No. 1

STUDY ON ECONOMIC DEVELOPMENT OF THE ARGENTINE REPUBLIC

FINAL REPORT

Vol. I: ARGENTINE ECONOMY

II. AGRICULTURE

JANUARY 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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1-1-1 Overview

The structure of output in the agricultural sector has undergone a remarkable change in Argentina during the 1970s and the early 1980s, which some even approximates to the country's second agricultural revolution. The change has evolved most prominently in the Pampas which traditionally produce the bulk of the country's exports, but is also observable, though to a lesser extent, in other regions. This change principally stemmed from the dynamic expansion of the crop sector relative to the livestock sector, on the one hand, and from the increased predominance of the five major crops of wheat, maize, sorghum, sunflower and soybean vis-a-vis the other crops, on the other, as chiefly observed in the pampean agriculture.

The expansion of the crop sector was partly brought about by the changes in world market conditions for Argentina's major export products. Most notably, EC's increased protectionism and subsequent subsidized export drive since the mid-1970s substantially reduced the demand for beef, among others, in Argentina's traditional export markets. As a result, the country's livestock sector reduced its economic importance in the Pampas relative to crop production and has not entirely recovered from this setback to this day. In contrast, the world demand for major cereals and oilseeds on the whole continued to expand in the 1960s and the 1970s, though with some setbacks during two oil crises, and moreover, the USA's embargo of grain exports to the USSR in 1980 functioned to give a boost to Argentina's exports and production of major pampean crops. The USSR emerged as the country's major export destination, offsetting the shrinkage of its traditional export markets. These external factors supported the significant technological progress in the production of major export crops in Argentina during the 1970s.

Non-Pampa regions produce a variety of crops, taking advantage of their diverse agro-ecological environments: sugarcane, tobacco and beans in the Northwest, yerba mate, rice and tung oil in the Northeast, cotton in the North, apple and pear in Rio Negro, grapes for wine and certain vegetables in the West, and so forth. Agricultural production in non-Pampa regions are estimated to contribute approximately one-tenth of Argentina's total exports, but it is on the whole oriented to domestic markets. Some crops are grown partly for their export possibilities, but the increase of their production is at present being hampered by the long distance and difficult access to overseas shipping, especially in the case of the Northwest and the West, and by the limited prospects of external markets, as in the case of cotton, tobacco and sugar. Moreover, the limited size of domestic markets constrains the possibility of fully taking advantage of the diverse agro-ecological conditions in the non-Pampa regions.

The recent expansion of the areas under the five major crops in non-Pampa regions can be understood as one of the attempts to diversify the marketing horizon of regional agriculture, but this highlights the urgent needs for supportive efforts in developing efficient product marketing and evolving sustainable systems of crop production which are suited to their agro-ecological conditions.

The regional agricultural systems found outside the Pampa region have diverse socio-economic characteristics which significantly differ from pampean agriculture. Thus, their past evolution, future prospects and policy requirements vary, meriting separate analyses. Primarily because of the limited time schedule, the present study focuses on agriculture in the Pampa region which has been undergoing remarkable changes since the 1970s.

1-1-2 Trends in Production of Major Crops

(1) General Pattern

Table II-1-1 shows the production trends of major crop categories during the last 40 years or so on the basis of the statistics aggregated by the economic department of the Buenos Aires Grain Exchange. Both the sown area and production of total crops grown in Argentina recorded a distinct decline in the early 1950s compared with the early 1940s during the World War II when Argentina had benefited greatly from the increased external demand for its cereals and oilseeds. The total sown area recovered in the 1950s and remained more or less stable during the 1960s, but from the early 1970s to the early 1980s it showed a tendency of decline. However, the total production continued to increase from the early 1950s on through the early 1980s.

The breakdowns by major crop categories indicate some significant differences. With respect to cereals and oilseeds, which together provide the bulk of the country's agricultural exports, the sown area and production in the early 1960s still fell short of the levels in the early 1940s, indicating that the external demand for Argentina's output decreased as other countries began to recover and expand their own production for domestic consumption and/or exportation in postwar years. In contrast, all of the other crop categories recorded a steady increase in both sown area and production in the 1940s and 1950s, surpassing by the early 1960s the levels in the early 1940s.

From the 1960s through the early 1980s, however, the production of cereals and oilseeds continued to expand, the former despite the relative stability of the sown area during the 1970s and the latter accelerated by the tremendous expansion of the sown area during the same decade. As a result, the combined share of cereals and oilseeds in total sown area increased from 63% in the beginning of both the 1950s and 1960s to 84% in the early 1980s and in total production from 38% to 56% similarly. With respect to other crop categories, vegetables, industrial crops and fruits continued their slower but steady increase in both area and output during the 1960s and 1970s. However, forage crops recorded substantial reductions during both decades, partly reflecting a decline of activity observed in the livestock sector in the later 1960s and the later 1970s.

Table II-1-1 Structure and Trend of Crop Production by Major Categories

	Total Crops	Share (%)	Cereals	Share (%)	Oilseeds	Share (%)	Vegetables	Share (%)	Industrial Crops	Share (%)	Forage Crops	Share (%)	Fruits	Share (%)
Production (1,000 t)														
1940/41-42/43	34,441	100	15,409	44.7	2,390	6.9	1,983	5.8	5,888	17.1	6,452	18.7	2,319	6.7
1950/51-52/53	31,948	100	10,604	33.2	1,678	5.3	2,517	7.9	9,867	30.9	4,623	14.5	2,659	8.3
1960/61-62/63	40,879	100	13,308	32.6	2,109	5.2	3,300	8.1	11,453	28.0	6,824	16.7	3,884	9.5
1970/71-72/73	50,086	100	20,505	40.9	2,165	4.3	3,658	7.3	14,374	28.7	4,099	8.2	5,204	10.4
1980/81-82/83	64,991	100	29,765	45.8	6,740	10.4	4,157	6.4	16,275	25.0	1,956	3.0	6,196	9.5
Increase over 1960/61-62/63(%)	59.0		113.7		219.6		26.0		42.1		-71.3		59.5	
Sown Area (1,000 ha)														
1940/41-42/43	27,047	100	16,127	59.6	3,537	13.1	398	1.5	700	2.6	6,003	22.2	282	1.0
1950/51-52/53	25,767	100	13,726	53.3	2,562	9.9	432	1.7	1,000	3.9	7,652	29.7	395	1.5
1960/61-62/63	27,650	100	14,555	52.6	2,867	10.4	430	1.6	1,115	4.0	8,149	29.5	534	1.9
1970/71-72/73	27,748	100	17,233	62.1	2,818	10.2	463	1.7	1,050	3.8	5,604	20.2	580	2.1
1980/81-82/83	26,188	100	17,035	65.0	4,862	18.6	528	2.0	1,260	4.8	1,883	7.2	621	2.4
Increase over 1960/61-62/63(%)	-5.3		17.0		69.6		22.8		13.0		-76.9		16.3	

Source: Bolsa de Cereales de Buenos Aires, Numero Estadistico, 1984 and 1985.

To limit the period under consideration to the 1960s and thereafter, the total sown area of all crop categories declined from a little over 27 million ha in the early 1960s and the early 1970s to 26.2 million ha in the early 1980s, but the total production continued to increase from 40.9 to 65.0 million tons from the early 1960s to the early 1980s. The increase was most pronounced in cereals and oilseeds, which respectively increased from 13.3 to 29.8 million tons and from 2.1 to 6.7 million tons in 20 years (Table II-1-2). Indeed, the combined outputs of cereals and oilseeds accounted for nearly 90% of the total increase achieved in crop production over the said period.

This remarkable expansion of cereals and oilseeds was in turn due to the increased production of wheat, maize, sorghum, sunflower and soybean, which rose in aggregate from 11.8 to 34.6 million tons in two decades (Table II-1-2). Other cereals and oilseeds showed, on the whole, either a decline or only a relatively small increase in production over the period. The share of the five major export crops in total cereals and oilseeds consequently increased from 77% in the early 1960s to 95% in the early 1980s in production and from 59% to 77% in sown area.

Table 1-1-2 Production and Sown Area of Cereals and Oilseeds

Three Crop-Year Aver.	Total of Wheat, Maize & Sorghum	Total Cereals	Total of Sunflower & Soybean	Total Oilseeds	Total of Five Major Crops	Total Cereals & Oilseeds
Production (1,000 tons):						
1940/41-42/43	14,084	15,409	561	2,390	14,645	17,799
(%)	91	100	23	100	82	100
1950/51-52/53	7,930	10,604	714	1,678	8,644	12,282
(%)	75	100	43	100	70	100
1960/61-62/63	11,218	13,308	646	2,109	11,864	15,418
(%)	84	100	31	100	77	100
1970/71-72/73	18,563	20,505	982	2,165	19,546	22,670
(%)	91	100	45	100	86	100
1980/81-82/83	28,729	29,765	5,853	6,740	34,583	36,505
(%)	97	100	87	100	95	100
Sown Area (1,000 ha):						
1940/41-42/43	12,165	16,127	666	3,537	12,831	19,663
(%)	75	100	19	100	65	100
1950/51-52/53	8,912	13,726	1,351	2,562	10,263	16,288
(%)	65	100	53	100	63	100
1960/61-62/63	9,033	14,555	1,163	2,867	10,195	17,422
(%)	62	100	41	100	59	100
1970/71-72/73	12,540	17,233	1,689	2,818	14,228	20,051
(%)	73	100	60	100	71	100
1980/81-82/83	13,025	17,035	3,793	4,862	16,819	21,896
(%)	76	100	78	100	77	100

Source: Bolsa de Cereales de Buenos Aires, Numero Estadistico, 1984 and 1985.

In sum, five major export crops of wheat, maize, sorghum, sunflower and soybean led the remarkable expansion of the crop sector observed in Argentina during the last two decades. Two important dimensions of this process of expansion have been the increased "agriculturalization" vis-a-vis the livestock sector and the increased dominance of the five crops over other crops, and they have been observed most prominently in the fertile Pampas. Accordingly, the main emphasis of the present study is to ascertain salient factors which contributed to the evolution of this significant process in Argentine agriculture.

(2) Trends of Five Major Export Crops

It has been pointed out that the expansion of the crop sector in the last two decades or so, and more specifically the increased predominance of the five crops chiefly grown in the Pampas have been realized by a combination of technological factors: namely, (1) the introduction and wide diffusion of high-yielding varieties, such as the hybrids of maize, sorghum and sunflower and the early maturing Mexican varieties of wheat, (2) the increased use of chemicals for plant protection and, though to a much lesser extent, of fertilizers, (3) employment of more efficient and sophisticated farm machinery, and (4) technical improvements of farm management which accompanied the increased use of such inputs.

In addition to these factors directly connected to agricultural production, it would be necessary to refer to a few other important factors which supported the expansion of the crop production in Argentina, especially concerning the decade of the 1970s. Firstly, the slump in profitability, especially after the mid-1970s, of livestock rearing in the Pampas, coupled with the increased world demand for coarse grains and oilseeds during the 1960s and the 1970s, accelerated the process of "agriculturalization" as the most viable alternative in utilizing the fertility of the Pampas. Secondly, the virtual abolition of export taxes on traditional exports, the liberalization of imports including agricultural inputs and the overvalued Argentine peso during the later 1970s served to support the expansion of export-oriented crops. That is, these factors served to offset the drops in profitability per ton of export caused by the generally declining trends in real international prices of major cereals and oilseeds during the period, and also they improved the relative price relations between export crops and productive inputs. Thirdly, the generally favorable weather conditions during the later 1970s and the early 1980s rewarded the producers' attempts at export-oriented agriculturalization both within and outside the Pampas. These factors, among others, undoubtedly gave a decisive impetus to the technological changes which brought about the increased production of the five crops.

On the basis of a number of the studies[1)] undertaken to analyze the process of agriculturalization, the technological factors which supported the expansion of the five major export crops can be summarized as follows.

(a) Cereals

As shown in Table II-1-3, both the production and the harvested area of wheat remained stable in the 1950s and the 1960s, but showed a remarkable surge during the 1970s which continued through the mid-1980s. From 1970/71-1972/73 to 1980/81-1982/83, its production increased from 6.1 to 10.3 million tons, and the harvested area expanded by 40%. The average yield increased by 20% contributing 40% to the increase of production realized over the decade. The development and introduction by the INTA of early-maturing Mexican varieties in the beginning of the 1970s greatly contributed to this yield improvement. It is said that some 60% of the total production of wheat is accounted for by the varieties which originated in those varieties developed by the INTA.

The diffusion of non-traditional varieties of wheat, coupled with the introduction and expansion of soybean production, played an important role in the technological changes in pampean agriculture. Early-maturing Mexican varieties with higher fertilizer response were first adopted in the traditional maize zone in the south of Santa Fe and the north of Buenos Aires, or Region II North according to the classification by the National Grain Board of wheat-producing zones, rather than in the traditional wheat zone in southeast Buenos Aires, or Region IV (Figure II-1-1), partly due to the fact that the varietal development by the INTA emphasized the former region. As seen from Table II-1-4, the area under non-traditional varieties increased in Region II North from a little less than 20% in 1974/75 to nearly 90% in 1982/83. The diffusion of non-traditional varieties in Region IV began in the beginning of the 1980s when medium- and late-maturing non-traditional varieties were introduced by a private seed firm. Because yields of non-traditional varieties are widely variable depending on climatic and soil conditions, their diffusion still remains limited in regions with less rainfalls, cold weather and soil deficiency, such as in Region V North and South. Consequently, there are considerable variations in average yield by region, ranging in terms of the 1980/81-1982/83 average from 2.4 tons in the north of Buenos Aires Province and 2.0 tons in both the south of Santa Fe and the southeast of Buenos Aires to 0.9 tons in the south of Buenos Aires.

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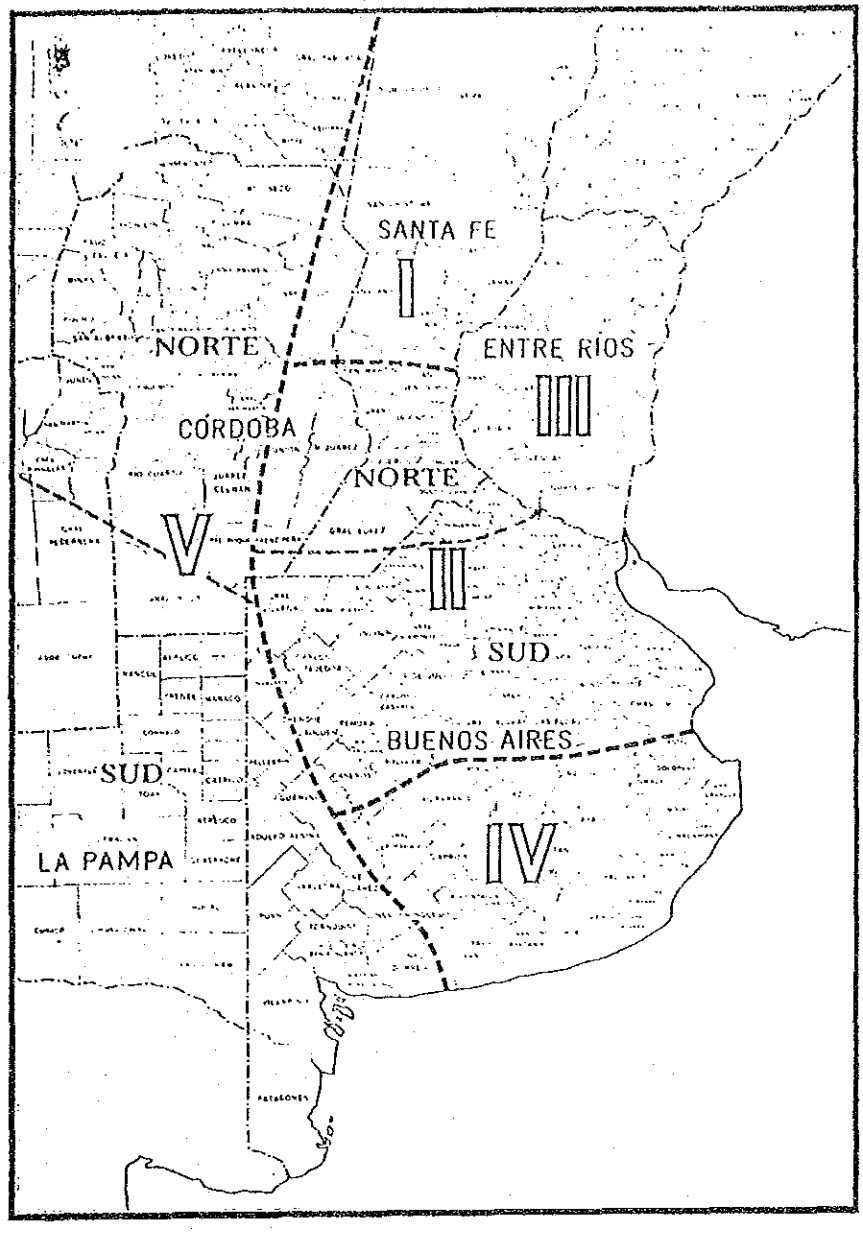
1) A series of papers are prepared by the research staff of CISEA (Centro de Investigaciones Sociales sobre el Estado y la Administracion) under the program called PROAGRO. The discussion in this section mainly relies on these papers: notably, E.S. de Obschatko, Los Hitos Tecnologicos en la Agricultura Pampeana, Document No. 10, Dec. 1984, and F. Sola, Empresas y Sujetos Sociales en la Agricultura Moderna: Hacia un Nuevo Modelo de Comportamiento, Document No. 7, March 1985.

Figure II-1-1 Classification of Wheat Producing Regions



Source: Junta Nacional de Granos

Table II-1-3 Production, Harvested Area and Average Yield of Five Major Export Crops

Three Crop-Year Aver.	Wheat	Maize	Sorghum	Sunflower	Soybean	Subtotal
Production (1,000 tons):						
1940/41-42/43	7,012	7,072		561		14,645
1950/51-52/53	5,177	2,753		714		8,644
1960/61-62/63	5,208	4,810	1,199	636	10	11,864
1970/71-72/73	6,073	8,497	3,993	846	136	19,546
1980/81-82/83	10,346	10,500	7,883	1,880	3,973	34,583
1983/84-85/86	11,700	11,400	5,767	2,950	6,800	38,617
Harvested Area (1,000 ha):						
1940/41-42/43	5,842	3,596		576		10,014
1950/51-52/53	4,520	1,834		1,002		7,356
1960/61-62/63	3,929	2,715	591	950	10	8,196
1970/71-72/73	4,320	3,593	1,928	1,312	87	11,241
1980/81-82-83	6,090	3,178	2,377	1,618	2,049	15,312
1983/34-85/86	6,088	3,288	1,912	2,360	3,163	16,811
Average Yield (kg per ha):						
1940/41-42/43	1,200	1,967		975		1,463
1950/51-52/53	1,145	1,502		712		1,175
1960/61-62/63	1,326	1,771	2,029	669	1,000	1,448
1970/71-72/73	1,406	2,365	2,071	645	1,567	1,739
1980/81-82/83	1,699	3,304	3,317	1,162	1,939	2,259
1983/34-85/86	1,793	3,435	2,676	1,337	2,223	3,354

Source: Bolsa de Cereales de Buenos Aires, Numero Estadistico, 1984 and 1985; and Servicio Nacional de Economia y Sociologia Rural, Secretaria de Agricultura, Ganaderia y Pesca.

Table II-1-4 Area under Non-traditional Wheat Varieties

Region	I	II		III	IV	V		Whole
Crop Year		North	South			North	South	Country
1974/75	5	17	20	1	8	7	2	10
1976/77	27	51	54	29	3	22	4	36
1978/79	32	76	57	24	27	26	4	36
1980/81	59	90	70	28	67	51	4	59
1982/83	75	89	64	43	75	39	13	58

Source: Edith S. de Obschatko, Los Hitos Tecnologicos en la Agricultura Pampeana, CISEA, PROAGRO Document No. 10, Dic. 1984

One important technological change which accompanied the introduction of early-maturing non-traditional wheat was the expansion of double cropping, most notably with soybean as the second crop in the traditional maize zone. The possibility of obtaining income twice a year instead of once in the case of maize production was attractive during the period of rapid inflation and high interest rates after the mid-1970s. In addition to replacing maize in areas where climatic conditions are less suited to maize cultivation, double cropping brought about the gradual decline of livestock rearing as an important component of the traditional mixed farming system. Coupled with the continued slump in livestock rearing since the later 1970s, permanent or continuous agriculture emerged and increased its importance mainly in Region II North.

Another notable technological change is the increased use of fertilizer, mostly nitrogenous, in wheat cultivation in the Pampas. Although the level of fertilizer application is still very low compared with some other producing countries, it became fairly common, especially in the traditional wheat zone. According to the estimate by Huici, for instance, wheat cultivation consumed 38% of total national consumption of N nutrient in 1983/84 compared with 7% in 1977/78[1]. The Argentina's recent national average wheat yield of 1.7 - 1.8 tons is lower, for example, than 2.3 tons in the USA and over 5 tons in France, but reasonable considering the current level of fertilizer application and in fact comparable to the average yields in Canada and Australia.

One of the problems associated with the wide diffusion of higher-yielding non-traditional wheat varieties is a significant decline of gluten content in the grain, and this seems to be aggravated by the expansion of continuous agriculture which depletes nutrients in the soils. This decline in quality seems to be related to the disparity in export price between Argentine wheat and US wheat in recent years.

As seen in Table II-1-3, the production of maize in Argentina doubled from 4.8 to 10.5 million tons from the early 1950s to the early 1980s. In terms of the growth rate, the production showed more rapid increases during the 1950s and the 1960s, by 75% and 76% respectively, than in the 1970s when the rate declined to 40%. The factors of increase significantly differed over three decades.

During the 1950s, 64% of the increase in production derived from an expansion in the area planted to the crop. Hybrid maize was commercially introduced in this decade, but its diffusion was limited because of the yet inadequate level of agricultural mechanization. During the 1960s, 68% of the increase came from the yield improvement, reflecting the rapid diffusion of high-yielding hybrid varieties in the traditional maize zone in the north of Buenos Aires and the south of Santa Fe, or Region VI of the maize-producing zones (Figure II-1-2). The diffusion of hybrid varieties spread to other areas in

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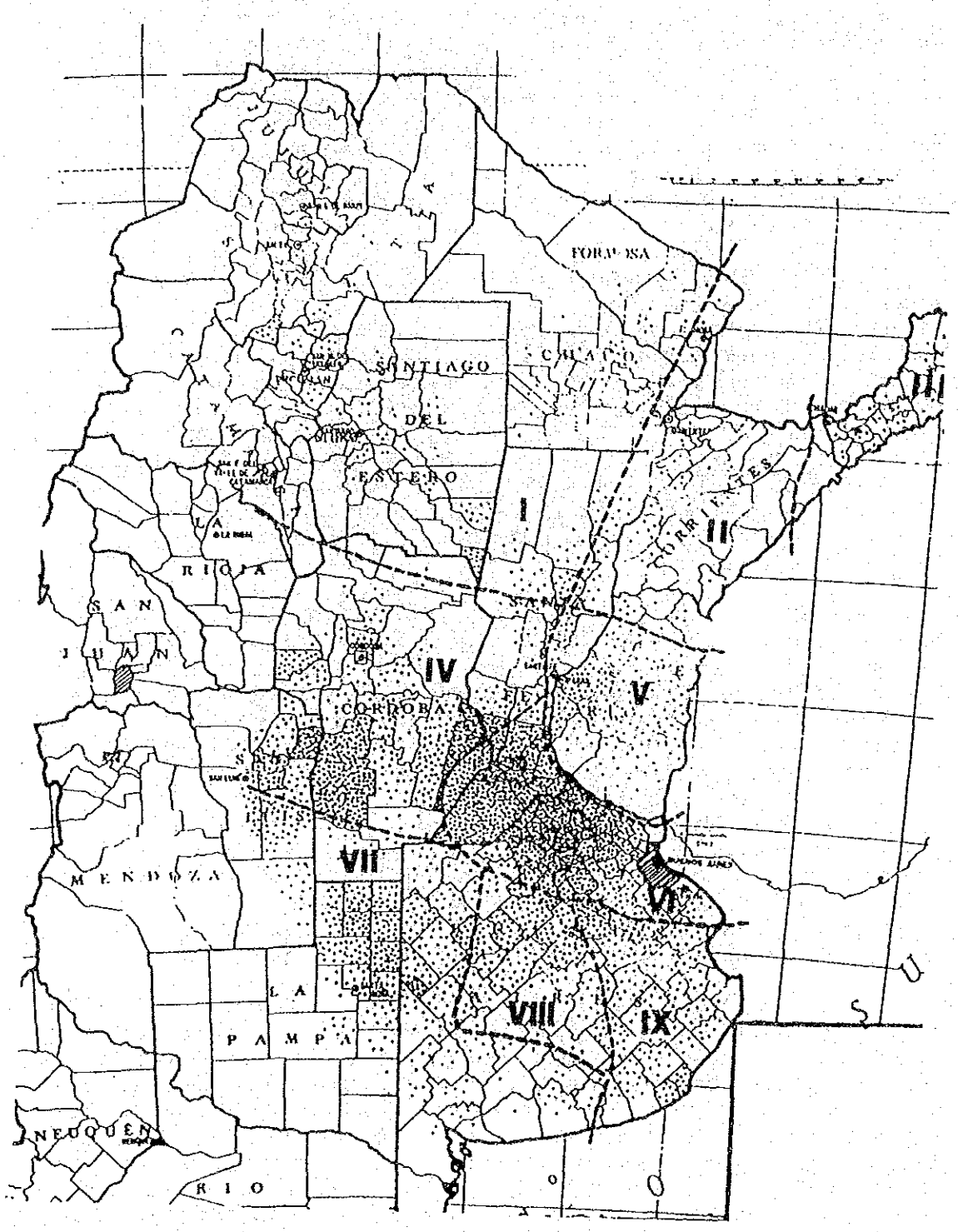
1) Nestor Huici, Requerimientos de Semillas, Fertilizantes y Maquinaria para la Expansion Agricola en 1985-1990, PPA Document No. 9, CISEA, Dec. 1985.

Figure II-1-2 Classification of Maize Producing Regions



Source: INTA EERA Pergamino.

Note : One dot represents 1,000 ha(sown area) in the 1975/76-79/80 average.

the 1970s, and the increase in production over the decade was entirely brought about by the yield improvement. As seen in Table II-1-3, the harvested area declined by 11% between the early 1970s and the early 1980s, while production increased nearly 24%.

The introduction of hybrid varieties of maize made the greatest contribution to the rapidly increased production in Argentina during the 1960s and 1970s. But this does not mean that the use of hybrid varieties alone realized the increased output. Along with the introduction of hybrids, the manner of cultivation changed with respect to the appropriate timing of land preparation, multiple sowing lines and higher sowing density, increased mechanical weeding and plant protection, etc., which were required to obtain better results from new varieties. But these changes basically derived from the introduction of hybrids. According to Nider and Mella, 80% of the increase in maize production during the 1960s and 1970s is said to have come from the use of hybrid varieties.[1)]

According to JNG's information as quoted by Obschatko, the rate of diffusion of hybrids in 1983 was 100% in the traditional maize zone (Region VI), 90 - 95% in Regions IV and V, and 80% in Region VIII, while the rate was 10 - 50% in Region VII where climatic conditions are not favorable to growing hybrid maize. This rapid diffusion was made possible by the private seed industry, in which subsidiaries of multinational seed companies have the combined dominance. For instance, three such firms have the combined market share of 75% in the early 1980s. The INTA and other public institutions had been doing research on hybrid maize since the 1920s, but after the seed law in 1959 which endorsed the closed pedigree of new varieties developed by private breeders, the share of the private sector in the seed market increased rapidly.

Because of the dynamic capacity of private seed companies of rapidly breeding new varieties, maize production expanded its horizon from the traditional maize zone to other areas. For instance, the early-maturing varieties introduced to the market in the late 1970s expanded the area under maize in the traditionally wheat-growing southeastern zone of Buenos Aires Province. Although Region VI still accounts for a little more than 50% of the total production and have the highest yield in the country, the other areas improved their respective yields more rapidly in the last decade, though the absolute levels of their yields are still substantially lower than in Region VI.

The yield improvement due to the use of hybrids is a world-wide phenomenon, and Argentina's national average yield of 3.3 - 3.4 tons per ha in recent years is only a half of the yield in the USA. But the yield in the traditional maize zone has been around 4.5 tons without fertilizer application, and some advanced farmers are said to have realized 7 - 8 tons. Because of the presence of perennial weeds like

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1) F. Nider and R. Mella, "El Incremento del Potencial de Rendimiento de los Hibridos de Maiz en la Argentina durante 1963-1979", Dekalb, 1983, as quoted by Obschatko, op. cit.

Johnson grass, fertilizer use was not recommended by the INTA for maize cultivation until quite recently, but the improved level of fertilizer application combined with better plant protection would surely bring a considerable increase in the country's yield level.

The increased production of sorghum has also benefited greatly from the introduction of hybrids. Sorghum was traditionally cultivated as one of the forage crops, but the first introduction of hybrid varieties of North American origin during the 1950s expanded the planted area and raised the yield of grain sorghum. Stimulated by the increased world demand, the production more than trebled during the 1960s chiefly due to the areal expansion, and nearly doubled during the 1970s. The diffusion rate of hybrids rose from some 50% in the 1960s to 100% by the early 1980s and the yield improvement accounted for three-fourths of the increase of production realized from the early 1970s to the early 1980s.

Because of its tolerance of aridity and other environmental stresses, sorghum is mostly cultivated in the areas with less favorable climatic and other natural conditions in Cordoba, Santa Fe and La Pampa. Thus, there are no great regional variations in yield as is the case with wheat and maize. Besides, the average yield of 3.3 tons per ha achieved during 1980/81-1982/83 compares well with the USA's 3.4 tons.

Because of its lower price, however, the traditional area under sorghum has been gradually switched to sunflower and soybean, pushing the cultivation of the crop to environmentally less favorable areas. This can be seen in the reduction of its area, yield and production in the mid-1980s. Under the circumstances, the future yield improvement is said to depend on the improved farming practices, especially better plant protection, or on another breakthrough in breeding.

(b) Oilseeds

One of the most significant changes in pampean agriculture during the last decade or so has been the increased production of soybean. The area under the crop, then mostly found in the northeastern region, was only around 1,000 ha during the 1950s, and increased to some 30,000 ha when the crop was introduced to the Pampa region during the 1960s. During the subsequent decade from the early 1970s to the early 1980s, the area increased 29 times and the production 24 times, and the trend continued through the mid-1980s.

The yield improvement was relatively low at 42% from the early 1970s to the mid-1980s, but this was primarily because soybean began to be cultivated as the second crop after wheat since the late 1970s. Although there is no statistical information, it is said that from 70% to 80% of the area under soybean in the major producing areas of Buenos Aires, Santa Fe and Cordoba Provinces are second cropping. According to an expert at the INTA's Regional Experiment Station (EERA) of Pergamino covering the northern region of Buenos Aires Province, the yield of its single cropping is 3.5 - 4.0 tons per ha and that of second cropping as low as 1.3 - 1.5 tons. Besides, the national average of 2.2 tons in the mid-1980s is comparable to the USA's level and more than 40% higher than in Brazil.

The expansion of soybean production differs significantly from the cases of maize, sorghum and sunflower in which hybrid varieties made the greatest impact. A combination of new varietal adoption, application of inoculants and pesticides, and better farming practices worked to expand the production and improve the yield of soybean. As was the case with wheat which is autogamous like soybean, the adaptive research and experiments on varieties brought from North America were started by the public sector institutions like the University of Buenos Aires and the INTA and played an important role in quickly diffusing the technology package. It is said that the two varieties developed by the INTA cover three-fourths of the area under soybean. In addition, the fact that soybean had been a new crop in Argentina enhanced the receptivity of farmers to technological innovations, such as application of soil inoculants to enhance the nitrogen fixation by Rhizobium in the soils and application of new herbicides like trifluraline to combat perenial weeds.

As already mentioned earlier, soybean changed the utilization of agricultural land in no uncertain terms, especially by enabling the double cropping with wheat and though to a lesser extent with other winter crops like linseed and lentil. In the area of single cropping, it replaced maize because the latter crop is susceptible to the dry weather during its short flowering period, or replaced sunflower as an alternative second crop. In Santa Fe Province, for instance, the sown area of maize was halved from 1 million ha and that of sunflower reduced from 260,000 to 140,000 ha during the period from 1971/72-73/74 to 1981/82-83/84, while those of wheat and soybean increased from 1.1 to 2.0 million ha and from 110,000 to 940,000 ha respectively. The increased importance of soybean as a summer crop also served to eliminate the livestock rearing phase in the traditional mixed farming system.

As mentioned already, the double-cropping of wheat and soybean increased the profitability of farming compared with the traditional single cropping of maize and with the mixed farming during the period of high inflation and the declining livestock sector since the mid-1970s. But it also brought some problems. Increased mechanized plowing by larger and more efficient agricultural machinery, which is necessary to effect a quick turnaround of the land from the first crop to the second, changed the soil structure, and coupled with the continuous exposure of the land surface, began to cause soil erosions by wind and water. It is said that some 50% of the area under the Regional Experiment Station (EERA) of Pergamino was affected by such erosion.

In order to combat the problem of erosion, the INTA is planning to introduce the method of "conservationist tilling" developed in the USA to the traditional maize area where continuous agriculture has been chiefly evolving. This farming method is based on the zero, minimum or reduced tilling, depending on the conditions of agricultural land, in order to retain soil moisture and develop humus by leaving the harvest remains over and in the soils. The program under consideration aims to diffuse the method to 800,000 ha during five years, and eventually to 3 to 4 million ha currently under more intensive land use.

As shown in Table II-1-3, the rapid expansion of sunflower production took place during the 1970s. This crop was traditionally grown, like sorghum, on land less favored by fertility and environmental factors, and there has been no regional concerntration like wheat and maize. Production jumped from 0.9 to 2.2 million tons between 1971/72-1973/74 and 1981/82-1983/84, with the average yield nearly doubling over the period, and the trend continued through the mid-1980s.

This rapid increase was also due to the diffusion of hybrids since the late 1970s. The number of registered hybrid varieties increased from three in 1975 to 41 by 1983, and the diffusion rate in the Humid Pampas reached 80 - 100% by the beginning of the 1980s. This rapid diffusion has been supported by the private seed companies as was the case with maize and sorghum. Because of its higher price, sunflower has been replacing sorghum in recent years, as shown by the 80% increase in its harvested area since the early 1970s through the mid-1980s. In certain instances, sunflower is grown as a second crop after early-maturing wheat, and it is estimated that one fifth of the area under this crop in Buenos Aires Province is second cropping.

Compared with the five export crops discussed above, the production of other cereals and oilseeds generally has been stagnant or declined, as shown in Table II-1-5. Their average yields show only a small gain since the early 1950s, while their harvested areas, except for rice grown in the northeastern region, show a large reduction. Especially notable is the decline of linseed which used to be an important export crop during the World War II. Except for rice, the selected minor crops are also grown in the Pampa region, and their reduced area indicate the progress of specialization in pampean agriculture.

(c) Movements of domestic prices

Table II-1-6 shows the trends of FAS (free alongside ship) prices of the five major crops in five-year intervals in real terms (constant 1960 prices). Although soybean and sunflower show some price recoveries in the 1970s, and wheat also in the early 1980s due to the USA's grain embargo, the overall tendency of their prices per unit of weight since the early 1970s has been a decline. However, when prices received per ha of production are calculated from the national average yield of each crop, the values generally show increasing trends, at least since the early 1970s. Although FAS prices are not producers' receiving prices, on which there is no ready time series statistics, their trends at least indicate that the technological progresses observed from the 1970s through the mid-1980s offset the declines in price per unit of weight, which basically derived from price changes in the export market and the varying rates of export taxes.

Table II-1-5 Production, Area and Average Yield of Selected Other Cereals and Oilseeds

	Rice	Barley	Oat	Rye	Linseed	Groundnut
Production (1,000 tons):						
1940/41-42/43	88	470	523	177	1,556	80
1950/51-52/53	170	758	813	682	485	151
1960/61-62/63	170	639	677	393	740	337
1970/71-72/73	281	600	467	376	442	360
1980/81-82/83	334	187	470	151	638	178
1983/84-84/85	425	184	534	133	565	262
Harvested Area (1,000 ha):						
1940/41-42/43	29	421	555	256	2,334	79
1950/51-52/53	55	590	671	850	721	141
1960/61-62/63	50	607	592	572	1,148	245
1970/71-72/73	79	479	352	513	592	328
1980/81-82/83	92	136	352	182	803	161
1983/84-84/85	123	117	397	159	724	142
Average Yield (kg per ha):						
1940/41-42/43	2,990	1,115	942	692	667	1,007
1950/51-52/53	3,105	1,284	1,213	802	673	1,071
1960/61-62/63	3,374	1,053	1,142	687	644	1,374
1970/71-72/73	3,553	1,253	1,327	732	747	1,098
1980/81-82/83	3,613	1,376	1,333	828	795	1,110
1983/84-84/85	3,458	1,578	1,344	841	780	1,844
Sown Area (1,000 ha)						
1940/41-42/43	35	752	1,652	1,397	2,693	91
1950/51-52/53	62	959	1,400	2,223	916	155
1960/61-62/63	56	1,181	1,380	2,591	1,313	256
1970/71-72/73	87	958	1,115	2,238	674	341
1980/81-82/83	104	439	1,730	1,437	847	169
1983/84-84/85	124	177	1,736	1,067	757	162

Sources: Bolsa de Cereales de Buenos Aires, Numero Estadistico, 1984 and 1985.
Servicio Nacional de Economia y Sociologia Rural, Secretaria de Agricultura, Ganaderia y Pesca

Table II-1-6 Domestic Prices of Major Export Crops and Steers

(1960 pesos)

	Wheat	Maize	Sorghum	Sunflower	Soybean	Linseed	Steer	
(1) Prices per 100 kg[1]								
1960-62	3.54	3.56	2.70	6.37		7.34	14.13	
1965-67	3.17	3.24	2.55	5.21	5.18	5.16	16.88	
1970-72	2.87	2.76	2.22	6.50	6.08	4.91	21.11	
1975-77	2.42	2.14	1.82	6.09	6.83	7.49	13.39	
1980-82	3.22	2.19	1.89	4.39	3.92	4.65	15.08	
1983-85	2.38	2.46	1.85	5.19	4.42	4.62	14.45	
(2) Prices per ha								
1960-62	44.74	63.69	54.79	44.68		49.50	35.32[2]	53.68[3]
1965-67	46.06	68.00	48.97	41.86	58.09	35.11	42.19[2]	64.13[3]
1970-72	37.72	61.11	42.77	45.95	77.50	38.03	52.77[2]	80.21[3]
1975-77	38.24	56.29	48.78	47.07	115.80	62.94	33.47[2]	50.87[3]
1980-82	49.77	68.72	57.41	44.77	76.03	35.62	37.71[2]	57.32[3]
1983-85	49.14	79.92	57.12	64.85	90.63	38.80	36.13[2]	54.92[3]

Source: AACREA, Precios Agropecuarios, various issues.
Bolsa de Cereales de Buenos Aires, Numero estadistico 1985.

Notes: 1) Prices for grains are FAS (DARSENA) prices at Buenos Aires Port, and prices for steers are prices in live weight at Liniers Market
2) Calculated by the upper-range productivity of 250 kg among the average farmers (cf. Section 2-1-3 on the livestock sector)
3) Calculated by the upper-range productivity of 380 kg among CREA members (cf. Section 2-1-3 on the livestock sector)

For the sake of rather simplistic comparison, the table also shows the trend of prices paid for steers at the Liniers Market in Buenos Aires. As will be described later in the next section on the livestock sector, the trend of prices per unit of live weight shows fluctuations according to the so-called livestock cycle, and was stagnant since the substantial drop in the mid-1970s. In terms of prices per ha, the prices paid to "average" livestock farmers since the mid-1970s were smaller than the cultivation of any one of the five major crops, although they had been higher than some crops in the beginning of the 1970s. The livestock farmers employing higher technology would have received adequate prices comparable to crop cultivation, but nonetheless, the different trends in price movements per ha point to the background of agriculturalization observed in the Pampa region.

The gap in profitability between crop cultivation and livestock rearing during the early 1980s is indicated in the model case study reported by Peluffo in December 1985 issue of CREA[1]. According to this study, the gross margin per ha, excluding the costs of capital and fixed assets from the calculation, averaged 140.73 australes (in July 1985 prices) during 1979/80-1983/84 at a farm which engaged in the cultivation of maize, wheat and sunflower in the average combined harvested area of 796 ha. By comparison, a cattle farm with the average area of 792 ha during the same period obtained the gross margin of 69.83 australes from the average productivity of 290 kg in live weight. And the rate of return on capital, which is the ratio of the gross margin to the value of land in the case of the former and the value of land plus the purchase cost of feeder cattle in the latter, was 10.73% and 5.09% respectively. Although it is not appropriate to generalize from this example, the study at least indicates that crop cultivation has had readier access to the means of increasing the productivity of, and the returns on, land compared with cattle farming.

1-1-3 Utilization of Modern Inputs

(1) Seeds

There is no doubt that the breeding of varieties of superior qualities and the quick diffusion of these varieties are among the key requisites to the advancement of contemporary agriculture. The capability of developing plant breeding technologies is one of the most important factors for agricultural development, and the situation of seed production in a given country usually gives a good general view of this capability.

With respect to five major export crops, the growth of Argentina's seed market made great contributions to the rapid expansion of their production in the last two decades. The seed market for the five crops can be divided into two types, namely, the market of hybrid seeds for maize, sorghum and sunflower and the other of autogamous wheat and soybean, and they have different structural characteristics[2].

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1) A. Luis Peluffo, "Iniciacion en tambo de un productor de carne: porqué y cómo", CREA, No. 116, December 1985, pp.32-41.

2) The description on the seed industry in Argentina in this section owes a great deal to the studies undertaken by Eduardo Jacobs and Marta Gutierrez at the Center of Social Studies on the State and Administration (CISEA) as follows; Jacobs, E. and Gutierrez, M., La Industria de Semillas en la Argentina, PROAGRO Document No. 2, CISEA, B.A., April 1984; and Jacobs, E., Algunos Comentarios sobre las Condiciones para el Desarrollo del Sector Privado en la Produccion de Semillas: el Caso de la Argentina, PROAGRO Document No. 7, August 1984.

The market of hybrid seeds is characterized by the predominance of private companies in breeding as well as marketing and by the large participation of the subsidiaries of transnational enterprises in seed business or in grain trade. It is said that there are some 30 major seed companies in Argentina, and eight of them are such subsidiaries.

Table II-1-7 shows the percentage of domestic seed supply for maize, sorghum and sunflower during the last decade or so. Argentina in the early 1980s is more than self-sufficient in the seed production of these crops. In terms of the planted area, hybrids accounted for about 97 - 98% for maize by the beginning of the 1970s, and a little over 80% for sunflower by the early 1980s (Table II-1-8). Although no similar statistics are available, the diffusion of hybrids is also said to be high for sorghum, generally ranging from 90% to 100% by region.

Figure II-1-3 shows the processes of introduction and distribution of hybrid seeds as elaborated by Jacobs and Gutierrez. There are at least four different external sources of research and development from which to introduce new varieties to Argentina. International Wheat and Maize Improvement Center (CIMMYT) provides new varieties of hybrids directly to either the INTA or domestic seed producers, and foreign universities are another source of supply for the INTA and some of the subsidiaries of transnational seed companies. The third and the fourth sources of new hybrid varieties are transnational companies and other foreign firms. Within Argentina, the INTA, subsidiaries of transnational companies and some national seed companies engage in research related to the breeding of new hybrids.

Research on hybrid maize in Argentina was started early in the 1920s, and the country developed the first double hybrid varieties in 1945, ten years later than the USA. Breeding efforts were then carried on by the University of Buenos Aires and the INTA's Regional Experiment Station of Pergamino, and the variety they developed became one of the important sources of the lines subsequently produced by various private seed companies. From the 1940s through the 1960s, subsidiaries of transnational companies and a few national companies entered the seed business, and their production increased rapidly.

By the early 1980s, private companies produced 1.5 million bags of hybrid seeds, compared with 100,000 bags in 1959/60 when the law endorsed the protection of new varieties developed by private breeders (closed pedigree). As a result, the importance of the public sector in the seed market declined. For instance, the number of official, i.e., open-pedigree, registered varieties was reduced to only two by 1983, and the share of open-pedigree varieties in the market declined from 22% during 1965-1970 to 2.7% during 1975-1980.

The situation is basically similar for sorghum and sunflower. Hybrids of sorghum were introduced in the mid-1950s by a subsidiary of a transnational seed company, and although the INTA had developed some varieties by then, the subsequent rapid diffusion was effected by the private seed industry. With respect to hybrid sunflower which was introduced to the country in 1972, the INTA developed no new variety of its own and mainly engaged in varietal improvement, while the

Table II-1-7 Self-Sufficiency in Seeds of Sorghum, Sunflower and Maize

(%)

Year	Grain Sorghum	Sunflower	Maize
1970	69	68	68
1971	104	66	107
1972	83	114	121
1973	86	71	86
1974	93	82	106
1975	120	82	102
1976	115	69	97
1977	149	104	110
1978	114	59	138
1979	122	69	130
1980	72	80	148
1981	140	139	128
1982	148	134	169
1983		113	127

Source: E. Jacobs and M. Gutierrez, La Industria de Semillas en la Argentina, PROAGRO Document No. 2, CISEA, April 1984.

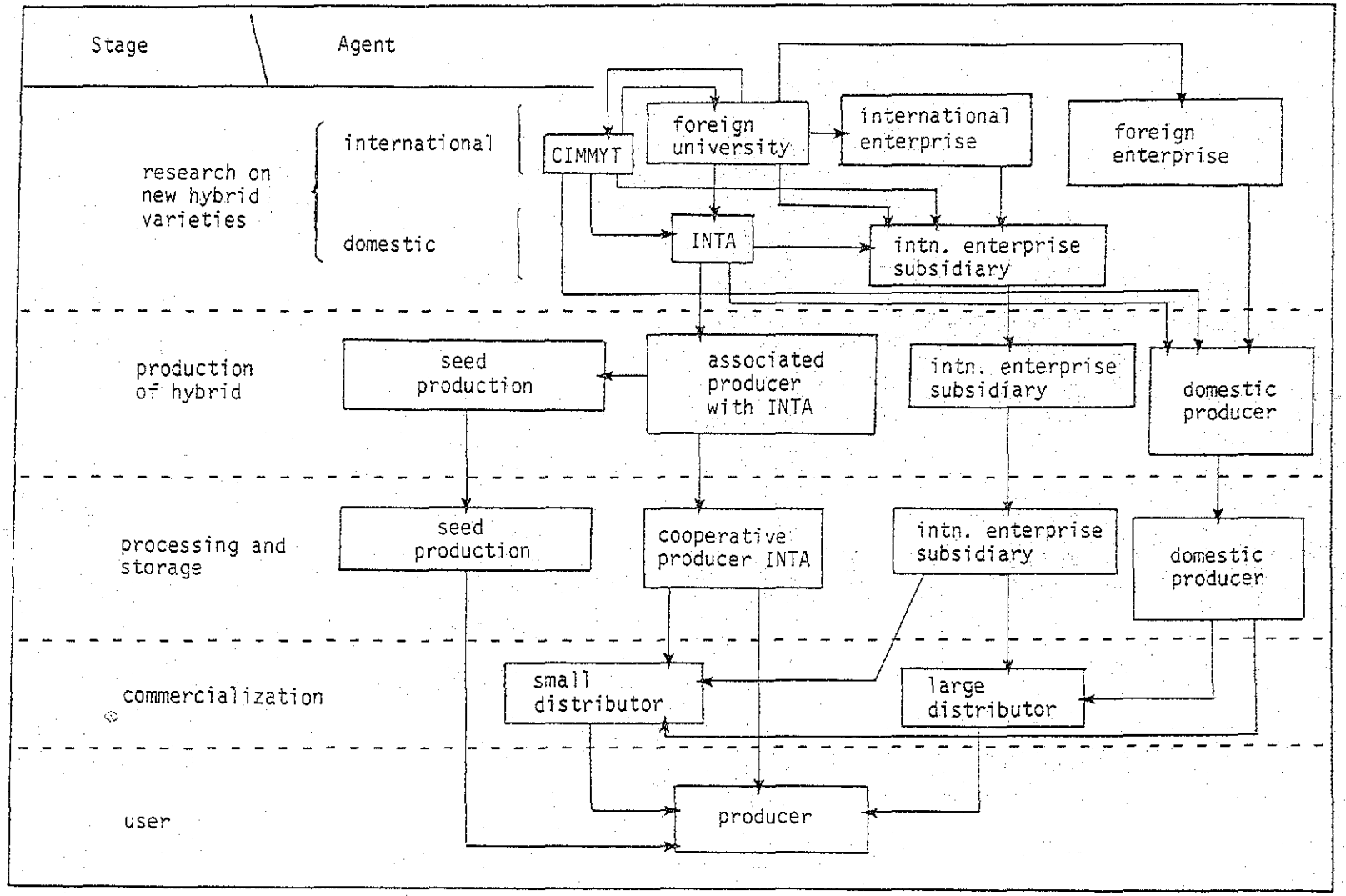
Table II-1-8 Use of Hybrid Seeds in Production of Maize and Sunflower in Argentina

(%)

Year	Maize		Sunflower	
	Hybrids	Others	Hybrids	Others
1970	98.4	1.5	0	100.0
1971	98.4	1.5	0	100.0
1972	97.8	2.2	0	100.0
1973	96.1	3.9	1.1	98.9
1974	96.8	3.2	0.4	99.6
1975	97.4	2.6	5.6	94.4
1976	98.7	1.3	7.9	92.1
1977	97.7	2.3	24.4	75.6
1978	97.7	2.3	58.4	41.6
1979	97.8	2.2	60.9	39.1
1980	97.3	2.6	77.7	22.3
1981	95.7	4.3	76.4	23.6
1982	96.7	3.2	79.5	20.5
1983	97.2	2.8	82.4	17.6

Source: E. Jacobs and M. Gutierrez, Ibid.

Figure II-1-3 Flow of Hybrid Seeds of Maize, Sorghum and Sunflower in Argentina



Source: Jacobs and Gutierrez, op. cit.

private companies had more than 40 varieties on the market in the early 1980s.

Table II-1-9 shows the shares of leading private companies in the market of hybrid maize seeds in Argentina. Four leading companies have the combined share of 85% in the early 1980s. The situation is similar for sorghum and sunflower, and four top companies make up 87% for the former, and 82% for the latter. These leading firms are mostly subsidiaries of transnational companies. The concentration and transnationalization of the hybrid seeds market do not necessarily imply, however, oligopolic control. The INTA which has a sizable collection of maize germplasm has the policy to assist national companies interested in hybrid seeds, thus ensuring a possibility of new entries. Moreover, the market competition among the leading companies is high enough to ensure the sustained efforts on their part in breeding new, better varieties.

With respect to wheat and soybean, the participation of private companies is relatively low. In contrast with hybrids, farmers themselves can produce seeds of adequate quality for autogamous plants like wheat and soybean. As shown in Table II-1-10, the certified seeds account for some 30% of the total seed production in Argentina in the early 1980s. It is said that the percentage share of seeds which farmers produce for themselves is about 50%, and that the remainder is "black-marketed" through grain merchants or cooperatives.

Because of the relatively small market of certified seeds, most of the subsidiaries of transnational companies either did not enter, or abandoned, the production of wheat seeds. In other words, hybrid seeds which have the genetically built-in protection and thus guarantee high returns are the main concern of these companies. As shown in Figure II-1-4, certified seeds are mostly produced by national seed companies, or producers cooperatives associated with the INTA which provides them with the basic seeds for a fee.

Research on varietal selection and improvement on wheat was started during the 1910s and 1920s by both the public and private sectors in Argentina, but research efforts relevant to the increased production of wheat in the 1970s began in the late 1950s when the INTA initiated its cooperative program with the CIMMYT. During the earlier half of the 1970s, the INTA developed several new early-maturing varieties on the basis of Mexican germplasm, which were especially suited to the traditional maize zone in Buenos Aires, Santa Fe and Cordoba Provinces. With respect to the traditional wheat zone in the southern part of Buenos Aires Province, a national seed company developed new medium- to late-maturing varieties in the late 1970s.

Table II-1-9 Shares of Leading Companies in Hybrid Maize Seed Market

(%)

Year	Companies					
	I	II	III	IV	V	Others
1974	57	7	8	7	-	21
1975	53	13	9	11	-	14
1976	54	16	8	8	-	14
1977	64	8	8	6	-	14
1978	58	20	5	8	2	7
1979	50	24	6	8	2	10
1980	47	24	8	7	4	10
1981	45	28	9	7	2	9
1982	31	32	19	7	6	5
1983	30	23	21	7	5	10

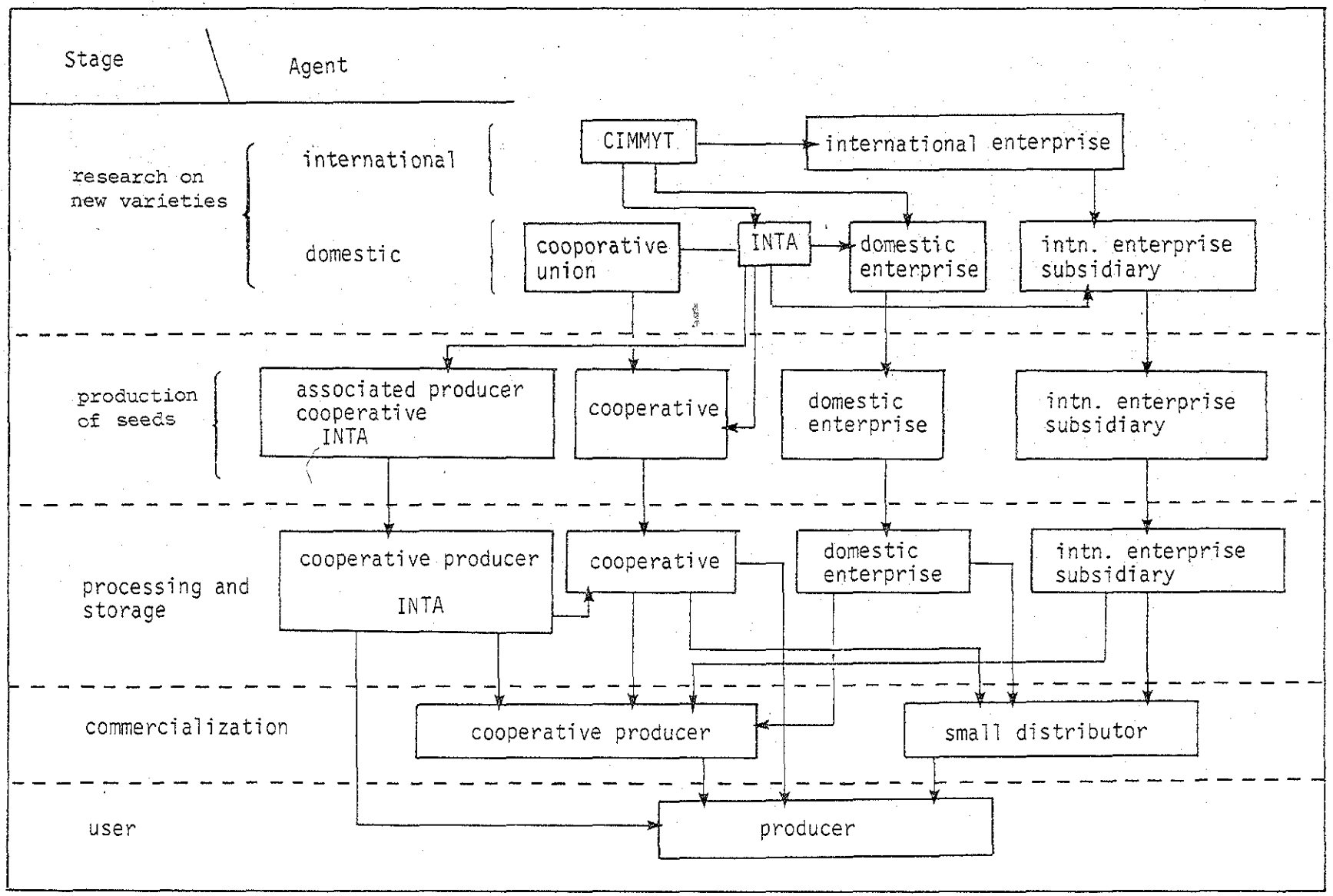
Source: E. Jacobs and M. Gutierrez, op. cit.

Table II-1-10 Use of Certified Wheat Seeds

Year	Total Production (1,000 tons)	% of Certified Seeds
1970	87.1	9.0
1971	71.3	19.5
1972	63.5	14.3
1973	84.2	11.3
1974	76.8	19.8
1975	91.5	14.8
1976	95.7	15.9
1977	113.7	13.3
1978	98.1	24.7
1979	167.4	18.8
1980	189.3	33.5
1981	225.5	30.6
1982	197.8	34.3
1983	321.7	26.7

Source: E. Jacobs and M. Gutierrez, op. cit.

Figure II-1-4 Flow of Wheat Seeds in Argentina



Source: Jacobs and Gutierrez, op. cit.

Compared with hybrid seeds, the importance of the public sector is larger in the seed market of wheat. According to Obschatko, the shares of the INTA and national seed companies in the total number of registered cultivars of wheat were 31% and 20% in 1983, compared with 22% of the subsidiaries of transnational companies[1]. In terms of the planted area in 1982/83, the INTA varieties accounted for 27%, national companies 57%, and the subsidiaries 4%. With respect to the traditional maize zone, the INTA's share was as high as 76%, whereas that of national companies was 96% in the traditional wheat zone.

A basically similar pattern is found in the seed market of soybean. About 50% of the seeds used in Argentina are estimated to be certified seeds, the rest being either produced by farmers themselves or "black-marketed" by grain merchants or cooperatives. Research on the crop was started by the University of Buenos Aires in the late 1950s on the basis of varieties introduced from North America, while the INTA developed four new varieties and collected some 2,000 varieties for varietal improvement. Private companies do not have any varieties they have developed in Argentina, their registered cultivars being all of foreign origin, and their interest in the soybean seed market is relatively weak chiefly for the same reason as for wheat.

As briefly described above, Argentina's capability in seed production has developed remarkably in the last two decades. With respect to hybrid seeds, the present technological standard is high, and because of high competition their markets are in oversupply rather than in shortage. Major problem areas appear to be in the apparent minor role the public sector institutions are playing in plant breeding, and the combined dominance of foreign subsidiaries. With respect to wheat and soybean, the key problem is the sizable presence of black markets, and perhaps to a lesser extent the smaller share of the certified seeds.

These problems are ultimately interrelated from the viewpoint of how to promote the nation's own capability of sound technology generation and diffusion in agriculture. This point is especially important in view of the on-going progress of modern biotechnology in the area of plant breeding. Agriculture can be considered the most classical industry based on biotechnology, but the expected speed-up and more flexibility in plant breeding through biotechnology development would revolutionize the seed industry and agriculture. For instance, hybrid varieties of autogamous wheat have been already developed and one is being marketed in Argentina, and this would surely lead to the restructuring of the crop's seed market, as already seen in the markets of maize, sorghum and sunflower during the 1960s and the 1970s.

It is generally observed that once an excellent plant variety is introduced and accepted, conventional varieties disappear before long due to the overwhelming attractiveness of the new one to agrigultural producers. Judging from the rapid expansion of hybrid seeds market, it seems that a similar trend has been happening in Argentina, more or less inhibiting the development of domestic breeding technologies in

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1) Obschatko, Los Hitos Technologicos en la Agricultura Pampeana, 1984.

the process. Technologies embodied in agriculture can be divided into upstream technologies consisting of breeding and related technologies and downstream technologies used for actual cultivation. And the genetic information of a given crop ultimately determines the structure of downstream technologies used for the cultivation of the crop. It is true that in agriculture downstream technologies are as important as upstream technologies, but downstream technologies alone do not suffice to ensure a stable supply of newer, better crops. When the seed industry is turning into a profitable delivery system of biotechnology, in which transnational chemical, pharmaceutical and food corporations are showing strong business interest, it is time to rethink the nature and the role of the public research institutions in upstream technology development.

(2) Fertilizers

The consumption of chemical fertilizers in Argentina is characterized by its extremely low level of utilization and substantial fluctuations from year to year. For example, the country's average application for wheat cultivation in the early 1980s was reported to be one hundredth of some European countries, one fortieth of the USA and one tenth to one twentieth of the levels in Chile, Uruguay and Brazil.[1)] According to the study by Reca and Cirio, fertilizer application per ha of agricultural land in 1979 was 3.7 nutrient kg ($N + P_2O_5 + K_2O$), compared with 479 kg in Japan, 111 kg in the USA, 58 kg in Brazil and 48 kg in Uruguay.[2)] On the other hand, the apparent consumption (total supply) of fertilizers fluctuated widely from less than 110,000 tons to 350,000 tons during 1972/73 - 1985 (Table II-1-11).

The consumption shows a declining tendency during the earlier half of the 1970s, influenced by the oil crisis and the import restrictive policy at the time. During this period, the fertilizer application was largely limited to intensive agriculture such as sugarcane, fruits and vegetables found outside the Pampa region. After the mid-1970s, the consumption continued to climb, doubling from 1977 to 1985. This increase was chiefly met by imports. This was partly because of the import liberalization during the latter half of the 1970s and the present Government's explicit policy to lower the prices of major factors of agricultural production. Nitrogenous fertilizers have increased their share from 66% in the mid-1970s to 76% in 1983-1985, accounting for 90% of the increase over the period. This was related to the fact that fertilizer application to wheat significantly expanded in the traditional wheat zone.

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1) E. Jacobs, N. Huici and H. Llera, Elementos para una Politica de Insumos Industriales, PROAGRO Documento NO. 4, CISEA June 1984.

2) L. Reca and F. Cirio, Fertilizantes Quimicos Fuente de Crecimiento Subutilizada en la Agricultura Pampeana, FUNDECO, Feb. 1983.

According to Reca and Cirio, the low level of fertilizer utilization in Argentina was mainly brought about by the following factors. Firstly, the price of fertilizer has been high relative to the price of crops; the average ratio in the price per ton of nitrogen to wheat during 1970-1981 was estimated to be 6.46 in Argentina, compared, for instance, with 3.58 in the USA, 3.36 in Brazil and 4.10 in Uruguay. This situation was due both to the higher price of the fertilizer and to the lower price of wheat in Argentina than in other major producing countries, to which export taxes on grains and protective tariffs on imports of those inputs locally produced contributed in no uncertain terms.

Secondly, the uncertainty of gains by fertilizer application, especially with respect to some traditional varieties of crops, and the system of extensive mixed farming developed in the Pampas for the maintenance of soil fertility did not lead to the wide diffusion of chemical fertilizers. Thirdly, fluctuations in the performance of the economy during the 1970s increased the risks involved in introducing new inputs like fertilizers. Lastly, effective policy incentives have been largely absent so that the domestic fertilizer industry lacked the dynamism to increase production and reduce prices.

Table II-1-11 Consumption of Chemical Fertilizers

(1,000 tons)

Year	Domestic Production	Import	Total Supply	Nutrients N	P	K	Total
1972/73	100.1	154.4	264.5	49.1	20.6	5.5	75.3
1973/74	102.3	111.9	214.2	45.3	10.8	9.4	65.5
1974/75	64.6	123.7	188.3	35.1	13.4	5.6	54.1
1975/76	63.2	46.9	110.1	27.6	4.0	3.0	34.7
1976/77	68.9	113.9	182.8	45.7	12.8	4.1	62.6
1977	75.4	97.8	173.2	40.2	12.1	3.6	55.9
1978	92.7	98.1	190.8	44.4	14.2	4.7	63.3
1979	82.9	218.1	301.0	60.6	28.2	10.2	99.0
1980	85.3	172.2	257.5	65.4	21.8	7.3	94.4
1981	63.7	115.9	179.6	51.2	12.6	4.4	68.2
1982	74.5	129.3	203.8	50.9	20.0	4.7	75.6
1983	76.8	176.2	253.0	64.6	24.5	8.7	97.8
1984	79.0	231.1	310.1	98.0	20.3	9.4	127.8
1985	84.3	269.8	354.1	119.4	19.7	4.7	143.8
72/73-74/75	89.0	130.0	222.3	43.2	14.9	6.8	65.0
1977-79	83.7	138.0	221.7	48.4	18.2	6.2	72.7
1980-82	74.5	139.1	213.6	55.8	18.1	5.5	79.4
1983-85	80.0	225.7	305.7	94.0	21.5	7.6	123.1

Source: Dept. de Fertilizantes, Secretaria de Agricultura, Ganaderia y Pesca, Abastecimiento de Fertilizantes y Enmiendas, various issues.

The use of fertilizers began to pick up after 1983 due to the abolition of import tariffs on fertilizers and the introduction of a new system of fertilizer distribution introduced by the present Government for the cultivation of wheat since 1984/85. The distribution system evolves on the annually adjusted specific formula of paying in the form of wheat equivalent in value to the price per ton of urea, which is imported by the National Grain Board and distributed through grain merchants and cooperatives. As shown in Table II-1-12, the application of urea to wheat cultivation increased from 25,000 tons in 1983/84 to 90,000 tons in 1985/86. Since 1985/86, triple superphosphate was included in the program, resulting in a substantial increase of its consumption. The system was also extended to maize cultivation, but the consumption was still low. In addition, the system apparently contributed to lowering the price of fertilizers in the market as shown in Table II-1-13.

Domestic production of fertilizers was limited to urea, sulfate of ammonia and anhydrous ammonia produced by Petrosur (Table II-1-14). One copper smelting company produce phosphatic fertilizers, but its output is extremely small (383 tons in 1985). Production of urea gradually increased since the beginning of the 1970s, reaching 90,000 tons during 1983-1985. However, all of the output is not used in agriculture. For instance, 75% of urea and 4% of anhydrous ammonia were used for agriculture in 1985.

The volume of imports fluctuated widely depending on the prevailing government policy. Table II-1-15 shows the composition of fertilizer imports under the present Government. Total imports of simple fertilizers increased by 50% from 1983 to 1985, and urea showed more than a six-fold increase. This spectacular growth compared with other fertilizers was due to the lifting of import restrictions by stiff tariffs, which used to be put on those products for which there is domestic production. In 1985, the import dependence in nutrient terms was 87% for N, 91% for P and 59% for K.

The present Government stresses the prime importance of increasing agricultural output, especially of raising the combined production of five major export crops up to 60 million tons. For this purpose, the Secretariat of Agriculture, Livestock and Fisheries has been implementing various policies, as will be discussed in the later section. With respect to fertilizers, the Secretariat estimates that the import needs in 1987/88 would increase to 400,000 tons of urea (the total demand of about 500,000 tons including domestic production), 130,000 tons of diammonium phosphate, and 70,000 tons of triple superphosphate. This means a nearly five-fold increase for urea, a 50% increase for diammonium phosphate and a seven-fold increase for triple superphosphate from the consumption levels in 1984/85.

There is some doubt about this ambitious estimation. Agricultural producers often respond to a decline in profitability by cutting down costs, and in the crop year of 1985/86 when the export price of wheat began to drop further, the initial target of the above-mentioned distribution system was 150,000 tons, but the actual consumption was around 90,000 tons. Accordingly, the plan for the coming year is reduced to 64,000 tons of urea and 15,000 tons of

Table II-1-12 Fertilization Distribution for Wheat Cultivation

	1983/84	1984/85	1985/86		1986/87
	Urea	Urea	Urea	Triple Super-phosphate	Urea
Exchange Rate of Wheat per Ton of Fertilizers:					
Distributors to JNG		1.95	2.05	2.55	2.01
Producers to Distributors					
Up to 200 km		2.45	2.65	3.15	2.51
Up to 400 km		2.60	2.80	3.30	2.61
Distribution to Wheat (tons):					
Urea	25,000	75,000	90,000		
Triple Superphosphate	500	1,000	30,000		
Diammonic Phosphate	45,000	65,000	50,000		
Ammonia	1,300	1,800	2,500		

Source: Secretaria de Agricultura, Ganaderia y Pesca

Table II-1-13 Prices of Fertilizers

(1000 pesos/ton; 1975 prices)

	Urea	Diamm. Phosph.	Triple Superphos.	Sulf. of Ammonia
1976	12.4	30.4	20.0	8.8
1977	11.7	17.4	12.3	6.2
1978	11.8	16.1	14.7	6.5
1979	8.3	12.4	10.9	4.9
1980	8.7	14.3	10.3	5.6
1981	13.4	15.4	11.1	8.5
1982	12.8	18.1	13.9	8.7
1983	14.4	15.7	14.3	10.9
1984 Jan.	13.1	15.9	11.1	7.4
Apr.	11.3	13.8	11.1	7.8
Jul.	9.8	13.5	10.2	7.4
Oct.	7.4	13.7	11.8	5.6
Dec.	7.8	14.6	11.5	5.9
1985 Jan.	7.7	16.0	12.9	5.8
Apr.	8.0	15.2	12.6	5.2
Jul.	9.4	14.9	11.2	4.1

Source: SNESR

Table II-1-14 Domestic Production of Chemical Fertilizers

(tons)

Year	Urea	Sulphate of Ammonia	Anhydrous Ammonia
1970	51,606	35,285	
1971	49,178	38,252	
1972	58,894	47,667	
1973	51,412	49,600	
1974	36,717	38,379	
1975	34,128	27,314	
1976	37,699	30,809	
1977	45,687	32,138	
1978	58,544	34,884	
1979	65,488	36,208	
1980	59,669	32,768	64,146
1981	52,848	16,796	54,363
1982	79,491	19,107	78,458
1983	89,237	18,260	81,110
1984	86,994	14,147	62,033
1985	95,755	8,905	68,431
1971-73	53,161	45,173	
1978-80	61,234	34,620	64,146
1983-85	90,075	12,724	78,465

Source: SNESR and Tendencias Economicas 1985.

Table II-1-15 Composition of Fertilizer Imports

(tons)

	1983	1984	1985
Nitrogenous Fertilizers			
Urea	23,090	86,235	146,852
Anhydrous Ammonia	2,107	2,693	-
Sulfate of Ammonia	500	8,050	-
Subtotal 1)	29,491	106,960	158,101
Phosphatic Fertilizers			
Triple Superphosphate	15,294	10,665	34,329
Subtotal 1)	16,544	11,715	36,379
Potassic Fertilizers			
Potassium Chloride	7,630	12,101	6,240
Subtotal 1)	19,655	16,611	9,078
Nitrogenous/Phosphatic Fertilizers			
Diammonium Phosphate (18-20-0)	97,320	89,534	58,323
Subtotal 1)	105,049	89,589	61,691
Nitrogenous/Potassic Fertilizers			
Potassium Nitrate	1,350	3,316	880
Subtotal 1)	4,450	5,176	2,680
Total Simple Fertilizers	175,189	230,062	269,804
Nutrient N	32,334	63,969	81,950
Nutrient P	24,437	20,189	19,527
Nutrient K	8,582	9,342	4,502

Source: Dept. de Fertilizantes, op.cit.

Note: 1) Subtotals include other related products.

triple superphosphate, mainly using the stock left over from the previous year. As mentioned earlier, fertilizer use for wheat is largely limited to the traditional wheat zone in the south of Buenos Aires, but in other areas agricultural producers are not used to fertilizer application. Through intensified extension services, the demand would begin to increase eventually, but it is doubtful that the consumption will grow at the speed implied by the estimation. According to another projection to 1989/90, which was done on the basis of increasing the production of five crops to 60 million tons, the import requirements are estimated to be 25,900 tons of urea, implying practically no growth since 1983/84, and 77,700 tons of diammonium phosphate.[1)]

On the basis of the above-mentioned estimation, the Secretariat is considering the construction of a large-scale fertilizer factory with internationally competitive productivity. In view of the country's large reserves of natural gas, it is technically possible to construct the factory. But considering its huge initial investment costs and the present soft world market of petroleum-derived products, it may not be wise to promote the project implementation too early. It would be necessary to coordinate the implementation schedule by monitoring the effects on actual fertilizer consumption of price and tax policies, which have been proposed by the present Government to stabilize the profitability of farming.

(3) Pesticides

As shown in Table II-1-16, Argentina's domestic market of pesticides in the early 1980s amounted to US$130 million, doubling in real terms from 1970-72 to 1981-83. The consumption during the 1960s was largely limited to some intensive agriculture outside the Pampa region, which used mostly insecticides and fungicides. Herbicides were rarely used then. Local manufacturing of insecticides (DDT and HCH) began in the late 1960s. The consumption of pesticides began to increase since the mid-1970s along with the expansion in the area planted to soybean, which used herbicides to combat Johnson grass and other perennial weeds. According to Leon et al., the consumption of pesticides in 1984 consisted of 61% of herbicides, 30% of insecticides and 9% of fungicides.[2)]

The breakdown by major crop, as seen in Table II-1-17, indicates that soybean consumed some 30% each of insecticides and herbicides, while the shares of other crops are relatively small except for maize with a share of 20% in herbicides and potatoes 38% in fungicides. In all, five crops mainly grown in the Pampa region have the combined share of 64% in insecticides and 72% in herbicides. It has to be noted, however, that the percentage in terms of value is not an accurate indicator of the crops' different levels of pesticide application.

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1) N. Huici, Requerimientos de Semillas, Fertilizantes y Maquinaria para la Expansion Agricola en 1985-1990, CISEA, PPA Document No. 9, Dec. 1985.

2) C. Leon, L. D'Amato and M.E. Iturregui, El Mercado de Plaguicidas en Argentina, Secretaria de Planificacion, Mar. 1986.

Table II-1-16 Consumption of Pesticides

Year	Consumption (1,000 tons)	Domestic Market Size in Value		Average Price/Ton	
		Current US$ Million[1)]	Constant US$ Million[2)]	Current US$	Constant US$
1970	17.5	24.0	38.0	1,371	2,173
1971	29	20.3	31.1	700	931
1972	20	23.0	33.8	1,150	1,689
1973	21.5	34.0	44.2	1,581	2,054
1974	53	100.0	109.3	1,886	2,062
1975	34	78.0	78.0	2,294	2,294
1976	35	65.0	62.1	1,857	1,775
1977	32	67.0	60.4	2,094	1,886
1978	32	77.8	65.0	2,432	2,031
1979	40	120.9	89.8	3,022	2,244
1980	21	95.2	62.0	4,531	2,951
1981	25	88.8	53.0	3,550	2,121
1982	38	123.0	71.9	3,237	1,892
1983	n.a	180.0	103.8	-	-

Source: C. Leon, L. D'Amato and M.E. Iturregui, EL mercado de plaguicidas en Argentina, Direccion Nacional de Analisis y Proyecciones Sectoriales, Secretaria de Planificacion, March 1986.

Notes : 1) Prices at the level of distributors.
2) Deflated by the wholesale price index in USA (1975=100).

Table II-1-17 Utilization of Pesticides by Major Crop (1983)

Crops	Insecticides		Fungicides		Herbicides		Acaricides	
	US$ Million	%	US$ Million	%	US$ Million	%	US$ Million	%
Soybean	14.9	28.7	-	-	32.1	30.9	-	-
Sunflower	10.7	20.6	-	-	6.3	6.1	-	-
Apple	5.5	10.6	1.6	8.0	-	-	3.6	90.0
Wheat	4.3	8.3	1.3	6.5	14.0	13.5	-	-
Cotton	2.6	5.0	-	-	1.8	1.7	-	-
Tobacco	1.9	3.6	-	-	-	-	-	-
Sorghum	1.9	3.6	0.5	2.5	2.4	2.3	-	-
Potato	1.6	3.1	7.5	37.5	-	-	-	-
Maize	1.4	2.7	0.6	3.0	20.6	19.8	-	-
Others	7.2	13.8	8.5	42.5	26.8	25.7	0.4	10.0
Total	52.0	100.0	20.0	100.0	104.0	100.0	4.0	100.0

Source: Minoru Harada, Mercado mundial de piretroides agricolas y sus caracteristicas, Nov. 1984, as quoted in C. Leon et al., ibid.

In contrast to the fertilizer industry, the pesticide industry in Argentina is characterized by market segmentation. According to Leon, there are 36 companies which produce pesticides, of which two-thirds are formulators. The presence of foreign firms is important in terms of market share and in terms of patents on specific products. Some 150 firms are authorized by the Secretariat of Agriculture, Livestock and Fisheries to market pesticides in the early 1980s, but over 90% of total sales are accounted for by 20 - 25 firms.

During the later 1970s when the consumption picked up partly due to the import liberalization, the domestic production capacity virtually did not increase, and furthermore the rate of operation declined significantly. In other words, the increased consumption was primarily met by imports. There seems to be no comprehensive information on the level of domestic production, but as shown in Table II-1-18, the combined imports of intermediate inputs showed a declining tendency since the late 1970s, while those of formulated herbicides recorded a nearly eight-fold increase to 8,800 tons during 1977-1984. Formulated insecticides and fungicides also showed a gradual increase. However, the drop in imports is larger in formulated products in 1985 when the national economy experienced extreme destabilization.

According to Jacobs et al., the market participation of domestic industry was 31% during 1977-1981, but was very low, at 3.4%, with respect to herbicides.[1] Furthermore, because many domestic firms use imported intermediate inputs, which amount to 90% or more of the local production costs with respect to newer products like glifosato, trifuralina and triclorfon, the dependence of the domestic market on imports must be in fact higher than the estimate.

As can be seen from the relative multiplicity of firms engaged in manufacturing, formulating and distributing pesticides, the market is characterized by a proliferation of products. It is said that there are 140 - 150 active chemical substances in use, out of which some 2,000 brands are produced. Many of the products are interchangeable in their function. At the same time, the consumption pattern shows concentration. According to Leon et al., of 22 active substances marketed as herbicides for soybean, only four (fluazifop butil, bentazon, trifluralina and glifosato) account for 60% of the total consumption.

According to the National Agricultural and Livestock Program (PRONAGRO) announced by the Secretariat of Agriculture, Livestock and Fisheries in 1984, increased plant protection and fertilizer application are considered crucial means to increase the production of five major grains. Herbicides in particular are considered as a strategic input, and their value-added tax has been reduced to 5% compared with 18% for other pesticides. The current proliferation of products and market segmentation despite the concentration in consumption seem to be in need of rational restructuring in order to increase the industry-wise efficiency. Considering that the application of pesticides seems to be more widely spread in pampean

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1) Jacobs, Huici and Llera, Elementos para una Politica de Insumos Industriales, 1984.

Table II-1-18 Imports of Pesticides

(tons)

	Intermediate Inputs				Formulations			
	Insecticides	Fungicides	Herbicides	Total	Insecticides	Fungicides	Herbicides	Total
1972	512	-	66	578	1,292	1,130	1,148	3,570
1973	1,315	14	240	1,569	1,347	1,615	845	3,870
1974	2,627	129	1,179	3,945	2,631	2,823	2,102	7,556
1975	456	17	67	540	326	711	636	1,673
1976	2,084	62	414	2,560	1,223	1,444	1,416	4,083
1977	3,591	171	966	4,728	2,350	1,419	1,313	5,082
1978	2,786	72	1,242	4,100	1,565	1,348	1,177	4,091
1979	6,284	148	694	7,126	3,286	2,911	2,205	8,402
1980	2,518	143	332	2,993	2,174	2,822	2,709	7,707
1981	1,829	63	453	2,346	1,704	1,862	3,334	6,900
1982	2,310	31	831	3,172	2,442	2,275	5,398	10,115
1983	2,713	127	1,175	4,015	3,457	2,631	5,920	12,009
1984	3,197	73	667	3,937	2,723	2,285	8,857	13,865
1985	1,915	54	1,059	3,027	1,136	1,789	5,834	8,761

Source: SNESR

agriculture than fertilizers, and that the method of conservationist tilling, now being promoted by the INTA and other technical assistance organizations, relies on heavier application of pesticides, it is possible to foster national companies for selective import substitution.

In contrast to fertilizer industry for which the standardized production technology is available, however, the import substitution policy for pesticides must take note of rapid technological innovations which are taking place over the world. Especially important to note is the on-going merging of chemical industry and seed industry, new development of biological control and other products for selective plant protection, and tied breeding of cultivars tolerant to specific pesticides. In this sense, it would be necessary to formulate a master plan of plant protection including a strategy to enhance the capability of the domestic industry in research and development.

(4) Mechanization

Agricultural mechanization has been essential to the development of extensive agriculture in the Pampas, and along with the import substitution pursued after World War II, Argentina completed the mechanization of pampean agriculture by the end of the 1960s. During the 1970s, larger and more sophisticated agricultural machinery was introduced effectively to support the process of agriculturalization.

Except for the national census undertaken in 1960, there is no statistical information on the total number of machinery currently in use in Argentina. According to the estimate made by Huici on the basis of the said census and annual sales of machinery[1], the total number of tractors in 1984 is about 180,000 units and that of harvesters 34,000 units, compared with 100,000 and 40,000 units respectively in 1960 (Table II-1-19). Over a quarter of a century, tractors increased not only their number but their average capacity, and as a result, the total available horsepower in 1984 is more than three times larger than in 24 years ago. Larger and more efficient models of harvesters were also introduced to the market during the 1970s, and this seems to be reflected in the average harvested area per unit.

Table II-1-20 shows the evolution of production and sales of tractors and harvesters. As a general tendency, both domestic production and sales declined considerably from the mid-1970s to the mid-1980s. Total sales, for instance, were less than halved from 1974-77 to 1982-85. Production shows a similar pattern, but during 1980-1982 after the import liberalization of agricultural machinery in 1979, the domestic output slumped drastically to some 3,000 units compared with over 20,000 units in the mid-1970s. However, it has to be taken into account the continuous increase in the capacity per unit, which rose from 76.8 hp in 1977 to 105.7 hp in 1983. Nonetheless, the destabilization of the economy since the beginning of

1) Huici, Requerimientos de Semillas, Fertilizantes y Maquinaria para la Expansion Agricola en 1985-1990, 1985.

Table II-1-19 Estimated Utilization of Tractors and Harvesters

	Tractors				Harvesters		
	Units	Total Power (1,000hp)	Average Power (hp)	Years of Use	Units	Years of Use	Area Harvested Per Unit
1960	104,306	4,025	38.6	7.8	39,834	18.3	207
1969	190,663	8,805	46.2	8.9	39,274	11.5	303
1977	233,844	13,638	58.3	8.6	38,853	12.5	341
1981	214,107	14,029	65.5	8.9	37,587	12.2	364
1982	202,120	13,583	67.2	9.2	35,481	12.5	430
1983	191,280	13,229	69.2	9.4	34,325	12.5	490
1984	183,410	13,179	71.9	9.5	33,885	12.1	500

Source: N. Huici, Requerimientos de Semillas, Fertilizantes y Maquinaria para la Expansion Agricola en 1985-1990, CISEA, PPA Document No. 9, Dec. 1985.

Table II-1-20 Production, Sales and Trade of Tractors and Harvesters

(Units)

Year	Domestic Production	Sales of Domestic Products	Stock of Domestic Products	Imports	Sales of Imported Products	Total Sales	Exports
(1) Tractors							
1974	24,573	10,650	892	150			4,233
1975	18,827	15,210	678	234			3,831
1976	23,823	20,966	1,749	128			1,786
1977	25,845	21,932	3,855	572			1,807
1978	5,939	6,309	733	777			2,752
1979	10,610	7,117	1,282	2,527	1,034	8,151	2,944
1980	3,658	3,481	641	5,141	1,481	4,962	818
1981	1,359	1,507	220	2,713	1,547	3,054	273
1982	3,828	2,806	595	418	768	3,574	647
1983	8,126	8,125	591	598	164	8,289	5
1984	12,322	12,376	496	185	135	12,511	41
1985	6,378	6,510	175	200	79	6,589	189
(2) Harvesters							
1974	1,736	1,633					
1975	1,602	1,427					
1976	1,438	1,468	77	0			
1977	1,891	1,756	212	17			
1978	1,654	1,582	284	67			
1979	1,341	1,294	331	76			
1980	311	399	243	246			
1981	112	234	140	45			
1982	989	1,047	82	108			
1983	1,790	1,526	346	108			
1984	1,647	1,469	524	n.a.			
1985	554	715	363				

Sources: SNESR

the 1980s dampened the domestic demand considerably. The trend in the production and sales of harvesters is very similar, including the impact from increased imports.

Concerning the trend of mechanization observed during the 1970s, it is necessary to mention the increased role of contractors (contratista) in farming operations. To have land preparation and harvesting done by contractors has long been practiced in Argentina, but the increased use since the later 1970s of larger, more efficient and thus more costly machines further popularized mechanized farming on the contract basis. Partly because of the importance of contractors in mechanized farming, the level of machinery utilization in Argentina is said to be high. For instance, the annual average harvested area per harvester in 1982 was estimated to be 549 ha in Argentina compared with 160 ha in the USA, while a study made by the Regional Experiment Station (EERA) of Pergamino showed that 17 contractors logged on average 570 - 760 ha per harvester in 1981.[1)]

Moreover, the recently emerged tendency is to have an entire annual farming operation undertaken by contractors on the share-cropping basis. According to the experts at the Regional Experiment Station of Pergamino, roughly 50% of the farmed area under its supervision was said to be worked by contractors. In the traditional maize zone where continuous agriculture has increased its importance, the on-going expansion of contract farming is a cause of some concern because of its possible deteriorating effects on farm land. The afore-mentioned program of diffusing the method of conservationist tilling is expected to include a credit line for the purchase of suitable machines by contractors as well as by farmers themselves.

According to Huici (1984), Argentina's agricultural machinery industry is divided into three subsectors of tractors, harvesters and agricultural implements, each with its unique characteristics. First, the tractor industry is oligopolistic consisting of four subsidiaries of foreign firms and one national firm. The oligopolistic nature of this industry originated from the time when the import substitution of tractors was undertaken in the 1950s, and the foreign subsidiaries have long been protected from competition with imports and new entries, and received preferential treatment concerning imports of intermediate inputs. But their combined participation in the domestic market underwent a significant change over the last decade. Four subsidiaries had the combined share of 98% in the total sales in the mid-1970s, but in the early 1980s 69%.

Their relative decline was due to the entry of a national company Zanello which commenced the manufacturing of tractors in the beginning of the decade. Starting from an annual production of some 100 units, the company which had been a manufacturer of road construction and forestry equipment increased its output to 1,000 units by 1981, and then quintapled it to 5,500 units by 1984. Its success derived from

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1) N. Huici, La industria de la maquinaria agricola en la Argentina, PROAGRO Document No. 9, Dec. 1984.

effective targetting of the market by producing larger machines than the models manufactured by the other four, experiences in mechanical engineering, introduction and adaptation of new designs and technology from the USA, purchase of parts from other producers both inside and outside the country, which is not commonly done by the other four, and so on. When the domestic market was opened in the late 1970s, bringing in more efficient and sophisticated imports, domestic tractors, except for Zanello's products, were generally of old models lacking even three-point hitches and four-wheel drive. The imports and the presence of the company gave a decisive impetus to the other producers to manufacture new models.

In contrast to tractors, the production of harvesters is in the hands of 12 national companies. But the degree of concentration is high, with the top firm producing 43% in value terms, or top three accounting for 66% in 1982. Other than the leading firm which has the capacity of 1,000 units per annum, the operating scale is small, ranging from 50 to 300 units, and there is little possibility of an economy of scale. Due to the limited resources, product research and development efforts are weak among the majority of firms, and the harvest loss is said to be as high as 10 - 15%. As was the case with tractors, the increased imports in the beginning of the 1980s is said to have motivated the leading firms to develop better models.

Some 240 companies participate in the production of agricultural implements, and the market is highly fragmented. Three leading firms accounted for 14% of total production value in 1982, or 15 companies 38%. Moreover, most of them are not specialized in agricultural implements. Because the implements are relatively simple in their mechanics, and easier to incorporate new technology from abroad, technical levels of their manufactures are said to be adequate.

In the National Agricultural and Livestock Program (PRONAGRO), agricultural machinery and seeds are not considered serious structural constraints for facilitating the increased production of five major crops. The existing agricultural machinery manufacturing firms in the three subsectors have sufficient productive capacities to meet the expected increase of demand. But especially with respect to the harvesters and agricultural implements, it appears necessary to take measures for enhancing their product development capability and infusing economies of scale to reduce costs of production.

1-1-4 Research and Development Efforts and Technology Diffusion

(1) Outline of agricultural research and development in Argentina

Agricultural research and development in Argentina is carried out by both public and private sectors. In the public sector, the National Institute of Agricultural Technology (INTA) with its national network of experiment stations and extension offices conduct the most comprehensive spectrum of research and development efforts and extension services. In addition, provincial governments, crop-specialized national research institutes and universities undertake agricultural technology generation and/or diffusion. A number of research institutes associated with the

National Council of Scientific and Technological Research (CONICET), as will be described in the next section on biotechnology, also conduct agriculture-related research. In terms of the distribution of manpower, the public sector is tentatively estimated to have some 3,400 professionals trained in agriculture-related sciences as shown in Table II-1-21.

Although details are not known, a number of private-sector organizations and firms engage in technology generation and/or technology diffusion. As shown in Table II-1-21, they comprise manufacturers of agricultural inputs such as seeds, pesticides, fertilizers and agricultural machinery, processors of agricultural produce, grain merchants, farmers' associations or groups organized for the diffusion of improved farming technologies like Argentine Association of Regional Consortiums of Experimentation (AACREA).

Table II-1-21 Institutions for Technology Generation and Transfer

Types of Institutions	No. of Professionals Trained in Agricultural Sciences
Public Sector:	
1. INTA	984
2. Depts. and research institutes of provincial governments	453
3. Specialized national institutes	10
4. Universities	1,500
5. Institutes of CONICET	423
Private Sector:	
a. Agro-Industrial complexes	n.a.
b. Manufacturers of agricultural inputs (Seed business, pesticides, fertilizers, agricultural machinery, animal medicines, etc.)	245
c. Those related to agricultural products	
1. Large grain merchants	381
2. Grain merchants	200
3. Associations of farmers (CREA, coop, groups of technical assistance)	n.a.
d. Research foundations	57

Source: Martin Piñeiro, Marta Gutierrez and Eduardo Jacobs, Reflexiones para la Politica Technologia Agropecuaria, PROAGRO Document No. 3, CISEA, June 1984, Table 3.

In the public sector, the INTA has been the central institution playing the extremely important role in agricultural research and development in Argentina. The INTA was founded in 1956 for the purpose of promoting and strengthening agricultural research and extension, and thereby facilitating the technification and improvement

of farming. The INTA performs a very broad spectrum of functions from planning and evaluation, basic research, experimental trials and extension work.

The institutional structure of the INTA is as follows. Basic research is carried out by three national centers at Castelar: namely, National Research Center of Natural Resources, National Research Center of Agronomic Sciences, and National Research Center of Veterinary Sciences. Applied research on crops and livestock and extension services are conducted through the INTA's 13 Regional Agricultural Experiment Stations (EERA), 21 Agricultural Experiment Stations (EEA), one Cooperative Station of Experimentation and Extension, 5 Agricultural Experiment Substations, and some 220 rural extension agencies (AER). The INTA also operates 10 Annexed Farms for seed production.

Research activities of the INTA are very broad and cover most of the areas essential for agricultural development, such as breeding, improvement, adaptation, management, plant protection, agricultural engineering, economic evaluation, etc. In the field of plant breeding and adaptation, which is the main subject of this study, the research on cereals is mainly concentrated in the Pampa region. Experimentation on maize is conducted at eight stations in the middle Pampas, for wheat and barley at six stations, and for sorghum at six locations in the semi-arid region of the Pampas. Rice research is done at two stations in the Northeast mainly for breeding and cultural improvement. With respect to oilseeds, which are as important as cereals in the Pampa region, research and experimentation on sunflower, soybean, linseed, groundnut, etc. are carried out at stations in major areas of production, mainly focusing on adaptation, breeding, cultural management and plant protection.

Research on fruits and vegetables is mainly carried out at eleven locations corresponding to major concentrations of production, such as EERA at Mendoza for grapes, Sub-EEA at Junin for pomegranades, EEA at Concordia for citrus fruits, EERA at Balcarce for potatoes, and EEAs at Cinsulta and San Pedro for vegetables. Regional industrial crops are studied at stations like EERA at Saenz Peña (cotton), EERA at Corrients (mate, black tea), EERA at Famílla (sugarcane), and so on.

As mentioned above, there are 220 AERs responsible for extension services, under the board of directors of the INTA and local agricultural experiment stations. Their activity is not only to transfer the technologies developed by INTA stations to the farmers, but also to feedback specific local problems to INTA stations and centers. Currently, some 350 workers are engaged in this activity. Among them, 4% are working at the INTA headquarters, 7% are supervisors and the remainder of about 90% are stationed at local AERs.

The main problem of AER activities is that the number of workers engaged in extension services is too small. It is estimated that the average of 1,700 farmers have to be taken care of by one AER worker. This situation limits the activities of

AERs, and the current activity of AERs is mainly to promote the diffusion of seeds recommended by the INTA, cooperatives and the representatives of farmers.

In the public sector, universities also play significant roles in agricultural development and their activities are more in the fundamental research. Some examples of their research in the area of plant breeding are shown below.

University		Type of Research
Univ. Nacional del Sur	--	Genetic improvement of maize
Univ. Nacional de Buenos Aires	--	Collection of germplasms Development of dwarf varieties of wheat
Instituto Fitotecnico de Santa Catalina	--	Production of hybrid maize Production of hybrid wheat
Univ. Nacional de Tucuman	--	Tissue culture
Univ. Nacional de Cordoba	--	Meristem culture Genetic improvement
Univ. Nacional de Rosario	--	Haploid tissue culture Genetic improvement of soybean

As mentioned in the beginning, a considerable number of private organizations and firms participate in agricultural technology generation and/or diffusion in Argentina. Especially in the field of plant breeding and adaptation, the private sector plays a large role with respect to major export crops. As shown in Table II-1-22, private plant breeders have more registered new varieties than the public sector (INTA) and their combined share is especially large in maize, sorghum and sunflower for which hybrid varieties are predominant. As already discussed elsewhere, the private seed companies dominate the market of hybrid seeds.

According to the information of the Association of Argentine Seed Producers, the association has as its members 17 major seed companies operating in Argentina, as shown below.

Asgrow Arg. S.A.
Atar S.A.
Criadero Buck S.A.
Cargill S.A.S.I.
Ciba Geigy Arg. S.A.
Cia. Continental S.A.
Comega y Cia. Merc. y Gansd. S.A.
Cia. Quimica S.A.
Crawford Keen y Cia. S.A.
Dekalb Arg. S.A.
Interstate Semillas
Oscar Klein
Northrup King Semillas S.A.
Pioneer Arg. S.A.
Palaversich y Cia. S.A.

Santa Ursula S.A. (Morgan)
Semillas Meriel S.A.I.C.

Among these companies, ten are national and seven are of transnational origin. It is clear from Table II-1-22 that transnational plant breeders have larger potentials in breeding new varieties than the national companies especially with respect to maize, sorghum and sunflower.

Table II-1-22 Structure of Registered Seeds of Major Crops

	Maize (%)		Sorghum (%)		Wheat (%)		Sunflower (%)		Soybean (%)	
Subsidiaries of Foreign Companies:										
Asgrow	10	(6)	4	(4)			2	(2)	8	(9)
Cargill	33	(19)	11	(11)	6	(8)	10	(10)		
Ciba Geigy	3	(2)	8	(8)			3	(3)		
Continental	14	(8)	13	(13)			15	(15)	4	(5)
Dekalb	15	(9)	11	(11)	3	(4)	7	(7)		
Northrop King	10	(6)	9	(9)	6	(8)	7	(7)	3	(4)
Pioneer	9	(5)	10	(10)						
Subtotal	94	(54)	66	(65)	15	(21)	44	(45)	15	(18)
Major National Companies:										
Atar	5	(3)	1	(1)						
Comega			1	(1)			4	(4)		
Gear	2	(1)								
Jose Buck	1	(1)			16	(22)	2	(2)		
Klein					11	(15)	2	(2)		
Morgan	12	(7)	4	(4)			3	(3)		
INTA	17	(10)	6	(6)	20	(27)	8	(8)	4	(5)
Others	43	(25)	24	(24)	11	(15)	35	(36)	66	(78)
National subtotal	80	(46)	36	(35)	58	(79)	54	(55)	70	(82)
TOTAL	174	(100)	102	(100)	73	(100)	98	(100)	85	(100)

Source: Servicio Nacional de Semillas, Catalogo Cultivares Inscriptos, 1985

The improvement of the productivity of crops is one of the major goals in agriculture. The yields of crops on the fields are influenced by many factors like weather, water, soil fertility, application of fertilizers and pesticides and so on, which in turn depend on how responsive given crops are to these factors and inputs and how much farmers can spend on the inputs. In brief, the yield increase can be ascribed to 1) better varietal adoption, 2) better agronomic practice, and 3) greater genetic yield potential. Among the three factors, the improvement of genetic yield potential, or plant breeding, is expected to be the major factor of yield increase through the beginning of the next century, as shown in Table II-1-23. The data on the table was the result of the technology assessment study conducted by the University of Minesota on maize production in the USA, and also indicates that the emerging modern biotechnology will begin to exert a greater impact than the conventional plant breeding in the 1990s.

Table II-1-23 Projected Impacts of Various Technologies on Maize Yields for the Years 1981 to 2000

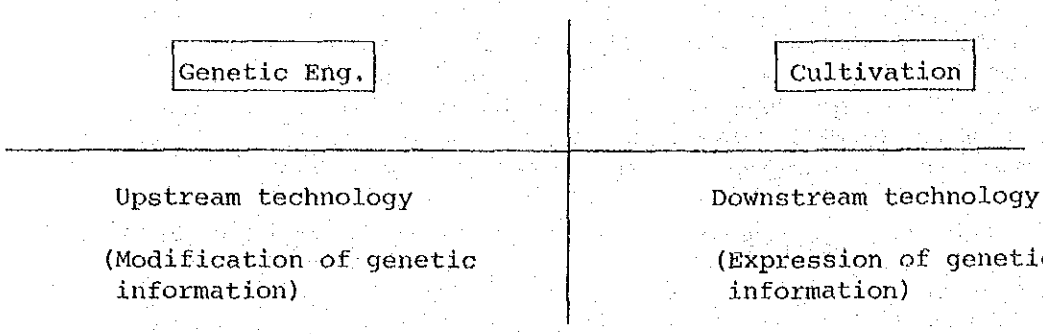
	Yield Increases (Bushels/Acre/Year)
Conventional Plant Breeding	1.0 (1981 to 2000)
Additional Nitrogen	0.4 (1981) to 0.1 (1994) No impact 1995 to 2000
Production Management Technologies	0.2 to 0.3 (1981 to 2000)
Emerging Biotechnologies	No impact through 1988 0.1 (1989) to 1.7 (2000)

Source: Pleum, Genetic Engineering of Plants, 1983

Plant breeding is a technology for the modification of genetic information, and the functions of a living organism, or the yield of a crop, for example, are essentially determined by its built-in genetic information. This means in the case of crop production that the nature of technologies used for the cultivation of a given crop is basically constrained by the crop's original genetic traits. A change in genetic information of the crop thus may change the nature of the technologies of cultivation and eventually the industries which supply technological inputs.

As shown in Figure II-1-5 below, technologies related to the modification of genetic information are upstream technology and technologies related to cultivation are downstream technology. It is obvious that the development of upstream technology is essential in developing total agricultural systems. Since upstream technology might influence not only the efficiency of cultivation itself, but also rule the total agricultural systems through changing the nature of downstream technology.

Figure II-1-5 Structure of Agricultural Technology



Source: BioTechno System Inc.

As already pointed out, the development of upstream technology with respect to major export grains in Argentina is heavily dependent on the activity of transnational plant breeders. The key problem in this situation is that the crucial part of the research and development activities is carried out abroad, and essentially exert limited effects on the domestic research potentials and on the domestic possibilities of industrializing research results.

It is true that the present technologies of cultivation in Argentina, especially for major grains grown in the Pampa region, use much less modern chemical inputs like fertilizers and pesticides compared with other major producing countries, or in other words, that the genetic potentials of the available seeds are yet not fully exploited. Therefore, it is true that the standard improvement of downstream technology will greatly contribute to the yield increase of the crops grown in Argentina, as long as the economic conditions of farming are favorable. In the era of modern biotechnology, however, it is expected that the upstream technology based on this new technology would rule the downstream technology more drastically than have been in the past. In this respect, Argentina will have to step up its efforts in developing domestic research potentials in upstream technology generation.

(2) Modern agricultural biotechnology development in Argentina

Agriculture can be said as the most classical biotechnology. Modern agricultural biotechnology, which consists essentially of genetic engineering and cell culture techniques, has attracted wide attention and deep concern, because it is believed to be able to provide unlimited possibilities of using living organisms to solve the problems like food and energy supply, environmental conservation which mankind faces today.

Many of the technologies being developed for human health care contain analogies for agriculture. The new processes for manufacturing new or less expensive drugs, vaccines and diagnostics will provide more efficient means with which to combat diseases and productivity losses which have always been the major concerns in agriculture. Furthermore, genetically engineered microorganisms might be used to produce feed additives, growth enhancers and other

compounds that will boost agricultural yields. But modern biotechnology has fundamentally different functions from agriculture. It can potentially be used to change the genetic constitution of microorganisms, plants and animals to make them more productive, more resistant to diseases and environmental stresses, or more nutritious. In this sense, biotechnology could have a dramatic effect on the problems of food production and hunger around the world.

Figure II-1-6 shows the basic structure of biotechnology and its possible applications to agriculture. It should be emphasized here that biotechnology has very broad impacts on agriculture, and that in order to realize these impacts, interactions between agricultural research and biosciences research are essential. It is clear from the figure that the promotion of research and development in biotechnology is a key issue in Argentina. The current state of research and development in modern biotechnology in Argentina is as follows.

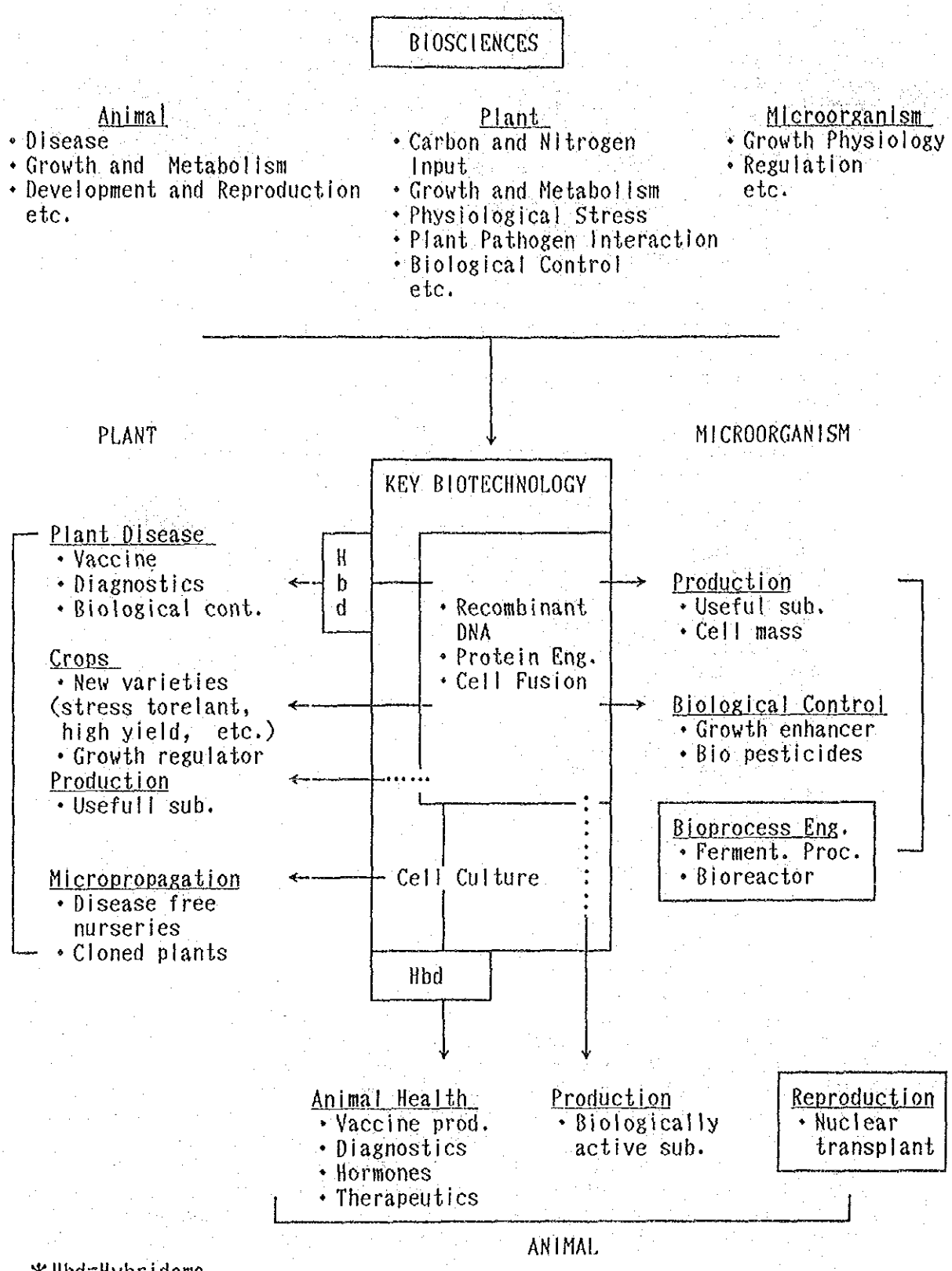
At present, both the public sector and the private sector are promoting biotechnology research. In the public sector, the INTA and the CONICET are two major institutions pursuing research in this new technology. The areas which the INTA is developing are as follows.

* Animal health
    - vaccine production
    - diagnostics
* Plant diseases
    - diagnostics
* Micropropagation
    - disease-free nursery
    - clone plant production
* Biological control
    - growth enhancer
* Bioprocess engineering
    - fermentation process development
* Production
    - cell mass production

On the whole, the areas of modern biotechnology that the INTA is currently pursuing are mostly based on the hybridoma technology and cell culture technology, and the key technology related to plant breeding is completely missing. As shown in Figure II-1-7 which indicates the areas of biotechnology Argentina is currently developing, it is clear, by comparison with Figure II-1-6, that the "core technology" of modern biotechnology should be emphasized more in Argentina. The INTA of course is arranging some research programs with cooperation from foreign countries like France and Sweden to promote genetic engineering. However, the present writer is not convinced by the size of the prospective programs that they are in the first priority among the on-going INTA programs.

National Council of Scientific and Technological Research (CONICET), because of its different orientation, has a slightly

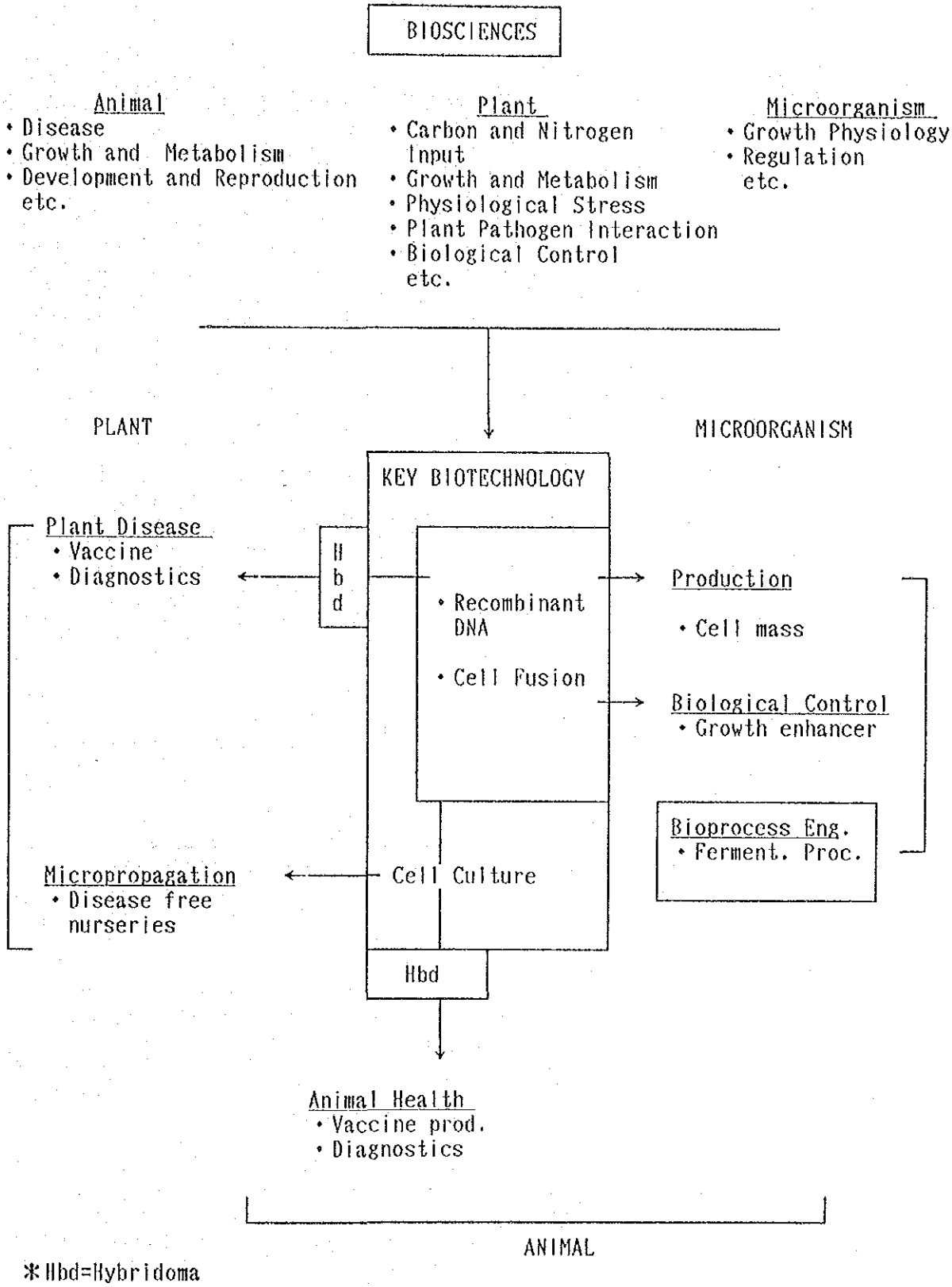
Figure II-1-6 Structure and Possible Application of Agricultural Biotechnology



※Hbd=Hybridoma

Source: BioTechno Systems, Inc.

Figure II-1-7 Areas of Biotechnology Currently Developed in Argentina



*Hbd=Hybridoma

Source: BioTechno Systems, Inc.

different biotechnology program from the INTA. The current program of the CONICET emphasizes the following six areas.

- Bioprocess development
- Nitrogen fixation symbiosis
- Plant physiology, molecular biology, biochemistry
- Plant cell culture
- Vaccine and biologically active substances production
- Diagnostics (DNA probe, monoclonal antibodies)

The CONICET is apparently interested in plant biotechnology like the INTA, but at the same time it emphasizes fundamental biosciences research for industrial development more than the INTA. The CONICET has under its administrative supervision more than 200 research institutes manned with more than 90% of the total scientists in the country (excluding those at the INTA). However, one problem is that the "National Biotechnology Program" of the CONICET is too narrow to be called a national program, if one judges by the areas of biosciences it covers in relation to Figure II-1-6.

During the present Study, it was found that there are at least 23 groups involved in nitrogen fixing symbiosis research. This figure seems to be an unusually high concentration of manpower in too small an area of research. This is not a desirable condition when a country wants to develop biosciences and biotechnology. It is understandable that nitrogen fixing symbiosis is one of the key issues for Argentine agriculture, but this subject is not the only problem to be solved.

In most of the advanced countries in biotechnology, the profile of areas under research is more or less well balanced. Table II-1-24 shows an example. There were 2,115 papers presented in 1985 at the annual meeting of the Agricultural Chemical Society of Japan, which is the major society of biotechnologists involving both academic and industrial communities. The research papers presented on the areas related to microbiology and enzymes were 437 and 244 respectively. Japan is one of the leading countries in the area of applied microbiology and enzyme technology, but the percentage of reports on these two areas are only 20.5% and 11.5% respectively compared with other areas like plant cell culture, animal cell culture, food technology, organic chemistry and natural product chemistry. This data does not necessarily reflect the real composition of on-going activities in biotechnology development in Japan, but is still a good indicator to illustrate what is going on. It is believed that such a relatively well balanced approach is one of the factors which has made Japan one of the leaders in applied microbiology and enzyme research and development.

Another important problem in biotechnology development in Argentina is that there seems to be no full-scale coordinating efforts between the INTA and the CONICET. Biotechnology is a technology based on the biosciences, and has a very broad spectrum of the areas of research. Even in most of the countries advanced in biotechnology, there are the problems of the limited availability of necessary financial and human resources, and setting research priorities is considered the most important issue. At the present moment, there

Table II-1-24 Percentage Distribution of Research Articles in Japanese Biotechnology

Area		No. of papers	Percentage of total[1)]
Microbiology			
- genetics, breeding, mutations		207	9.8
- metabolism, regulation		37	1.7
- fermentation (enzyme, cellmass)		34	1.6
- ecology, taxonarsy		48	2.3
- membrane permeation		3	0.1
- antibiotics (mech. of action)		8	0.4
- growth physiology		31	1.5
- production		64	3.0
- bioengineering		5	0.2
	subtotal	437	20.5
Enzymes			
- protein, amino acid related		53	2.5
- biosynthesis (sugar, lipid, nucleic acids)		62	2.9
- immobilized enzyme		32	1.5
- polysaccharide hydrolysis		67	3.2
- others		30	1.4
	subtotal	244	11.5

Source: Journal of Agricultural Chemical Society of Japan, Vol. 59, No. 5, 1985

Note : 1) Total No. of papers presented was 2,115.

seems to be no integrated research program at the INTA, while the present National Biotechnology Program of the CONICET is not necessarily able to cover the problems in agriculture that the country is now facing. It will be urgently necessary to establish a comprehensive and complementary program framework and coordinate the research and development activities of the key participating organizations in terms of priority projects and resource allocation.

Biotechnology development activities in the private sector are still very limited in Argentina. Four to five biotechnology companies have been established during the last two years in the country, and most of them are developing their business based on the currently available technologies in human and animal health, such as diagnostics and vaccines. These companies are also working closely with the academic community to develop new technologies. For example, Polychaco S.A.I.C. is funding some research projects of the CONICET groups in genetic engineering, virus and hormones. The total amount of the fund is said to be US$200,000 a year, and although not a big

amount compared with the standard in advanced countries, it is still effective in stimulating new activities in the country.

This type of approach is essential for the private industry to develop new business opportunities in the area of knowledge-intensive industry. Judging by the past experiences in the USA and Japan, the establishment of close working relationships between the academic community and the private industry is indispensable to develop new lines of business related to biotechnology. The problem is how the academic community in Argentina can play such a role to meet the growing needs of the private industry.

In brief, Argentina's on-going efforts in agricultural biotechnology have the following characteristics.

1) Argentina had excellent achievements in medical sciences in the past. The on-going activities related to biotechnology are under the influence of the past experiences and mostly concentrated in human health and animal health.

2) Because of this reason, research potentials of plant biotechnology in both the public and the private sector are relatively weak by comparison with those in human and animal health care.

3) There seems to be no clearly defined national research strategy and priorities for biotechnology development in the public sector research establishments. This can be seen by their small research funds and the lack of integrated, centralized research programs.

4) There are no biotechnology-based bioindustry establishments such as fermentation and antibiotics in Argentina, except for a few newly established small biotechnology companies. This situation will limit the research activities only to a small number of areas.

(3) Constraints of agricultural biotechnology development in Argentina

There are both technical and non-technical constraints for developing agricultural biotechnology in Argentina. However, it should be emphasized here that non-technical factors like systematic research policies, strategies and priorities usually govern the efficiency of technical development. Therefore, the discussion will mostly focus on non-technical constraints.

It is generally considered that there are five interrelated conditions for developing biotechnology: namely, 1) intellectual resources, 2) germplasm resources, 3) industrial support, 4) economic support and 5) national strategy. The discussion of constraints will be done in relation to each of these conditions.

(a) Intellectual resources

Scientists play no doubt an important role in technology development. Biotechnology is multidisciplinary, and thus needs a group of scientists trained in a broad spectrum of disciplines working together. The current weak activity in biotechnogy in Argentina is apparently due to the insufficiency of well-trained human resources. To solve this problem, it will be indispensable to create an optimal research environment and attract more scientists to the areas of biotechnology. The reason is simple. The amount of knowledge produced is generally proportional to the number of scientists working.

Based on the Japanese experiences, there are several possible approaches. Providing enough and flexible research funds is one. With respect to the INTA, the total fund available for its activities is said to be between US$50 million to US$60 million chiefly provided by the INTA tax on traditional exports. The amount is too small judging by the multiplicity of functions expected of the INTA. According to the CONICET, US$1 million is going to be spent to support its National Biotechnology Program. This amount of money is obviously too small for some 200 research institutes associated with the CONICET. Adequate research budget by all means is essential for technology development.

Providing efficient training programs is another important step. For example, cooperative academic/industry programs involving both training and research would provide young scientists better opportunities for communication and interaction. Opportunities of attending national and international scientific meetings are of critical importance for young scientists working in the various areas of biotechnology. Face-to-face communication is the most effective method for the exchange of information. Accordingly, meeting attendance should be given the highest priority in budget allocation.

Promotion of bioindustries could be another effective approach. Quite a few Japanese biotechnology-related companies have attracted young scientists successfully through their aggressive promotion of biotechnology research. Expansion of research activities will create new job opportunities and hence attract more young scientists.

Another approach has to do with efficient technology transfer. Experiences tell us that the period of time from basic discovery to its application has been growing shorter and shorter, and that it is obviously necessary to develop an efficient system to integrate the academic community and private industries. From the viewpoint of the bioindustries, the quickening pace of basic discovery and its industrialization has enhanced their desire to have closer association with the sources of new knowledge, especially in the biological sciences, and this has facilitated the development of both new knowledge and human resources. The linkage of industries with academic communities like universities are in fact very common in most of the advanced countries. The basic idea of close industry-university research partnership is not only for meeting

immediate market needs but also for broadening the basis of knowledge integration.

It is generally considered that technology development involves possibilities of misuse and abuse. This suggests the need of orienting the industries to the generation of new basic knowledge which will support, and expand, the pools of knowledge serving important needs, and also the need of forcing them to recognize that technologically created problems may require basic information for their solution. An adequate industry-academic integration system is one of the best approaches to answer economic and more broadly, social, requirements.

Argentina is currently working on establishing such a system. The critical issues are how to expand basic research activities in the public sector, on the one hand, and how to foster a close but flexible linkage between research communities and private industries, on the other.

(b) Genetic resources

Genetic resources are the key materials for plant breeding. For example, it is said that every Canadian wheat variety contains genes introduced over the decades from up to 14 different countries. The tomato canning industry would have disappeared long ago if there had not been the constant introduction of wild and primitive tomato varieties from Central America. These examples are enough to emphasize the prime importance of genetic resources, and the availability of genes is becoming more important in the era of modern biotechnology. Technology development without support of genetic resources is futile like a wax fruit. This is true not only in plant biotechnology but also in microbiology and even in animal research. The history of the antibiotics industry is the history of screening microorganisms which contain genetic traits for antibiotics production.

The prime concern in most of the advanced countries in the era of modern biotechnology is the availability of genetic resources, because the lack of access is a serious constraint. Argentina has a great advantage in its access to plant genetic resources. The country already has germplasm banks of significant size for maize, potatoes, etc. The constraint is the limited availability of budgets, and hence human resources also, judging by the slow pace of gene analysis on collected varieties. The struggle for the collection and conservation of plant genetic resources and for the political and commercial control of these resources is now taking place across the world. Argentina should understand the present situation, and focus its efforts on utilizing those valuable genetic resources for its own agriculture.

(c) Industrial support

As mentioned earlier, the intervals between basic discovery and its application have been steadily decreasing in the 1980s in biotechnology development, and indeed in all advanced technologies. One reason of such shortening chains of innovations is that the market

is demanding more for sciences in general and biology in particular to provide new products. Biotechnology, a technology based on biosciences, is expected to give the solutions to the market needs, and the bioindustries, which are based on biotechnology, are expected to play the key role in providing such products.

As seen in Japan and the USA, bioindustries like fermentation and antibiotics have played a crucial role in developing biotechnology. It should be noted that biotechnology is a science-based technology directed towards economic objectives. Whatever the type of new products, the general pattern of biotechnology development is cyclical, that is, the market demands for more research and the research gets more support. Bioindustries have served the central intermediating function between the market and the research, particularly at the initial phase of technology development in Japan and the USA. The development of an efficient "incubator" system of new knowledge and technology is urgently necessary to foster bioindustries in Argentina.

(d) Economic support

Economic support is essential for developing any type of technology, but it has a special meaning in biotechnology development. As mentioned earlier, biotechnology is a multidisciplinary technology by its nature. Accordingly, broad comprehensive studies are usually required to develop a new technology, and generally speaking, such comprehensive approaches cannot be done by a single laboratory or research institute. This implies that a broad and sufficient financial support is essential for developing biotechnology.

As indicated before, Argentina's biotechnology currently has a limited support in term of funds. Because Argentina has tremendous possibilities in biotechnology, more funds should be channelled to its development to achieve the national goals.

(e) National strategy

Because of the rapid progresses expected in genetic engineering over the next two decades, it is important for every country to appraise these progresses and their socio-economic implications. Biotechnology is believed to give an infinite possibility of utilizing organisms for productive purposes including agriculture. However, it does not necessarily mean that each country should develop the same set of biotechnology. Table II-1-25, for example, shows the number of companies committed to the new drug development through modern biotechnology. It is clear that the competition is stiff.

There is another example to show the importance of a strategic approach of setting priorities. Most of the developing countries show strong interest in developing industrial enzyme production processes. The current global enzyme market is estimated to be about US$450 million, of which detergent protease has a share of 25%, and amylase and renin 18% and 13% respectively. The problem is obvious if one realizes that the two leading European companies have the combined share of 60% in the world industrial enzyme market. In other words, the industrial concentration is already high and there

Table II-1-25 Competition in Biotechnology-Related Drug Development

Product Target	Number of Companies
Alpha-interferon	34
Interleukin-2	29
Beta interferon	22
Gamma-interferon	21
Unokinase	17
Hepatitis B vaccines	13
Tissue plasminogen activator	12
Human growth hormone	9
Tumor necrosis factor	9
Factor VIII	8

Source: SRI-International

is a definite barrier for new entry. It is said that Novo, one of the leading companies, has 600 research and development staff among the total employees of 3,000. Because of the highly knowledge-intensive nature of the industry, it is said that 15 years are required to acquire necessary skills and experiences.

These examples show the importance of a strategic approach for establishing national research goals. As long as Argentina is interested in establishing its national strategy for biotechnology research, it is necessary to identify and select specific program objectives for both short- and long-term research in accordance with a central national strategy.