their breeding program.

Two companies have large corn breeding programs backed up by scientists in other disciplines. Other programs seem to be doing a small amount of breeding but primarily screening hybrids from elsewhere.

All of these companies see their Philippines programs as part of a regional strategy. Almost all of the diseases that are a problem anywhere in Southeast Asia flourish in Mindinao which makes it an ideal place to screen hybrids. Varieties that are produced there do well in Indonesia and Thailand. In contrast, corn varieties and hybrids developed in Thailand frequently do not do well in Mindinao. One of the companies uses part of its Philippines research station to multiply and screen material for its Japanese research program.

The companies working on corn and several additional companies are doing research on other crops - hybrid sorghum, hybrid sunflower, soybeans and hybrid rice. Most of these programs are small and none have produced commercial varieties.

Agricultural Chemicals

To characterize the research activities of the agricultural chemical industry, it may be useful to use the categories used in the United States. In 1983, the United States private R and D by the agricultural chemical industry was distributed as follows: (NACADA)

Synthesis and screening	28%
Field testing	16%
Toxicology and metabolism	14%
Formulation and process development	21%
Registration and administration	8%
Environmental testing and residue analysis	6%
Other	7%

There is no synthesis and little screening done in the Philippines. Environmental and toxicology data from countries like the United States are acceptable for registration. Most local research is field testing and development, registration and formulation.

Most of the new chemicals and new processes for making chemicals in the Philippines have been used commercially elsewhere first. Research is necessary to make the most efficient and safest use of these chemicals. Local R and D by companies (1) tests the efficacy of the pesticide under Philippine conditions, (2) modifies the formulation of the pesticide or the recommended application methods to meet the special characteristics of the local markets, and (3) meets the specific requirements of the government to get registration or labels for new uses. The local R and D required for process innovations

are adaptions to local input supply conditions and plant safety regulations. Almost all of the chemical companies who sell and manufacture pesticides in the Philippines do some research of this type.

Some companies carry out another type of pesticide research in the Philippines. This research is part of the central research function of multinational chemical companies. Most major companies have a network of research stations or farms in which they can test the effectiveness of new chemical compounds against pests of major crops and in various climactic conditions of the world. At least five, and possibly six, MNCs do field testing of new compounds that have not yet been registered for use anywhere. Much of their work concentrates on rice pesticides, but they are also working on growth regulators for rice. In addition, they work on plantation crops and corn.

There is little cooperative public-private sector research. Planter's Products (the main locally owned agricultural chemical firm) has been doing some research in cooperation with government institutions on local materials that can be used to produce active ingredients that are now imported. One subsidiary of a multinational has had discussions with PCARRD about funding research on local plants that might be used to produce pesticides. However, this is still in the discussion stage.

Agricultural Machinery

Only a small percentage of the firms in Mikkelsen's sample of agricultural machinery manufacturers in the country had formal R and D personnel and budgets. Nearly all of them, however, had some type of innovative activity. "To obtain a measure of innovative effort which

encompassed both formal and informal activities, each firm was asked how many persons, if any, were inventing new products, improving products, and improving production methods." (Mikkelsen, 43, 1984,. Over 90 percent attempted to improve production or production methods while 79 percent said that they tried to invent new products.

Livestock and Feed

Several companies are doing research in animal feed and husbandry. The technology of commercial poultry production was primarily imported from Western poultry breeders, feedmillers, pharmaceutical companies and machinery suppliers. These sources continue to be a major source of new technology and new ideas for research. Several of the local integrated poultry producers have started doing research on feeds and management. SMC appears to have the largest research program. It conducts trials on the efficiency of different ingredients and combinations of ingredients on poultry production. There has been a lot of research to find substitutes for imported inputs like corn ad soybeans. SMC's central laboratory is doing work on treatments to minimize the toxin in ipil-ipil leaves so that higher percentages of this high protein leaf can be used in producing feed. A separate branch of SMC imported shrimp production technology from Taiwan and now is doing research to adapt this technology to the economic and technical conditions of the Philippines. They do research on appropriate feed mixtures and management practices like size of ponds.

One of the major swine operations near Manila has built up a large research program to find ways of reducing the cost of feed and recycling the manure produced by 80,000 pigs. They have developed biogas plants that use

the manure to meet all the needs of their swine operations, commercial feedmill and flour mill and still sell some electricity. They are able to recycle some of the manure as feed. They also are doing research on using alternative fuels which are available locally. These include rice hulls and alcohol. They have also been working on farming systems under coconuts and farm level coconut mills. Their newest topic was conditioning sludge to be used for fertilizer.

The beef operation surveyed does not have its own research department but does have some trained people who take care of research along with other duties. This company is primarily a supplier of breeding animals. They import some germplasm using embryo transfer from a company in the United Kingdom. They are doing some joint research with PCARRD and UPLB to test the efficiency of beef cattle produced by crosses of imported semen and their cattle. They have another joint project to test different pastures in Mininao. They are trying a variety of legumes and legume-grass combinations along with different levels of fertilizer.

Processing and Plantation Industries

I have grouped these industries together because they have a common aim to reduce their cost of production or improve the quality of the agricultural product. By reducing the costs of farmers through research, the industry hopes to push down prices of their inputs and increase profits. If the processors own plantations to supply their factories, which is usually the case, they are sure that they will benefit by developing new agricultural technology.

Their research consists of a number of activities which vary by

commodity and the state of knowledge about the commodity. Table 11 shows the major areas of research reported by the companies interviewed.

The major private sugarcane research program is the Victorias Milling Company (VMC) program. The research program began in 1928. It began its breeding program in the mid-1960's because the government was not producing adequate varieties. It provides technology for the plantations and contract growers of VMC and to other sugarmills and plantations who pay a fee for varieties and technical advice. VMC has an important sugarcane breeding program which some observers in the industry feel has been more productive than the government breeding program. The other main thrust of their research is micro elements and micro organisms in the soil.

At least two other mills or plantations have small research programs. Hacienda Luisita has a small research program to adapt the Australian system of mechanized cultivation to conditions in Luzon. The Ledesma Foundation does plant nutrition and other management research.

Banana production technology was initially imported from Latin American and Taiwan (which had originally imported its technology from Latin American, also). The initial planting material of the export variety was brought in from Taiwan by small Philippino and Japanese companies. Then Dole and United Fruit brought in planting material from Latin America. They, along with Delmonte, also brought in scientists from Latin America and the United States to provide technical assistance in establishing the plantations and the research and extension programs. As exports developed several companies also set up laboratories to test bananas for pesticide residues to meet Japanese import requirements.

Table 11. Major Research Activities of the Processing and Export Industries.

Tobacco	Selection of varieties and agronomic practices of Virginia and Burley tobacco.
Sugarcane	Selection from exotic varieties, breeding new varieties, agronomic practices, plant protection.
Bananas	Plant protection and residue analysis to meet Japanese import requirements and reduce cost of production, nutrition research.
Pineapple	Plant protection and residue analysis, varietal selection.
Tomatoes	Breeding and selection.
Coconuts	Varietal selection.
Rubber	Selection of varieties and agronomic practices.
Cocoa	Selection of varieties and agronomic practices.

There are now three major banana research programs - Dole, Philippine Packing (Delmonte) and Twin Rivers Research Center. United Fruit also had a research program until two years ago when they closed all of their research programs around the world. The research programs concentrate on plant protection and nutrition. There is no research on breeding - everybody uses the same variety. Two research programs are constant in size while a third has been declining since 1981.

Dole and Delmonte are also the main pineapple producers and conduct most of the pineapple research. Much of the initial technology was imported from Hawaii. Plant protection and nutrition are two major subjects of research, but they also do some variety selection work. Delmonte also has a tomato breeding and selection program for canning tomatoes.

Cocoa was not an important crop in the Philippines until recently. The clones are mainly from Malaysia. At least three companies have a formal research program to select varieties and develop appropriate agronomic practices for the Philippines. A fourth company, which is a multinational, is trying out management practices that are very different from the practices they use in Malaysia. These trials are presumably run under the supervision of consultants from Malaysia.

There are two active private tobacco research programs. Colombia tobacco is working with flue cured Virginia in Bukidnon. Philip Morris has a research program on Burley. Both of these programs started in the late 1970's.

POLICY DETERMINANTS OF PRIVATE RESEARCH AND TECHNOLOGY TRANSFER

The first chapter listed many of the policies that determine the size and structure of the industries in which the private sector plays an important role in transferring technology and doing research. This chapter focuses on policies which specifically affect the research and technology transfer decisions of firms.

Industry Case Studies - Seed Industry

The only foodgrain in which the private seed companies have actually transferred technology or developed new technology for farmers is hybrid corn.

Firms' research decisions are based on both economic forces and government policies. The earliest research on hybrid corn was carried out by San Miguel Corporation from 1954 to 1964. The company was developing their feed business and apparently felt that hybrid corn could contribute to that. They cooperated with UPLB (then the Agricultural College) and Dr. Hayes from the University of Minnesota who was a consultant to the College at that time on hybrid corn. However, neither of these efforts was able to overcome the downy mildew problem. San Miguel had to close its research program because only firms which were 100 percent Philippino owned were allowed to deal with rice and corn. At that time, San Miguel was 30 percent foreign owned. About the same time, the government research program and the Rockefeller Foundation regional corn program with its headquarters in Thailand, decided not to work on hybrids and to concentrate their effort on open pollinated varieties. The Rockefeller program searched for sources of resistance to downy mildew in the 1960's. Thai Government/Rockefeller/CIMMYT corn rogram in material collected

and developed in Mindinao. These sources of resistance were used to produce commercial hybrids and the public open pollinated varieties which were released in the mid 1970's. In addition, a professor at UPLB showed that seeds could be treated with a fungicide to precent downy mildew attacks. These two methods of controlling downy mildew made the hybrid seed industry possible in the Philippines.

In 1976, Pioneer established wholly owned subsidiary which started a small research program in Mindinao. The same year, another foreign company set up a joint venture and started testing hybrids. In 1977, San Miguel set up their research program and, in 1981, a testing program was established by the third foreign company. This sudden "loom" in corn research was due to the combination of the technical solution of the downy mildew program; the promise of government support prices for yellow corn and subsidies from inputs; and 197H law which allowed foreign subsidies to work on rice and corn.

IRRI is playing a role in the development of hybrid rice that is somewhat similar to that of the Rockefeller Foundation in corn. IRRI is doing research that is essential to the development of hybrid rice as a commercial crop. There are at least two potential methods for producing hybrid rice. One involves the use of cytoplasmic male sterility (CMS) and the other uses gametocides. The CMS method is the only one that has been used on a wide scale and then only in China. The Chinese rice that had the CMS gene was a temporate variety that could barely survive in the tropics. Thus, the key role of IRRI has been to breed tropical characteristics into this CMS line and to identify tropical rice with the CMS characteristics. They have done this, and they have been working on lowering the cost of hybrid seed production.

This makes it possible for seed companies to further reduce costs to the point where it is profitable to sell these seeds. Cargill is financing research in China and the Philippines and conducting trials of hybrid rices in several countries in Southeast Asia and in Pakistan which indicates that they feel there is a possibility for getting into the rice seed business in the near future.

Pesticide Industry

Pesticide research programs by local affiliates of multinationals grew in response to the growth in demand for pesticides and the growth of regulation. Before, 1977, pesticides could be sold without formal registration of the chemical with the government. It was, however, important to do some local research to convince the government of the effectiveness and safety of the chemicals so that the government would approve the pesticides for their special production programs like Maisagana 99. Subsidized credit could not be used for pesticides that were not approved. In addition, the extension system recommended the approved pesticides.

The Fertilizer and Pesticide Authority (FPA) was established in 1977 to regulate the pesticide industry. They established a registration and labeling procedure based on FAO guidelines modified to fit the conditions in the Philippines. The industry was required to do research which would provide data on bioefficacy in the Philippines.

Many companies in the United States singled out the Philippines as one of the Asian countries with an effective patent system. The consequence of strong patents and the relatively low cost of registration is that many new

products are introduced into the Philippines before they are introduced in other Asian countries with much larger markets but less patent protection.

The multinationals did not establish any experiment station which were part of their central research programs until 1970. The number grew slowly to five experiment stations at present. This growth was primarily due to the companies' interest in the regional market for rice insecticides. The five stations are all in lowland rice areas and four of the five are near UPLB and IRRI. They needed their own experiment station in Asia because they wanted complete secrecy about their new products; the spectrum of pests is different in tropical Asia than the United States or Europe; and the activity of the pesticide may be quite different in Asian conditions.

Companies located these stations in the Philippines because of (1) the proximity to IRRI and UPLB, (2) the availability of skilled scientists and (3) ability of Filippinos to communicate with Western scientists. There are also some tax breaks which may have had some influence on the companies' decisions. One company has registered their research program as a foundation which reduces taxes. Another experiment station is a regional research headquarters of the company which qualifies it for some tax benefits.

IRRI spends a considerable amount of time testing new chemicals supplied by private companies. If IRRI's results are favorable, the company uses them in promoting their chemicals around Asia. In addition, if their results show that these chemicals are detrimental-for example, if they lead to hopper resurgence in rice-governments may recommend against their use or even ban their use. Thus, IRRI plays an important role in Asia in promoting the use of effective and relatively safe pesticides.

The plantation industries have their own research programs which test chemicals for the chemical companies and do their own plant protection research. They also have to keep up with United States and Japanese import regulations which means they have to have residue testing labs and do research on safer chemicals.

Agricultural Machinery

There is evidence that two policies have been important in inducing more innovative behavior by private firms. The first is the IRRI/Ministry of Agriculture machinery extension program. Mikkelson tests whether this program was a substitute for private research or an incentive to do more. His statistical analysis indicates that they definitely were not substitutes for private research and that they probably induced more research. In addition, in his survey he asked firms to evaluate the importance of various sources of technology and new ideas on a scale from 1 (not important) to 4 (extremely important). IRRI got the highest rating.

The utility patent system of the Philippines provides an extra incentive for machinery companies to develop improved machines. Under this system, a six year patent is granted to people who make relatively small changes in their product. The main incentive is not that it stops other firms from copying its product but that the company who registers the patent does not have to pay taxes on the sales of this machine for a period of time. Mikkelson's sample of 54 agricultural machinery firms had 3 invention patents and 88 utility patents.

Processing and Plantations

There are few technology policies that have affected the processing and plantation industry. There has been a decline in private sugarcane research, but this is due more to the decline in the sugar industry than government policy. Some sugarcane plantation representative complained about the uselessness of PHILSUCOM research and the negative affects of its monopoly on the import of sugarcane varieties from abroad for testing. They recognized the danger of importing disease along with varieties but said that PHILSUCOM did not provide them with good varieties and would not allow them to import anything. Thus, plantations were resorting to smuggling in varieties which makes the possibility of importing diseases even more likely.

The policy of allowing foreign consultants in with relatively low taxes both for the individual, and the firm that hires him has reduced the cost of research for many companies. The coconut seed company, tobacco industry, banana research programs, and pineapple companies have made extensive use of foreign scientists in their research programs. In recent years because of the cost of these scientists, the banana and pineapple research programs have shifted almost entirely to local scientists.

Policies of the United States and Japanese have had more impact on research of fruit exporters than Philippine policies. Companies have had to identify low cost substitutes for pesticides that are banned in the United States. The companies have stopped using some pesticides banned in the United States but not in the Philippines even though they do not show up in residues. Their concern is about the health of their workers and the potential bad publicity of using the banned products.

Private coconut research, particularly on seed, was given a boost by the government's decision that the seed of the dwarf hybrids should all be purchased from one company. This company has a research program in Davao that employs expatriots to work on coconuts and several other tree crops.

Aid Programs

AID's core funding for IRRI has supported the effective and safe use of the pesticides supplied by the private sector. The hybrid rice research may lead to a private hybrid rice seed company. Core funding and the special funds for the IRRI rice mechanization program has been very successful in promoting local production of two wheeled tractors and rice threshers. In addition, the IRRI ministry of agriculture program in rice mechanization has encouraged innovation in that industry.

AID/Manila has made some efforts to assist private agribusiness recently. They established a Joint Agricultural Consultative Corporation in the Philippines which developed some project proposals. However, there was no money from Washington to support any proposals. Therefore, the Committee is not active at the moment.

In another attempt to assist private industry, several Kellogg executives came out to assist the food processing industry. They came under Project Sustain which is funded by the Science and Technology Bureau of AID/Washington.

THE IMPACT OF PRIVATE RESEARCH AND TECHNOLOGY TRANSFER

Phase II of this project is supposed to identify where private sector research and technology transfer has had some impact on agricultural production. There is no attempt to quantify this impact here since this will be done in the next phase of this project.

Impact on Government Research

The chemical companies have permanently hired at least 5 PhD and 12 MSc entomologist and plant pathologists from the universities and IRRI and hired many more university and government scientists as part-time consultants. At least an equal number of plant protection people have been hired by companies working on bananas and pineapples. This means that a substantial portion of the plant protection profession in the Philippines is working on chemical plant protection. At present, the main supporters of IPM research on the main foodgrains are FAO, GTZ (the German assistance agency) and IRRI. A more appropriate mix would have many more people working on IPM and biological control.

The private seed industry has hired 4 or 5 PhD and 8 to 10 Masters level scientists. Most of these scientists are plant breeders, but there are also several physiologists and plant protection scientists. There are no full-time expatriot scientists, although scientists from abroad work closely with the Philippine programs. Most of the Philippino scientists worked at UPLB for some period of time before taking jobs with these companies. The last three leaders of the corn research program at UPLB have all gone to the private sector. This leaves only 2 PhDs in the public sector working on open

pollinated varieties of white corn which make up 80 percent of total corn production and all of the corn that is consumed as food.

The plantation and processing sector in the past relied more heavily on expatriot scientists than most other sectors. Today, there appear to be, at most, 8 to 10 expatriot scientist working on these crops in the Philippines. There were many more five to ten years ago, but most programs have replaced them with local scientists which has pulled people from public sector research.

The private sector has helped the geographic allocation of research resources. Most of the public sector research is located in Los Banos and Manila. It is quite weak in important agricultural islands like Mindinao. In contrast, the private sector research has a large presence in Mindinao. Most of the corn research, all of the pineapple, banana and rubber research and some of the cocoa and tobacco research are located in Mindinao. The private sector's contribution to rice research has not been as positive since it has concentrated on pesticides in lowland irrigated area.

Impact of Technology Transfer and Diffusion on Agricultural Production

Bananas and pineapple exports, rubber, cocoa and oilpalm production are primarily based on imported technology. The variety of banana used is from Central America; the pineapple varieties are from Hawaii; the rubber, cocoa, and oilpalm varieties are from Malaysia.

Production of high yielding rice and vegetables is probably up due to the imports of pesticides.

Poultry and swine production have grown rapidly in large part due to

new breeds, improved feed technology and improved management that were imported by the private sector. The period required for a broiler to reach one kilo liveweight has declined from 14 weeks to 6 weeks and the feed requirement declined from 8 kilos to 2 kilos. It now takes only 2 kilos feed to produce a dozen eggs while it used to require about 8 kilos (Cabanilla, 1983).

Shell played a key role in the development of the Maisagana-99 program. They worked with IRRI scientists to develop a plan for increasing rice production. They also financed some of the training and initial field trials of their plan. Then this plan was taken over by the Ministry of Agriculture and expanded very rapidly - more rapidly than the original plan had called for.

Esso played a role in disseminating the use of fertilizer and high yielding rice varieties in the early days of the green revolution. They had a series of demonstrations throughout the country and sizeable technical staff to set up the demonstrations and educate farmers. Since then, Planters Products has run thousands of fertilizer and modern variety demonostrations annually.

Impact of Local Innovation on Agricultural Production

The research accomplishments that agricultural chemicals companies claim are fairly modest. The centrally funded research programs of MNCs have been in operation for only a short time with the exception of (The Cyanamid Agricultural Research Foundation, Inc.). CARFI has been successful at bringing three different types of compounds to the commercial stage. First,

CARFI did the testing required to register insecticides being used commercially elsewhere. Second, CARFI showed that a corn herbicide, which is used commercially in the United States, is very effective in controlling a weed (Rottboellia exaltata) which is not important in the United States. This is the most important weed in corn in the Philippines. CARFI proved its efficacy and provided the other data required for registration. Third, CARFI found that a new compound which had been sent as a herbicide, was an effective plant growth regulator of sugarcane. When sprayed at the proper time, it causes the tillers to ripen simultaneously and this leads to a fifteen percent increase in yield per acre. This discovery has led to a worldwide project to develop and promote this chemical.

Most companies do research to meet registration requirements and several do research to develop new uses without having a research station of their own. There are a large number of pesticides that are on the market which indicates that they either were widely used before 1977 or there was some local R and D on their bioefficacy. However, as one company official commented, most of these pesticides are older pesticides and the initial testing which led to their use in the Philippines was conducted either by universities, government research programs or IRRI. Testing coded compounds and products which are used commercially elsewhere is the main activity of private experiment stations.

Other than registering products, the main output that local pesticide research can take credit for is the herbicide to control rottboellia in corn. This chemical is being used on only about 3,000 hectares. When used properly, it can double or triple yields over fields where no control measures are

practiced and increase yields substantially in fields where hand weeding is practiced. This may displace some labor in the weeding process, but Cyanamide argues that it allows farmers to produce more acres of corn and thus raises the total labor requirement.

The hybrid corn seed developed by research programs in the Philippines covers at most 50,000 hectares of corn out of a total of about 3 million hectares. The improvement in yields has been substantial but so has the increase in inputs and cost of production. The average corn yield in the Philippines in 1982 was about one ton/ha. The yields for the first season in 1982 in the Maisagana program are shown on the first column of Table 12. The second column provides 1983 data for one region in Mindinao which was covered by the Maisagana program. Much of the difference in yields of the hybrids is due to higher levels of fertilizer and pesticide applications on the hybrids than were applied to either the local white corn or IPB Var I. In Philippine seed board test during the dry season in 1984-85 using high levels of fertilization private hybrids yielded 5.7 t/ha. while IPB-Var I yielded 4.7 t/ha.

More appropriate mechanical technology is available due to local innovation in the agricultural machinery industry. Innovations have saved some foreign exchange because most two wheel tractors are now produced in the Philippines rather than abroad. However, these innovations probably led to the displacement of some people.

Sugarcane varieties developed by VMC have increased sugarcane yields by 10 to 20 percent on about 32,000 ha. of VMC and San Carlos mill areas. In addition, there has been considerable spread of VMC varieties in other regions

Table 12. Average Yield of Corn by Type.

(Tons/ha.)

	Maisagana Program 1982	Sultan Kudarat Mindinao, 1983
Hybrids	4.07	2.85
IPB Var I	2.20	1.39
Local White Corn	1.69	1.40

Source: 1982 unpublished data, Ministry of Agriculture; 1983 unpublished data, Maisagana Program Officesr in Sutton Kudarat Province.

which they have not been able to document. They know of at least 300 ha. in Luzon and more in parts of Negroes.

The banana and pineapple people claim that they have been able to substantially reduce the cost of production of their commodities through changes in the plant protection techniques. Philippine Packing claimed that they were able to reduce the cost of production by 40 percent on the 6,000 ha. they farm.

RECOMMENDATIONS

The private sector agribusiness could and should play a larger role in research and technology transfer in the Philippines. Although the investment in research by private firms is large relative to other countries in South and Southeast Asia, it is small relative to the size of the agricultural sector - less than one peso for every thousand pesos of value added in agriculture or 0.1 percent. In contrast, the private sector in Brazil invest .75 percent of agricultural value added, and the United States invests almost 2 percent.

Where might this expansion take place? The plantation and processing sector is the most promising possibility. Other countries in Southeast Asia have much larger private investments in research on plantatión agriculture. In the input industries, seed research is large relative to the size of its sales and will not increase much unless there are major changes in property rights on seeds or increases in the general profitability of the hybrid seed industry. Agricultural chemicals research might expand if corn became a major commercial crop in which herbicides were used or if there are breakthroughs in chemicals to control rice disease. Agricultural machinery research might expand with better patent protection or expanded IRRI/Ministry of Agriculture programs.

How might expansion be encouraged? Basically, the government has to find ways to increase the profitability of the investment in research. There are three types of measures that it can take. The first type is policies or activities that affect the cost of developing a new technology through research or importing the technology. Government research, education, import policies, registration procedures and tax policies all fit in this category.

The second type of policy affects the general profitability of the industry. These policies could include price policies and subsidies, export and import policies, antitrust policies, land ownership and other agroeconomic policies. The third type of policy affects a company's ability to appropriate the benefits from the new product he develops. These policies include patent policy, plant breeders' rights, monopolies and government procurement of the innovation.

Policies to Reduce the Cost of Innovation and Transfer

The agricultural incentives act of the early 1980's had some general provisions to encourage the private sector to import technology and carry out agricultural research. Some of the firms interviewed thought that this act had been useful but not a major factor in their decisions to do research and to transfer technology. The rest of the firms had not made use of it at all. The main articles which affected research and technology transfer were (1) waivers of import duties and permits on scientific equipment and on animal or plant germplasm and (2) permission for foreign consultants to work in the Philippines in technical and managerial roles. This law lapsed several years back and a new under discussion in April, 1985.

Another law that was under discussion was the Science and Technology Incentives Act. This would provide research programs with: (1) exemptions from taxes and duties on imported capital equipment and supplies, (2) tax credit on domestic capital equipment and supplies, (3) net losses in the first 10 years of operation may be deducted from taxable income in the next six years, and (4) employment of foreign nationals. Firms looked on these

incentives favorably but did not think that hey would greatly influence their decisions. Bills of this type can be constructed to reduce the cost of research and technology transfer, but they will not play a major role in the absence of a favorable business climate.

The government research system can play an important role in reducing the cost of private innovation. As described in chapter III, local and international agricultural research provided the basis for the successful development of corn hybrids. The key to the development of a hybrid corn industry in the Philippines was a means of controlling downy mildew. Genetic resistances to downy mildew was identified in the 1960's by the Thai government/Rockefeller/CIMMYT corn program. In addition, a professor at UPLB showed that seeds could be treated with a fungicide to prevent downy mildew attacks. Without government development of these two methods of controlling downy mildew, it would have been very expensive for companies to identify genetic resistance themselves or they would have had to wait until the fungicide was made popular by Ciba-Geigy who identified it. This would have either increased the cost and/or delayed the development of the hybrid seed industry in the Philippines.

The Ministry of Agriculture/IRRI farm mechanization program program is another example of government research which reduces the cost of innovation and, thus, provides an incentive to do more research. In that case, IRRI and the government provided the basic technology which machine shops could then modify to meet local conditions. This modification was inexpensive relative to the cost of inventing a local small scale thresher or power tiller.

Other Government Policies to Encourage Research

In his thesis, Mikkelsen discussed three other policy instruments which governments use to influence innovative behavior:

1. controlling the amount of imports
2. controlling firm size through
   a. capacity licensing
   b. rationing credit or foreign exchange
   c. public procurement policies
3. discouraging imitation and promoting domestic technology licensing.

Import controls restrict technology transfer but may not stimulate local research and development. Mikkelsen tries to test the relationship between the availability of imported technology and local research and development. More foreign technology stimulated domestic R and D in his mid-1960's sample of firms and had a positive but statistically insignificant effect in his 1980 sample. Therefore, there is no support for the argument that restricting the import of technology encourages the growth of domestic R and D. In fact, the opposite policy is supported - more imported technology means more R and D because it allows local companies to produce new products or processes through relatively low cost adaptive research.

The policy implications are that the Philippines should be relatively open to foreign technology imports. In particular, there is no economic justification for protecting government input organizations from foreign competition like the recent (March, 1986) ban on vegetable seed imports because the Bureau of Plant Industry could produce them. This will hurt many

vegetable farmers and some seed imports. The only people who will benefit are a few BPI bureaucrats.

Controlling firm size when combined with certain market structures can affect research. With the assumptions that inventions could be imitated at some cost by domestic competitors and opportunities for domestic licensing remain quite limited, which is quite realistic for the Philippines, Mikkelsen argues that an industry will have the maximum R and D when there is one dominant firm and many small firms in a market. This is because: (1) with only small firms, most firms fall below a threshold where it does not pay to do research, (2) among larger firms, research expenditure goes up as percent of sales as firm size increase, and (3) with three or four dominant firms, each would be aware that imitation could reduce profits.

The policy implications of this conclusion are not clear. Larger firms with a competitive fringe may be the most efficient for technology generation but may have many other negative impacts on the economy. Thus, the benefits have to be weighed against their cost. In addition, it is not easy for a government to engineer a particularly industrial structure.

Patents are the primary means used to limit imitation. The Philippines invention patent law is strong relative to elsewhere in South and Southeast Asia. There are no plant breeders' rights and Mikkelsen finds that there is little enforcement of patents in his case study of the farm machinery industry. In contrast, interviews with the pesticide industry suggested that large companies in that industry were able to enforce their patent rights. The use of the utility patent in the Philippines is an important way of increasing the incentive for innovation in the farm machinery industry although it did not decrease the ability to imitate much.

Strengthening enforcement of the invention and utility patent acts would probably increase inventive activity in agricultural machinery and perhaps a bit in agricultural chemicals. Plant breeders' rights would encourage more plant breeding, at least in sugarcane where Victorias Milling Company has been promoting them. This might also increase research on a number of other self pollinated or cloned crops. The question of plant patents is being debated in Europe and the United States. This debate should be monitored, and a decision on plant patents may have to be made in the near future.

Public Sector Research and Technology Transfer

No matter how many incentives are provided, there are still a number of important areas in which the private sector will not provide sufficient technology. In these areas, the public sector must either finance private research or do the research itself. It appears that the allocation of research resources in several areas have been skewed by the private sector. Four 2 or 3 five PhDs are breeding mainly hybrid yellow corn for the private sector, while only 2 government PhDs work part-time on white corn. A large number of scientists in the private sector are working on chemical pest control while a limited number of scientists in the public sector work on IPM and biological control. The policy implications are not to control the private sector research but to strengthen the public sector research. The government will have to pay sufficiently high salaries and provide other incentives so that highly qualified individuals will stay in the public sector. It implies training and hiring more people in the public sector to do

research on white corn varieties and seed production or IPM. It also implies policies that could induces the private sector to put more effort into white corn research and IPM. Pioneer has developed and released a white hybrid and other companies are working on white hybrids. Their acceptability to small farmers should be explored and perhaps subsidized until a program for disseminating white varieties can be developed.

There are other areas of research in which the private sector will not invest because there is no potential for profits. This includes agricultural policy research, much farm management and agronomic research. These are areas in which government research continues to be needed in the Philippines.

There are also some areas of technology transfer and diffusion which the private sector will never find profitable. These include the provision of agronomic information and new technology to subsistence farmers far from main input markets. There is little profit to be made and so major companies will not do it. This means that an effective government extension system is still needed.

The provision of varieties as opposed to hybrids is another area where private sector may not have sufficient incentive to play its optimal role. This was the justification for giving BPI some responsibility in seed multiplication. There seems to be general agreement among scientists, farmers and the private seed industry that BPI has not been very effective in multiplying and distributing seed. There seems to be a particular bottleneck in corn where good varieties are available but have not reached farmers. Two large companies are trying to produces IPB corn varieties profitably, and one is planning to produce rice varieties. In addition, there are many small rice

seed producers who multiply rice varieties when new varieties come along. These developments need to be monitored to see if some type of government activity is acting as a constraint on the private production of corn and rice varieties or some government intervention is needed.

AID's Role

There are at least four types of activities which would encourage more private research and technology transfer. First, AID can assist public sector research which will, in turn, induce more private sector research. Public sector research in the Philippines is now in a financial and perhaps an intellectual crisis. It requires continued assistance from AID. This will, in turn, assist private agribusiness - particularly, if government research will open up more to the needs of agribusiness. Some resources might be provided an a competitive grant basis which would be open to private and public sector research organizations.

Second, AID can assist the universities which educate the scientists for both the private and public research systems. Private sector researchers were educated at Los Banos, USM and other government universities. Many of them also did graduate work in the United States. There are signs that its human capital is not sufficient to meet the country's needs. A number of companies located regional research programs in the Philippines because of the availability of well trained scientists and the presence of IRRI and UPLB. The Philippines no longer has the comparative advantage in scientific manpower that it once had over its neighbors. AID assisted in developing scientific manpower to its present level. AID should look for ways in which it can continue to support manpower development.

Third, AID can play the role of intermediary between United States an local companies who could benefit by joint ventures or trade. The JACC committee has been established although not used. Other programs like the AID/India PACT project which is supposed to improve communication between potential United States and Indian joint venture partners should be investigated.

Finally, AID is in a good position to promote dialogue between the public and private sector on issues of science and technology policy. It can do this through informal contacts, formal seminars and through its programming in research and development projects. It might also finance research at UP Diliman, UPLB or PIDE on science and technology policy. These studies could look at the impact of changes in industry structure on innovative behavior; the potential benefits and problems of biotechnology research; the potential for greater regional cooperation in agricultural research and technology and a number of other issues.

Appendix A

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