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Consultative Group on International Agricultural Research

Study Paper Number 20

Chile and the CGIAR Centers

A Study of Their Collaboration in Agricultural Research

Eduardo Venezian

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Chile and the CGIAR Centers

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CGIAR

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At its annual meeting in November 1983 the Consultative Group on International Agricultural Research (CGIAR) commissioned a wide-ranging impact study of the results of the activities of the international agricultural research organizations under its sponsorship. An Advisory Committee was appointed to oversee the study and to present the principal findings at the annual meeetings of the CGIAR in October 1985. The impact study director was given responsibility for preparing the main report and commissioning a series of papers on particular research issues and on the work of the centers in selected countries. This paper is one of that series.

The judgments expressed herein are those of the author(s). They do not necessarily reflect the views of the World Bank, of affiliated organizations, including the CGIAR Secretariat, of the international agricultural research centers supported by the CGIAR, of the donors to the CGIAR, or of any individual acting on their behalf. Staff of many national and international organizations provided valued information, but neither they nor their institutions are responsible for the views expressed in this paper. Neither are the views necessarily consistent with those expressed in the main and summary reports, and they should not be attributed to the Advisory Committee or the study director.

This paper has been prepared and published informally in order to share the information with the least possible delay.

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SUMMARY

Modern agricultural research is a relatively recent activity in Chile. It emerged in the 1950s, expanded vigorously in the 1960s and 1970s, and has tapered off in the past 6 or 7 years. Its origin and evolution are closely associated with North American aid programs, particularly those of the Rockefeller Foundation. In 1964, the Agricultural Research Institute (INIA) was created as a result of one of these programs. INIA forms the centerpiece of the National Agricultural Research System (NARS) and is a well-organized institution with national coverage. Currently, research in Chile is carried out by three groups: government agencies, faculties or schools of agriculture at universities and private research centers.

INIA's objectives, since its founding, have been to generate or adapt production technology suited to the country's conditions, to test and validate these technologies at the farmer's level, to diffuse the recommended technologies and to train technicians and producers to use them through practical demonstrations. INIA is organized by crop, livestock and disciplinary programs such as wheat, fruit culture and soils which are under the direction of "national leader" researchers and which are executed in the various regional experiment stations. The Institute has a central administrative office in Santiago and carries out its research through five regional experiment stations.

The basic criteria that guide INIA's program formulation are the economic importance of given agricultural problems and the capacity of the institution to carry out the corresponding research with a reasonable probability of success. These criteria are bounded by the relevant economic policies of the government, and the Institute's research program has been remarkably stable through time, despite the radical shifts in national economic and agricultural policies that occurred between 1960 and 1984. From the outset, however, priority has been given to basic food crops and particularly wheat, which is by far the main food staple in Chile. Pastures and livestock production have also been a priority concern, although to a much lesser extent than would be expected given the share of GNP contributed by this sub-sector. In terms of program expansion over time, the most significant growth has been in horticulture and fruit culture research, items that received virtually no attention at INIA in the mid-1960s, and in dry legumes.

The International Agricultural Research Centers (IARCs) have collaborated extensively with the Chilean NARS, mainly with INIA, in a variety of ways. The longest and strongest collaboration has been established by CIMMYT, CIAT and CIP. IRRI has assisted mostly through CIAT, and since the late 1970s some collaboration has occurred through both ICARDA and ICRISAT. IBPGR has had some contact, primarily through the other IARCs, and there has been minor contact with ISNAR and IFPRI. Collaboration has centered mainly on wheat, beans and potatoes and other crops including maize, triticale, barley, rice, lentils

and chickpeas. Some assistance also has been provided in production systems research, collection of plant materials, seed production, technology transfer and research on supporting disciplines. The most important forms of collaboration from the standpoint of the NARS have been provision of biological materials, training of staff through a variety of schemes, facilitation of staff exchanges and international contacts and assistance in research techniques. The Chilean NARS has also contributed to the centers, mainly by conducting international trials, collecting or providing local biological materials and, occasionally, participating in center program reviews.

The cumulus of evidence suggests that the IARCs have had a definite positive impact--even though this impact is not strongly reflected in national average statistics because the food crops of primary concern to the IARCs have not generally been favored by government policy. The principal source of innovations in Chilean agriculture has been the importation of technology, much of it through the IARCs. This is most evident in fruit, vegetable and poultry production and in technologies embodied in inputs such as machines, pesticides and irrigation equipment. It is felt that effective adoption of foreign technologies has been made possible by the knowledge accumulated through local research on soils, insects, diseases and fertilizer response and the ability of the NARS to help adapt the foreign technology to national conditions.

ACKNOWLEDGMENTS

This study was made possible through the collaboration of many persons who generously gave time and shared information about agricultural research in Chile. The list is too long to name them individually.

Special recognition is owed Dr. Sergio Bonilla, whose remarkable knowledge of INIA's trajectory in research and institutional development was especially helpful. He provided valuable overall orientation, facilitated access to INIA researchers, and arranged visits to the INIA regional stations.

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ABBREVIATIONS AND ACRONYMS

CONAF	National Forestry Corporation
CONICYT	National Council for Science and Technology
CORA	Land Reform Corporation
CORFO	National Development Corporation
DEA/UC	Department of Agricultural Economics, UC
ENDS	National Seed Company
FIA	Foundation for Agricultural Research, Ministry of Agriculture
IA	Ingeniero Agrónomo
IANSA	National Sugar Industrial Company
IARC	International Agricultural Research Center
ICIRA	Land Reform Training and Information Institute
INDAP	Agricultural and Livestock Development Institute
INE	National Statistical Institute
INIA	National Agricultural Research Institute
NARS	National Agricultural Research System
ODEPA	Planning Office of the Ministry of Agriculture
ODEPLAN	Planning Ministry
SAG	Agricultural and Livestock Service, Ministry of Agriculture
SB	Baer Seed Company, Ltd.
SERPLAC	Regional Offices of the Planning Ministry
SNA	National Farmer's Association
UA	Austral University
UC	Catholic University of Chile
UCC	University of Concepción
UCH	University of Chile

I. BACKGROUND

1.1. The Country[1]

1.1.1. Natural and Political Setting

Chile's territory[2] occupies an area of 756,629 square kilometers, stretching from 17.5 to 56.0 degrees south latitude, or about 4,300 kilometers in length. The country is bounded on the east by the Andes Mountains, with altitudes of over 3,000 meters and on the west by the Pacific Ocean. The average width of the country is 160 kilometers. A lower chain of mountains along the coast runs the entire length of central Chile. In between the Andes and the coastal mountains there is a long valley that is the heart of Chile's agriculture (See Figure 1.1).

Chile is divided into thirteen administrative regions. The first three regions are desertic and contain rich mineral deposits, especially copper and nitrate; agriculture is minimal occupying 0.5% of the nation's arable land, and confined mostly to tiny valleys. This desert area contains 35% of the land and 6.8% of Chile's population. The two southernmost regions, of rainy and cold climate, encompass 30% of the land area and 1.6% of the population. This part of the country is almost completely forest land, except for the flat ranges near the Magellan Strait that are devoted to sheep and cattle raising.

The remaining one third of the country contains 91.6% of the population and the majority of domestic economic

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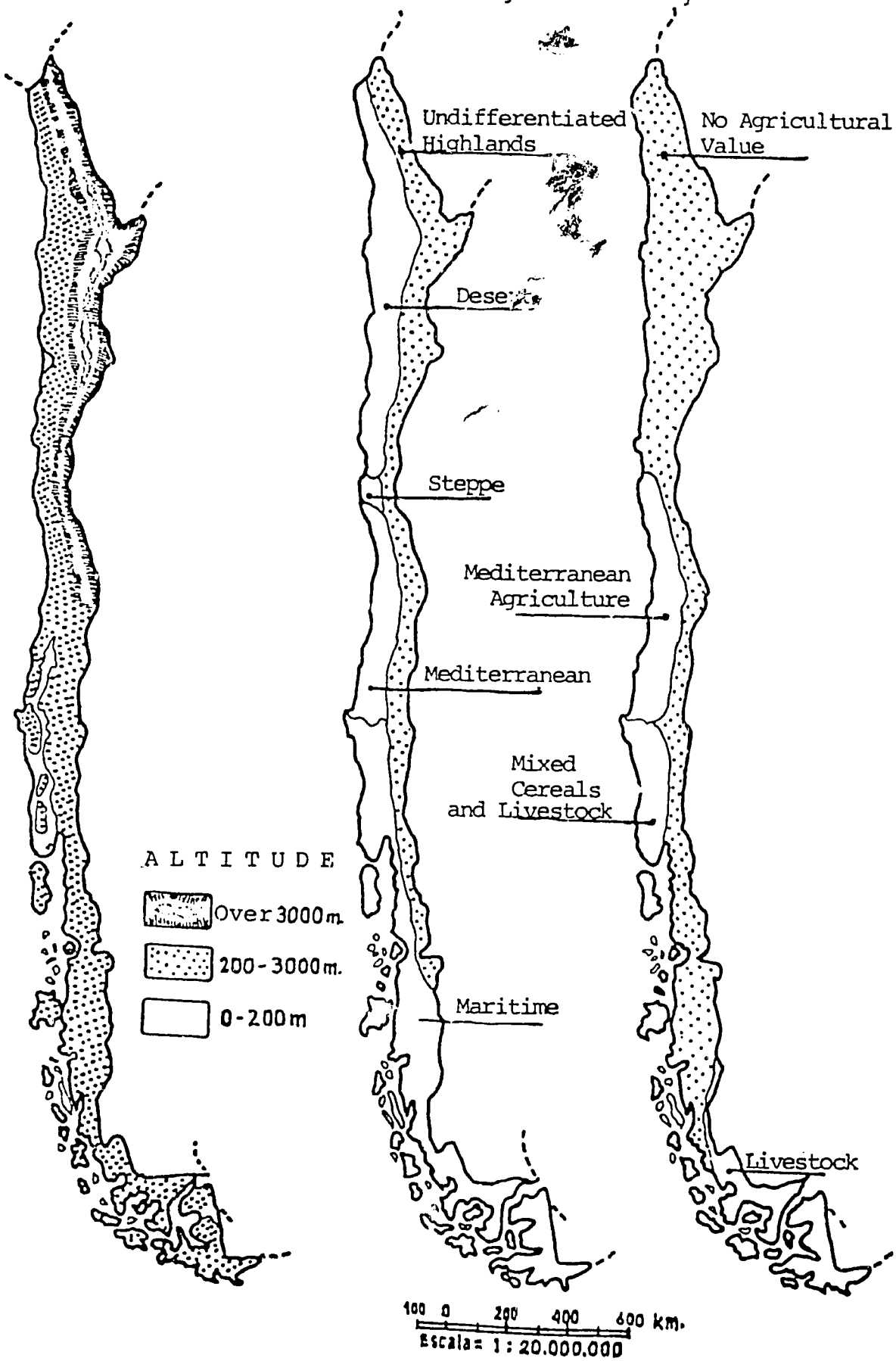
[1]This section is based on a variety of sources, the principal of which are quoted in the appendix tables to this chapter.

[2]In addition, Chile claims 1.25 million square kilometers in a sector of Antartica.

FIGURE 1.1. Chile: Relief, Climate and Agricultural Regions



Source: CIDA, 1966.

TABLE 1.1. Chile: Labor Force, by Sector or Activity, Selected Years

(thousand persons)

SECTOR	1966		1970		1982	
	N°	%	N°	%	N°	%
Agriculture	478.6	15.9	472.8	16.2	506.4	14.4
Mining	61.9	2.0	55.1	1.9	62.7	1.8
Manufacturing	731.4	24.3	709.8	24.4	483.6	13.8
Construction	218.3	7.3	220.8	7.6	160.9	4,6
Commerce	419.2	14.0	420.6	14.4	566.7	16.2
Transport	227.7	7.6	214.1	7.4	211.0	6.0

Source: Banco Central, 1983.

1.1.3. The Economy

Table 1.2 shows Chile's national product at constant prices for the period 1960-83. The average annual rate of growth over the entire period was a modest 2.7%, with violent fluctuations between some of the years. GNP per capita expanded at less than 1% per year; it is presently estimated at approximately US$ 1,200. Clearly, the evolution of Chile's economy was shaken by the policies implemented by the Marxian socialist administration of 1970-73, and the subsequent liberal economic policies of the present military administration.

The relative sector contribution to GNP is shown in Table A-1.1. This has remained fairly stable over time; the principal changes which have occurred are a contraction of the manufacturing sector since 1973, as a consequence of the reduction in tariff protection, and an expansion of the service activities. Agriculture has maintained its approximate 8% share of GNP for almost two decades, with minor fluctuations.

Prior to 1974, the level of open unemployment in Chile fluctuated under 6%; a relatively large traditional agriculture, import substitution policies, and artificial absorption of labor in the public sector explain this low rate of unemployment. After 1974, the shift towards a free market economy, open to foreign trade, and with the government retreating from active intervention in productive activities, has resulted in unemployment rates above 13%, reaching as high as 25% depending on the measurement criteria used. During this same period, agricultural unemployment has been lower, between 5 and 7% annually. (See Table A-1.2). Real wages that had increased steadily up to the early 1970s suffered a severe fall during the 1972-75 period of economic and political turmoil to recover strongly in subsequent years.

TABLE 1.2. Chile: GNP, Agricultural Product and Growth Rates, 1960-83
(pesos of 1984)

Years	Agric. GNP a/ (Mill $)	Total GNP (Mill $)	Ag GNP / Tot GNP (%)	Annual Rates of Change (%) Agriculture a/	Annual Rates of Change (%) Total
1960	94,966	926,486	10.25	-	-
1961	93,480	970,795	9.63	-1.6	4.8
1962	88,405	1,016,797	8.69	-5.4	4.7
1963	93,555	1,081,121	8.65	5.8	6.3
1964	93,688	1,105,177	8.48	0.1	2.2
1965	95,580	1,144,110	8.35	2.0	0.8
1966	115,583	1,238,347	9.33	21.2	11.2
1967	119,294	1,278,550	9.33	3.0	3.2
1968	124,900	1,324,325	9.43	4.7	3.6
1969	110,490	1,373,601	8.04	-11.5	3.7
1970	114,451	1,401,846	8.16	3.6	2.1
1971	112,372	1,527,384	7.35	-1.8	9.0
1972	104,072	1,508,855	6.90	-7.4	-1.2
1973	93,372	1,424,887	6.55	-10.3	-5.6
1974	118,314	1,438,772	8.22	26.7	1.0
1975	124,043	1,253,024	9.90	4.8	-12.9
1976	120,399	1,297,105	9.28	-2.9	3.5
1977	132,892	1,424,986	9.33	10.4	9.9
1978	126,415	1,542,081	8.20	-4.9	8.2
1979	133,531	1,669,789	8.00	5.6	8.3
1980	138,290	1,799,720	7.68	3.6	7.8
1981b/	144,291	1,902,648	7.58	4.3	5.7
1982b/	139,597	1,629,917	8.56	-3.3	-14.3
1983b/	137,572	1,616,280	8.51	-1.5	-0.8

a/ Includes agricultural and forestry sectors.

b/ Provisional figures.

Source: -Banco Central de Chile [1983] "Indicadores Económicos y Sociales: 1960-1980"
-Banco Central de Chile [1984] "Boletín Mensual N°671", Junio.

Chile's economy is heavily dependent on the export of minerals, mainly copper. (See Table A-1.3). Agricultural exports have expanded very rapidly since 1973, as a result of the open market policies of the present administration. The principal farm commodities exported are fruits (especially apples and table grapes), dry legumes, and wool and mutton. The main imports are petroleum, capital equipment and consumer goods; among food imports, wheat and powder milk are the most significant ones. As can be seen from the data in Table A-1.3, there has been a drastic transformation in Chile's international transactions over the last decade; imports increased nearly five-fold, being largely financed through external borrowing. The world recession setting in about 1982 has caused a severe impact on the country's economy, forcing a partial retreat from the extreme open-market policy implemented in the 1977-82 period.

Historically, the government has played a strong active role in the economy, which is reflected in the high level of public expenditure (current and capital). This has usually been above 30% of GDP; it surpassed 40% in 1970, and fell below 30% in 1979/80, during the height of the recent boom. The distribution of public expenditure according to sectors, or functions, is shown in Table A-1.4. The change in economic policy since 1973 can be appreciated by observing the reduction of goverment participation in "productive" sectors such as transport and communications, housing and agriculture. The increase in social security is due to the various unemployment compensation mechanisms put into effect.

A major historical problem of the Chilean economy has been inflation (See Table A-1.5), which reached hyper-levels in 1972-76. The stabilization policies of the present administration succeeded in bringing down the rate of inflation since that time and holding it around 20% up to the present.

The stern fiscal and monetary measures adopted, however, have apparently aggravated the cyclical fluctuations of the economy, as shown by the periodic severe falls in GNP.

1.2. The Agricultural Sector

1.2.1. Resources and Organization

A small proportion of Chile's land area is usable for agriculture. Of the total 75.7 million hectares of national area, only 5.1 million are tillable land (6.7%); 8.5 million are rangelands (11.2%); and 11.5 million are forest lands (15.2%). Of the tillable land, 1.2 million hectares are under irrigation and constitute the richest resource of the agricultural sector. The average per capita availability of crop and pasture lands is 1.2 hectares, one of the lowest ratios in Latin America.

Slightly over half of the tillable land is actually cropped or planted, as shown in Table 1.3, the remainder being in natural pastures. Further details on the use of land over the period 1960-84 are given in appendix Tables A-1.6. and A-1.7.

Agriculture employs over 600,000 people, or 18% of the nation's labor force. This share decreased steadily until 1973, despite the land reform program that should have stemmed out-migration from the rural sector (See Table A-1.8). Agricultural employment has expanded again over the last ten years, in response to the distribution of land parcels and normalization of tenure conditions, the increase in fruit culture, and probably as a consequence of the high urban unemployment. Low real wages in agriculture also have stimulated the use of more labor-intensive technologies in this sector (See Table A-1.2).

TABLE 1.3. Chile: Agricultural Land Use, 1979-80

Activity	Area (thous.Has)	Percent Distribution
Crops	1,227.7	42.8
Vegetables	86.7	3.0
Fruit trees	123.9	4.2
Vineyards	126.1	4.4
Pastures a/	1,306.0	45.6
Total cropland	2,865.3	100.0

Source: INE.

Note: The difference in area under crops shown in Table A- 1.6 is due to the source of data.

a/ Includes only seeded and improved pastures, and forage crops.

Practically 70 percent of the agricultural labor force is employed in cropping activities (crops, vegetables, fruits, vineyards), while the remainding 30 percent works in related activities (Hurtado, 1984).

It is estimated that towards the end of the 1970s the agricultural population included 385,000 families, of which 33,200 corresponded to "traditional" entrepreneurs, 42,000 were land-reform beneficiaries, 106,100 were small commercial farmers, 104,200 were marginal minifundia owners, and 100,000 were wage-worker families (Ministerio de Agricultura, 1981).

As indicated earlier, open unemployment in agriculture is low; however, disguised unemployment is pervasive so that the effective rate of unemployment was estimated at about 17% for 1980 (Hurtado, 1984).

Capital investment in agriculture is shown in Table 1.4 for two sub-periods between 1965 and 1979. Total public and private investment has represented a steady 10% of agricultural GNP, although its structure has changed significantly over time. Public sector participation has decreased from 80 to 62% of total investment, reflecting the move towards a "subsidiary" role for the state under the present administration's policy. On the other hand, the increase in private investment has concentrated heavily on fruit culture and livestock. Overall investment in mechanization has been slight, considering that a portion of public investment for land reform and "other" prior to 1974 included mechanization. This development is consistent with the shift in relative prices of labor and capital under the prevailing free market conditions (See below).

The land tenure structure was significantly transformed by the land reform in effect from 1967 to 1979. The sluggish growth of agriculture since the 1930s was

TABLE 1.4. Chile: Annual Public and Private Investment in Agriculture, Selected Periods

(thousand US$ of 1978)

Source and Purpose	Average 1965 - 69	Average 1974 - 79
Public Sector	71,360	59,530
Land reform, development and forestry	41,100	38,760
Rural Public works	12,480	18,130
Other	17,780	2,640
Private Sector 1/	17,008	36,343
Machinery and equipment	7,323	2,908
Fruit plantation	3,320	17,035
Vineyards	2,675	- 5,028
Livestock	3,691	27,244

Source : DEA 1982, Panorama Económico de la Agricultura, N°22.

1/ Shows gross investment less Depreciation of the Stock of capital.

attributed by many scholars and politicians to the unequal distribution of land and the predominance of inefficient, traditional latifundia (CIDA, 1966). As this view gained support, including from outside as expressed in the Alliance for Progress' Punta del Este Charter, a first mild land reform law was issued in 1962. The drastic redistribution of land however only occurred after passage of a new law in 1967. Massive expropriation and confiscation of land took effect especially over 1970-73; in the subsequent six years, the land reform process consisted of assigning the expropiated land in family parcels to former peasants, and reestablishing orderly property rights in the rest of the sector (See next section).

The change produced in the tenure pattern can be appeciated from the data in Table 1.5. A much more even distribution of land, especially irrigated land, exists at present, indicating a smaller average size of farm, with a predominance of farms under 50 hectares of tillable land. This drastic transformation in the organization of farming has been indeed the single most important factor affecting Chilean agriculture in the present century.

Chile has a fair physical and institutional infrastructure for agriculture, especially in the central irrigated areas. Transport and communication facilities, storage, agro-industry, service towns, rural schooling and health care, etc. have improved steadily over the last decades and are reasonably adequate to support a modern agriculture. Research and extension services are substantial, as is described in detail in Chapter II. Product and input marketing were considerably controlled and/or directly operated by the government prior to 1974, especially during the land reform period. These activities have been fully returned to the private sector in the last ten years.

TABLE 1.5. Chile: Distribution of Farm Numbers and Agricultural Land, Pre- and Post-Land Reform

Size of Farm (has)	1964-65			1979		
	Cumulative percentage of farms	Cumulative percentage of land a/		Cumulative percentage of farms	Cumulative percentage of land a/	
		Agricultural	Irrigated		Agricultural	Irrigated
L 5 (Minifundia)	48.8	1.3	8.1	40.8	1.5	5.7
5 to 10	61.9	2.6	11.9	55.2	3.8	14.1
10 to 20	73.7	4.8	16.0	69.9	8.0	31.3
20 to 50	85.3	9.3	22.0	84.1	16.3	53.7
50 to 100	91.1	13.9	28.6	91.0	24.3	67.0
100 to 500	97.5	28.9	59.0	97.7	44.9	88.3
500 to 1.000	98.7	37.4	72.9	98.8	52.7	92.7
over 1.000	100.0	100.0	100.0	100.0	100.0	100.0

Source : Muchnik, 1983.

a/ Agricultural land includes crop, pasture and forest lands.

1.2.2. Agricultural Policies, 1960-84

Policies for agriculture must be analyzed in the context of general economic policy for the country. In this sense, two fundamentally different periods have to be distinguished in Chile: prior to 1974, and from 1974 to the present.

For several decades and up to 1973, Chilean economic policy was characterized by pervasive government intervention, that determined (World Bank, 1980):

- Overvalued currency, maintained through high tariffs and controls, and multiple exchange rates.
- Negative real interest rates.
- Extensive price controls, especially of basic consumer goods.
- Legal minimum wages and compulsory increases to counteract the effect of inflation and to alter income distribution.
- Growing and extensive social security benefits.
- Systematic high public sector deficits.
- Widespread discriminatory measures in regard to taxation, custom regulations, price controls, etc. aimed at achieving specific economic objectives.

Within agriculture, these policies were complemented by setting up specific government programs, or institutions for farm credit allocation (BECH, INDAP, CORFO), for importation, storage, and marketing of food commodities (ECA), for land redistribution (CORA), for input production and distribution (ENDS for seeds, SAM for mechanization, SOQUIMICH for fertilizers, etc), for research and extension (INIA, SAG,

INDAP), for irrigation development (Comision Nacional de Riego), and so on. Price fixing for farm products and inputs was extensive, reaching over 70 commodities during the socialist administration of 1970-73. On the other hand, taxes on land and farm income were always quite low.

The general effect of these multiple control and subsidization policies on agriculture was to induce developments and resource allocation that departed from the natural comparative advantage conditions of the country (and regions within it), or from what a free pricing system would have determined. The distortions and inefficiencies provoked by this kind of economic policy were considered by many analysts as the main causes of the slow growth of agriculture, rather than the land tenure structure and big landowner irrationality hypothesis held responsible by other analysts (Valdés, 1971).

Government intervention in agriculture through all the above mentioned measures reached its height during the intensive land reform period of 1967-73. Over those years, 5,800 large farms were expropriated, with a total area of nearly ten million hectares; this area encompassed 48% of all cropland, and 60% of the irrigated lands of the country. The disruption caused by this process, notwithstanding the high public expenditure and bureaucratic management for agriculture, caused the severe temporary setback in production noted earlier.

The policies implemented since 1974 and up to 1983 are a clear departure from the whole economic strategy of the previous decades. In essence, the new economic approach consists in (a) letting the private sector be responsible for all productive activities, for which purpose the state guarantees the respect of private property; (b) relying on the free market price system as the primary mechanism for resource

allocation and distribution of goods; (c) opening the economy to the international markets, eliminating all trade barriers; and (d) restricting the role of government to a "subsidiary" function, i.e. intervention only in those activities that the private sector cannot effectively carry out. In particular, the government should not introduce any discriminatory controls or regulations, which means that economic policies apply to all sectors of the economy without distinction, or distorsions.

Given this general uniform policy, it is clear that the present administration has not had agricultural policies as such. The principal economic measures impacting on agriculture are:

- Free domestic prices, closely linked to international prices, have substantially changed the relative profitability of crops, and the nature of regional and national comparative advantage in agricultural production. The drastic change in real relative prices for the basic food crops and major farm inputs, before and after 1973, can be observed in Tables A-1.9 to A-1.12.

- Opening of the economy, by means of a uniform reduction in tariffs to a nominal 10% (ad valorem) by 1980, has changed the effective protection of agriculture from a negative rate of over 20%, to a slightly positive rate (See appendix Tables A-1.13 and A-1.14). This has made conditions more nearly uniform between different sectors of the economy; only export activities are modestly discriminated against, which affects some agricultural products, principally fruits. The exchange rate is set to reflect the real value of the dollar, and is uniform for the whole economy.

- The elimination of preferential interest rates on agricultural credit (and credit generally) has determined a change from a negative to a positive and high cost of credit

labor regulations that made labor dearer have also been eliminated, so that the effective cost of agricultural labor is now reflected in its market price.

Agricultural research and extension policy attempted to transfer to the private sector part of the execution and financing of these activities, but little progress was actually made on this. This is further discussed in another section of this report.

The above set of economic policies has undergone a number of changes since 1982-83, as the country suffered severly from the world recession and past errors in the implementation of certain policies. In particular, fixing of the exchange rate during 1979-82 resulted in a severe overvaluation of the Chilean peso, thus encouraging imports, discouraging domestic production of tradeable goods (most agricultural commodities, particularly wheat) and penalizing exports. Lack of control over the financial system resulted in an extraordinary level of private foreign indebtedness, widespread domestic bankruptcies, and growing unemployment, all of which has forced a partial closing of the economy and increased government intervention throughout.

With respect to agriculture, however, the principal effect has been favorable, as the need to generate (or save) foreign exchange has prompted some additional measures (e.g. establishing price support schemes for wheat and other basic crops, re-activating the sugar beet industry, cheaper agricultural credit, more readiness to apply anti-dumping tariffs, etc.) that are encouraging the expansion of traditional crops and of farm production generally.

1.2.3. Performance of the Agricultural Sector

Agricultural production increased at 2.2% per year on average over 1960-83, but showed marked differences in three

periods before, during and after the land reform. In fact, between 1960-67, the growth rate was 3.6% per year; between 1968-73 it was -2.7%; and from 1974-83 it was 4.3% per year (See Table 1.2). The fall in production during the land reform period must be attributed to the uncertainty and institutional instability the reform generated, rather than to the effect of objective economic parameters. On the other hand, the rapid rate of growth since 1974 is a result in part of the low base from which the measurement is taken, and also of the incentives the new open market policy has created for agriculture, especially its export oriented fruit sector, and the protected livestock sector.

The crops subsector includes basically fifteen so-called "traditional" crops (See Table 1.3), among which are the cereals, legumes and potatoes of concern to the IARCs. This subsector has reduced its participation in the agricultural GNP in the last ten years; for several of these crops, notably wheat, the total volume and value of production has actually decreased due to area and/or price effects (See appendix Tables A-1.17 to A-1.20). The only crop that has expanded significantly is maize, a performance that is explained by the highly efficient technology for this crop under irrigation, and by the extraordinary expansion of the poultry industry, principal consumer of maize.

The fruits and vegetables subsectors have increased their participation in the agricultural GNP; these have been the main beneficiaries of the open market policy, which has succeeded in reassigning land and other resources towards these species.

Within the livestock subsector, beef and dairy cattle have expanded significantly, while sheep and hogs have remained stationary (See Table A-1.21). Cattle production has

been stimulated by the non-tariff barrier to beef imports represented by declaring Chile free from foot and mouth disease; and dairy production has been protected by special tariffs to compensate for the subsidies imposed by exporting countries.

In sum, the composition of agricultural production has been changing in the last decade, in response to the change in relative prices provoked by the new economic policy. This change is expected to become more pronounced in the years ahead, given the long maturity period of fruit and livestock investments, which should also be reflected in a growing sectoral GNP (Hurtado, 1984).

The agricultural sector has responded strongly to the incentives generated by the post-1973 open market policies. While up to that year the value of farm exports had been practically stagnant, decreasing from 5% of total national exports to less than 2%, there has been more than a ten-fold increase in the subsequent ten years. Thus, the agricultural sector has increased its share of total exports to about 8% (See Table A-1.22). Over 90% of the value of agricultural exports corresponds to fruits, mainly apples and table grapes, with the rest contributed by the legumes (beans and lentils), and some livestock products.

The evolution of foreign trade in the basic foodcrops of IARC interest is shown in Tables A-1.23 and A-1.24. Chile is a heavy importer of wheat and maize (about 50% of the annual domestic consumption of each in the last ten years) and of rice; this last crop, however, is now close to self-sufficiency and there are actually significant exports in some years. Wheat imports have grown markedly since the early 1970s, reflecting mainly the fall in domestic production induced by the adverse price relationships prevailing since that time. On the other

hand, Chile exports important quantities of beans, although the extreme variation in international prices of this crop hinders the consistent development of bean production. A similar situation occurs with lentils.

The slow growth in agricultural production since 1960, especially of the "traditional" crops, reflects a rather stagnating technological situation. This can be appreciated from the yield data shown in Table 1.6 (See also Table A-1.12). Except for maize, yields have improved but slightly for most other crops. Technological change in Chilean agriculture will be discussed in greater detail in Chapter IV; however, it should be noted here that an important factor in this relative stagnation is the slowly expanding use of fertilizer (Table A-1.25). In fact, the fairly high levels of use of N, P and K reached around 1972-73, fell during the following decade. If allowance is made for the obvious increase in the share of fertilizers used on fruit trees, it is not surprising that yields of traditional crops have not improved much. Data on pesticide use is skimpy, but a similar situation is found in regard to these inputs (Hurtado, 1984).

With respect to average factor productivity, the following has been found (Muchnik, 1983):

a) Labor productivity has grown systematically over the last two decades as employment of labor decreased and agricultural GNP expanded.

b) The trend of average productivity of capital invested in machinery changed from 1960-73 to 1974-79. In the first sub-period, productivity decreased while the machine/labor ratio increased; in the second sub-period, the productivity of machinery increased, while the stock of capital in machinery decreased.

TABLE 1.6. Chile: Average Yields of "Traditional" Crops, Selected Years

(100 kg. / hectare)

Crop	1959 / 60	1969 /70	1979/ 80	1981/ 82
Wheat	12.5	17.7	17.7	17.4
Oats	10.3	15.2	18.7	17.2
Barley	17.9	20.6	21.6	20.5
Rye	7.7	12.9	12.6	11.0
Beans	9.1	11.5	7.6	13.4
Lentils	5.5	6.5	5.1	4.1
Chickpeas	3.8	4.8	5.6	4.0
Peas	5.0	6.9	7.5	6.1
Potatoes	78.1	95.4	101.8	108.7
Maize	19.5	32.4	34.9	45.2
Rice	27.6	30.2	23.4	35.5
Rapeseed	8.9	13.0	14.6	12.8
Sunflower	11.6	13.9	11.8	15.8
Sugar beet	293.0	396.9	405.6	438.7
Tobacco	21.9 a/	21.3	25.2 b/	...

Source : I N E.

a/ Year 1965.

b/ Year 1979.

c) Average productivity of nitrogenous and phosphorous fertilizers decreased up to 1973, while the ratio of fertilizers/land increased. Violent fluctuations in this ratio in the 1973-79 sub-period do not permit detection of a clear trend.

An analysis of the relationship between the ratio of machine/labor use and their price ratio did not yield the expected effect of prices on relative input use. Muchnik concluded, however, that non-price factors such as various legal measures pertaining to labor increased the implicit cost of this input, discouraging its use. Similarly, other subsidies and regulations pertaining to agricultural credit induced a more intensive use of machinery, fertilizers and other capital inputs. In sum, the "real" price ratio of capital/labor inputs made possible a substitution of capital inputs for labor up until 1973, because of the government policies implemented over that period of time. The elimination of subsidies, price controls, labor regulations and freeing of interest rates after 1974 eliminated the distortions in capital and labor costs, which would explain the falling trend in the machinery/labor ratio since that year (Muchnik, pp 22-24).

II. THE NATIONAL AGRICULTURAL RESEARCH SYSTEM

2.1. Overview

2.1.1. Definitions and Scope

The term "agricultural research" is often broadly used to include research on crops, livestock, forestry and inland fisheries, as well as on soils, water, pests and diseases, economics, etc. as they relate to agriculture. Several other distinctions can be made as to whether research is basic, applied, technological, strategic, etc.

For the purposes of this study, and given the form and availability of data in Chile, and other constraints, the following conventions will be followed:

- Agricultural research includes all crops (annual and perennial) and livestock and related applied disciplines. It excludes forestry and fisheries. Forestry in general is a large-scale, specialized economic activity in Chile which cannot be taken as part of normal farming. Fisheries concern exclusively ocean exploitation; there are no "farm fisheries" in Chile. Therefore, the specialized schools/faculties and institutes for these activities will be ignored, except for casual references.

- Basic research conducted in universities that may pertain to agriculture (zoology, chemistry, botany, entomology, genetics, etc.) will not be considered, except as it is conducted in an agricultural school or research institute, in which case it will become part of agricultural research in general.

- Livestock research excludes the work of the schools of veterinary medicine and animal disease institutes. This

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results in an underestimation of "agricultural research", since in Chile these schools carry out some production-related work with farm animals (pastures, nutrition, reproduction, etc.) However, data are not available to sort out the relevant figures for agriculture.

- Agricultural economics research (or "rural development", more generally) is included to the extent that it is conducted by the faculties/schools of agronomy or agricultural research institutes. Again this results in an underestimation, since some social science research on agriculture is done by other faculties or institutions as well.

- Nutrition and food technology research are generally excluded from the analysis, except as they are part of the work of agricultural institutions. This research however falls mainly in the medical, sociological and engineering areas, with not much direct bearing on agricultural research.

Thus, the definition of what is "agricultural research" stems essentially from the identification of institutions that specialize on crop and livestock production problems, in a fairly direct fashion. In the Chilean case, this definition is considered to result in an accurate description of the situation, given the type of research institutions in the country and their relative magnitudes.

As shall be shown later, most agricultural research is conducted by government-supported agencies. However, the few private institutions concerned are significant in regard particularly to some of the basic food crops, and therefore they will be included in the analysis.

The description and analysis of Chile's agricultural research system presented in this Chapter II provides a broad coverage of the national picture. Emphasis is placed on those institutional and program aspects that are of special interest to the CGIAR. For this reason, certain research institutions are mentioned, with no further reference to their work later on.

2.1.2. Brief Historical Background

The first steps in agricultural research in Chile were taken in the last century, when an agronomic station was founded near Santiago by the Sociedad Nacional de Agricultura (the National Farmers Association) in 1881. It was devoted to testing the introduction and adaptation of various crops in Chile. For the next fifty years, research and extension were dominated by the private sector, led by the big landholders grouped in the Association. A significant formalization of agricultural research occurred in 1925, with the creation of the SNA's Experiment Station, on a 50 hectare plot near Santiago. German agronomists were hired for its programs. This station introduced the concept of improved seeds into Chile. Since 1928 it has initiated the production and distribution of genetic wheat seed in the country. It has also initiated livestock research, especially that focussed on dairy production (Elgueta, 1982).

Agricultural research by the university sector also has its roots in the last century, with the founding of the Agronomy Institute in 1872, which later became the Faculty of Agriculture of the University of Chile, a State University. French scientists were brought in to organize this school.

Public sector research dates from the 1930s, when the Ministry of Agriculture formed a Crop Genetics Department, which worked on the introduction, selection and production of

improved seeds, complemented later by studies on soils, fertilization and irrigation.

Modern agricultural research, however, conducted by trained scientists in a systematic and organized way, is a relatively recent activity in Chile. It emerged in the mid-1950s and expanded vigorously in the 1960s and 1970s, tapering off in the last six or seven years. Its origins and evolution are closely associated with North American aid programs, particularly those of the Rockefeller Foundation. These programs, among other things, supported long-term, sizeable fellowship schemes to train Chilean agronomists to advanced degrees abroad. This training started in the 1940s with Ministry of Agriculture staff (who usually were also professors at the faculties of agriculture, since these had no full-time staff at the time) but expanded to the universities in the late 1950s and especially in the 1960s causing a drastic transformation of the agricultural faculties towards research-oriented institutions, as shall be seen later.

Besides the steady effort at training agricultural scientists, two very significant foreign aid programs for agricultural research were:

(a) An agreement between the United States ICA (forerunner of USAID) and the Ministry of Agriculture for technical agricultural cooperation -DTICA- which launched a regional integrated rural development project called Plan Chillán, over 1952-57; and

(b) Establishment of the Office of Special Studies by the Rockefeller Foundation and the Ministry of Agriculture in 1957, to work jointly with the latter's Department of Agricultural Research (formerly crop genetics). This program centered its research on wheat and livestock.

Out of the second of the above programs, the National Agricultural Research Institute (INIA) was created in 1964. Out of the first one, INIA's large Center-South regional center (the Quilamapu Station) was formed, as well as the Faculty of Agriculture of the University of Concepción.

The last significant large-scale foreign aid program for agricultural research was the so-called Chile-California project, supported by the Ford Foundation at the University of Chile over 1965-74. This focussed mainly on developing technical and scientific capacity for non-traditional crops (i.e. fruits and horticulture) and livestock. Under this program, many staff members of this University received advanced training in the United States.

In the evolution of the Chilean economy after the Great Depression, national economic policies and foreign aid programs after World War II combined to determine a shift of agricultural research, as it was strengthened, from the private to the government sector. This feature became consolidated with the creation of INIA as a well-funded and organized institution of national coverage. The trend towards growing stabilization of agricultural research was only arrested in the late 1970s, as a consequence of the liberal economic policies introduced by the present administration.

This brief historical note should not ignore the existence of the Agronomic Society of Chile, founded in 1910, which is the scientific society for agriculture. Its significant contributions to research have been the regular publishing of a journal since 1920; holding the annual national agronomic meetings since 1949; and distributing prizes and distinctions for important contributions to the advancement of agricultural science.

2.1.3. Agricultural Research in the Context of National Science and Technology Research

Even more than in the case of agriculture, general scientific and technological research had been little developed in Chile prior to 1950, being limited mostly to the bio-medical area, and concentrated in the University of Chile (Lavados, 1983). Since that time, government efforts and foreign assistance have determined a substantial expansion of this activity. The principal bases for it have been: (a) the creation of about a dozen specialized research institutes, often supported by the National Development Corporation - CORFO, among which there are two related to agriculture for renewable natural resources and for forestry besides INIA (CONICYT, 1982); (b) the expanded support for university research, especially through the establishment of full-time academic careers; and (c) the creation of a National Council of Science and Technology (CONICYT) in 1965 with promotional and coordination functions. On the other hand, private sector R and D, outside of agriculture, is still virtually non-existent in Chile.

Table 2.1 shows the relative importance of the various types of research institutions in Chile in 1980.

The figures reported are considered to provide a fair picture of the relative situation over the last decade. It can be estimated that about a quarter of the total expenditures for R and D of the country are directly devoted to agriculture[4]. In terms of the usual breakdown by sectors of economic activity, agriculture appears to receive the largest share of the national research effort.

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[4]Considering only 1/3 of the IREN and Fundación Chile expenditures as directly for agriculture.

TABLE 2.1. Chile: Total Expenditures on Research and Development, by Institutional Groupings, 1980

Institutional group	Expenditure (million $ of 1980)	Percent of total
Universities	1,705.9	38.2
Agriculture a/	(306.0)	(7.0)
CORFO Institutes	957.5	21.5
Natural Resources	(453.7)	
Forestry	(71.6)	
Other Institutes	1,796.5	40.2
INIA b/	(455.8)	(10.2)
Fundación Chile c/	(459.4)	
TOTAL	4,359.9	100.0

SOURCE : CONICYT, 1982.

a/ The Conicyt study does not show a break down by disciplines. This figure for agriculture is estimated from data reported by Cañas, 1981 and it includes some subjects noted in Section 2.1.1 as excluded from the present study.

b/ The figure for INIA does not coincide with that reported elsewhere in this study, because CONICYT adjusts the expenditures to make the data comparable to that of the other institutions.

c/ This institution devotes a significant share of its resources to food technology research and transfer in agriculture (fruits, horticultural crops, dairy) forestry, and coastal fisheries.

2.2. Institutional Structure

Chile's agricultural research is carried out by a variety of institutions, which are not centrally coordinated or otherwise structurally organized as a system. To some extent control and planning is exercised through the allocation of public funds, but this has been generally very loose, as shall be shown in Section 2.3. The research institutions can be grouped in three categories: government agencies, faculties or schools of agriculture of universities, and private research centers. Extension services are partially combined with research, as described in a sub-section below.

2.2.1. The National Agricultural Research Institute (INIA)

INIA is the only government agency with specific responsibility for all agricultural research; i.e., there are no other regional or commodity research institutions of the public sector concerned with agriculture in Chile[5]. As mentioned earlier, INIA was created by the Ministry of Agriculture in 1964, evolving from previous programs and departments within the ministry. It was set up as an autonomous agency (i.e., incorporated as a private institution) and fully funded by the government, characteristics that it still essentially maintains, despite

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[5]An exception to this was the case of sugar beet in the 1950s and 1960s. The state sugar company, IANSA, was responsible for introducing, adapting, and developing local technology for this crop in Chile. IANSA had a research division, operated experiment stations, cooperated with INIA, and maintained a significant extension activity. At the peak of the industry, there were 60,000 hectares planted to this crop in Chile. Economic policies post-1973 sought the dismantling of IANSA and the research activity was discontinued [Elgueta, 1982, pp. 122-124].

changes introduced in its statutes and operational practice over time (Muchnik, 1983; Elgueta, 1982; Ortega, 1983).

Organizationally, INIA has essentially maintained its basic structure through time. This currently consists of a board of directors, a director-general (ex-president), three managers, and seven area or activity directors in the central office, nineteen research program leaders, and five regional experiment station directors.

From its founding and until 1968, when INIA's statutes were modified by the Land Reform Law, the Board of Directors included 10 members, representing the founding institutions, i.e., the Ministry of Agriculture, CORFO, INDAP, the University of Chile, the Catholic University and the University of Concepción (Faculties of Agriculture and Veterinary Medicine). This composition was intended in part to serve as a means of coordination among the agricultural research institutions at the time. It is significant that producers had no representation on the board. The predominance of the Ministry of Agriculture was insured through its designation of the director-general and the deputy director.

The reform of 1968 expanded the board by 7 members drawn from the public sector, and made the Minister of Agriculture the chairman of the board. This increased the government's direct control of INIA, with the intention of focussing its work exclusively on research (it had previously done also some extension) and with greater attention to the emerging land reform sector. Another reform in 1972, during the socialist administration, further strengthened the government's hand by adding serveral non-voting political appointees to the board. However, in practice, the research conducted by INIA was not seriously altered by this change,

because of the relatively short period during which it was in effect.

From 1973 to 1980 the board was in recess and INIA was directed by a president, appointed by the President of the Republic, with full powers as "government delegate". This situation was normalized in 1980, when INIA was reaffirmed as a semi-autonomous enterprise, in accordance with the liberal economic policies of the military government. A new board was appointed, formed by INIA's president, as chairman, and four members named by the Minister of Agriculture. Two of these are selected from representatives proposed by farmers' associations, one from a pool of outstanding agricultural professional researchers, and one from among INIA's own researchers.

It is clear that INIA remains firmly under government control, but an attempt has been made to put decision-making about its research programs more in the hands of professional researchers and producers, rather than government bureaucrats. This strategy responds also to the official policy of reducing INIA's dependency on direct government budgetary allocations, and forcing it to raise its own funding by selling its services, or by competing for public research funds in open bids with other research institutions. The state would only provide direct budgetary funds to INIA for specific activities considered to have a high social pay-off and which could not be funded by the private sector. This aspect is further discussed in the section on Resource Allocation.

Institutional Objectives and Responsibilities

INIA's objectives, since its founding, have been (a) to generate and/or adapt production technology suited to the country's conditions; (b) to test, validate and

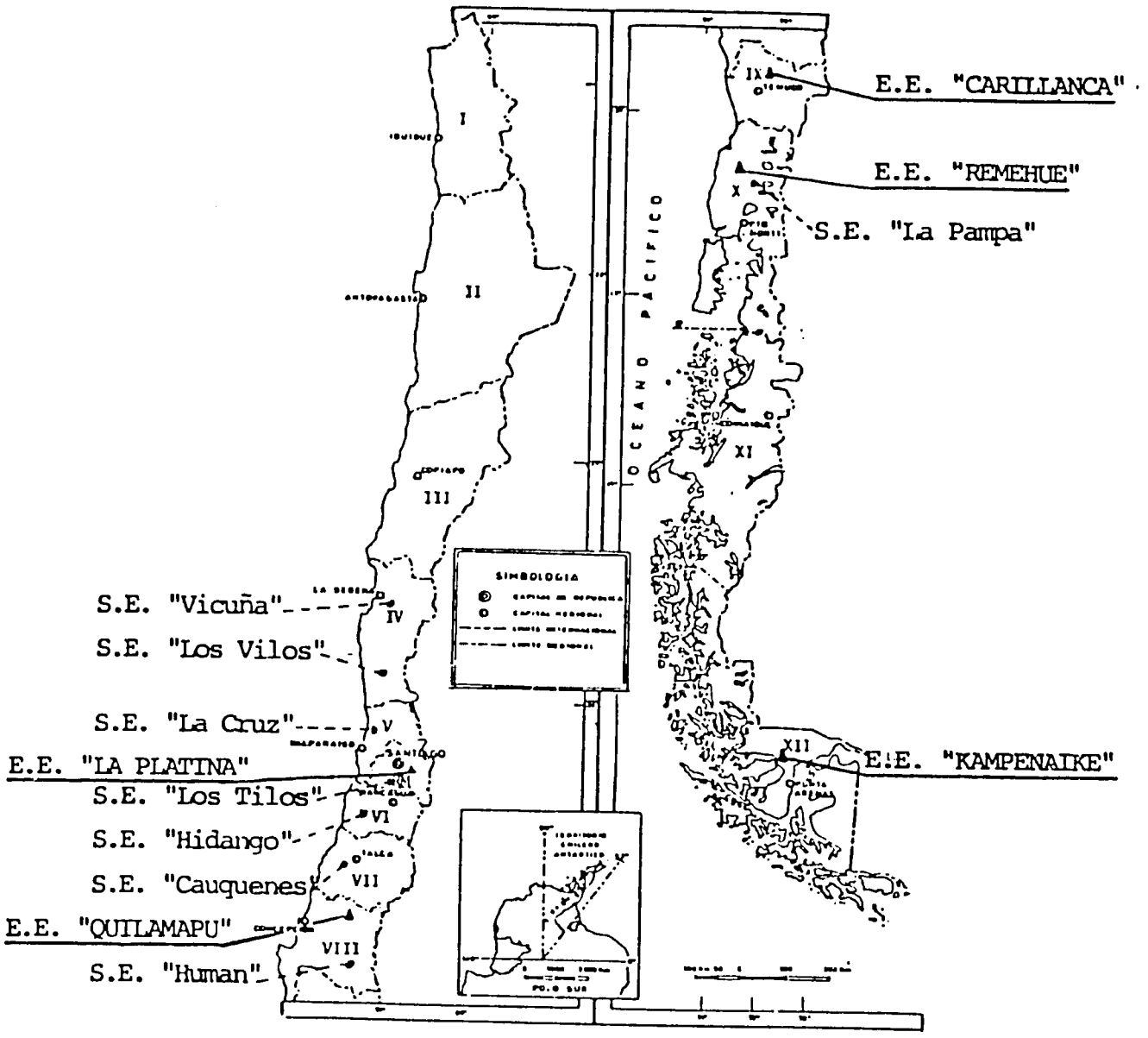
demonstrate these technologies at farmers's level; (c) to diffuse the recommended technologies, and (d) to train technicians and producers in the use of these technologies, through demonstration practices. While the first two objectives have been vigorously pursued continously, the other two that refer to technology transfer have varied in importance according to government policies or interests under different national administrations. In general, INIA's role in the transfer of technology was significant until 1968, and it has only regained priority attention since 1982, when the Ministry of Agriculture assigned INIA responsibility for it in regard to medium and large farmers. The extension of technology to small farmers remained INDAP's responsibility.

Organization and Researcn Facilities

To conduct its activities, INIA is organized in crop, livestock and disciplinary "programs", such as wheat, potatoes, fruit culture, soils, etc. which are under the direction of "national leader" researchers, and are excecuted in the various regional experiment stations. This organization by programs has been handicapped since the late seventies and especially in the 1980-83 period, because of the funding mechanism adopted by the government, but in practice INIA's administration has been able to preserve its organization up to the present. This is important because of the key role played by INIA's own scientists and administrators in the selection and formulation of research programs, as shall be discussed subsequently.

The Institute has a central administrative office in Santiago and carries out its research through five regional experiment stations, distributed from north to south of the country as follows (see Figure 2.1).

FIGURE 2.1. Location of INIA Experiment Stations and Substations



- La Platina (LP) located near Santiago, constitutes the main research center, concentrating nearly one-half of INIA's scientists. It covers roughly Regions III to VII of the country, where the most intensive and diversified farming is found. Fruit and horticulture, vineyards, maize and intensive beef fattening operations are predominant in this area. It has five research substations: Vicuña, Los Vilos, La Cruz, Los Tilos and Hidango.

- Quilamapu (Q), in the outskirts of Chillán, covers Region VIII and part of VII. This is a mixed farming, agricultural transition area, devoted to food and industrial crops (e.g. sugar beet) and beef livestock. It is the most important wheat and rice producing area of the country. INIA has substations at Cauquenes and Human.

- Carillanca (C), near the city of Temuco, serves especially Region IX, where winter cereals, dry legumes and potatoes are the principal crops, with livestock (beef and dairy) growing in importance.

- Remehue (R), in Osorno, with a substation nearby at La Pampa, covers mainly Region X. This is the most important dairy and beef livestock area of Chile; potatoes and winter cereals are the main crops grown. Leadership of INIA's national potato program is based in this station.

- Kampenaike (K), near Punta Arenas in the XII Region, is a small station concerned with pastures and sheep production. Sheep (and some beef cattle) are almost the only agricultural activities possible in this part of the country.

All of the stations, and INIA generally, is well endowed with physical facilities, and field and laboratory equipment.

Program Development and Priorities

The basic criteria that guide INIA's program formulation are the economic importance of given agricultural problems (crop, pests, farm techniques, etc.) and the capacity of the institution to carry out the corresponding research with a reasonable probability of success. These criteria are bounded by the relevant economic policies of the government. Within these general guidelines, INIA determines its projects through an internal process of review, discussion and selection that starts with the researchers' initiative and imagination and proceeds through different administrative levels. Individual projects are first discussed at the local experiment station level by the researcher, the regional station director, and the corresponding local and national (crop or subject) program leader. Next, they are discussed at the national level by INIA's Research Director, the program area directors, and the specific program leader. The selected projects are finally approved by a planning committee, at which point projects are automatically incorporated into INIA's national program. Allowing for changes in administrative structure and titles, the same strong participative procedure has been followed by INIA throughout its history (Ortega, 1983, p 21; Elgueta, 1982, p. 115). The existence of this programming mechanism is considered extremely important by INIA's senior staff and administrators, as it has helped build a strong esprit de corps in the institution, which has preserved it and its research programs rather unscathed throughout the extreme political vicissitudes lived by Chile over the period 1960-84.

INIA's annual national program has normally been approved by the agricultural, planning and finance ministries without technical review of its research content, except in certain epochs when national economic policies demanded

substantial shifts in traditional trends. Perhaps the most critical period in this respect has been 1980-82, when ODEPA firmly instituted a project-by-project rather than program funding scheme (see Section on Funding of Research).

The Institute's research program has been remarkably stable through time, despite the radical shifts in national economic and agricultural policies that occurred between 1960 and 1984. This general fact can be appreciated from historical data on staff and expenditure distribution among activities, presented in Sections 2.3 and 2.4. The program has been characterized by its broad coverage of crops, livestock, and resource problems of agriculture. From the outset, however, there was a clear priority established on basic food crops, and particularly on wheat which is by far the main food staple in Chile. Pastures and livestock production have also been a priority concern of INIA, although to a much lesser extent than would be expected, given the share of agricultural GNP contributed by this sub-sector. In terms of program expansion over time, the most significant growth has been in horticulture and fruit culture research, items that where virtually nil at INIA in the mid sixties, and in dry legumes. This development denotes a response by the Institute to changes occurring in agricultural production, even though this response has been constrained by the government's policy towards state-funded research.

The data in Table 2.2 provides an approximate description of INIA's research coverage and distribution. The original data refer to "experimental units", which obviously are not a homogenous measure of research effort; however, they complement the quantitative financial and staff information and help to better appreciate INIA's program conformation in recent years.

TABLE 2.2. INIA: Distribution of Research Work, by Commodities and Regional Stations, 1976-82 (percentages)

	L.P.	Q	C	R	K	TOTAL
Cereals						23.7
Wheat	6.0	4.4	4.3			14.8
Maize	2.5	1.6				4.1
Rice		2.6				2.6
Oats Barley		0.2				2.2
Legumes						12.3
Beans	3.2	1.9	0.9			5.9
Lentils	0.9	1.6	0.5			3.0
Chikpeas	1.3	0.5	0.2			1.9
Peas		0.8	0.7			1.5
Oilseeds						5.1
Rapeseed	0.8	0.9	0.9			2.7
Sunflower	1.1	0.5				1.9
Soybeans	0.4					0.5
Potatoes	3.8		0 6	3.2	0.2	7.8
Vegetables	4.3		2.2			6.6
Fruit trees	7.4	0.6	0.2			8.2
Vineyards	5.0	2.4				7.5
Livestock						22.4
Pastures	3.0	3.9	1 0	2.5	0.8	11.2
Dairy cattle	0.8	0.8	0.5	1.7		3.9
Beef cattle	0.4	1.1	0.3	0.8	0.4	3.1
Sheep	1.2	0.3	0.3		0.5	2.4
Poultry	1.1		0.7			1.8
General support	3.0	0.7	2.7			6.4
TOTAL	47.0	25.0	18.0	8.0	2.0	100.0

SOURCE: Calculated from Ortega et al. (1983), p. 48.

Outstanding characteristics of INIA's research program are: (a) heavy concentration in the main station near Santiago; (b) broad coverage of crops and livestock species; (c) strong emphasis on cereal crops, particularly wheat, and on potatoes; (d) strong emphasis on pasture research; (e) concentration of research on particular crops at outlying regional stations in only a few cases (rice, lentils, potatoes, cattle).

It is unfortunate that there has not been a thorough analysis made of INIA's allocation of research resources (funds and staff) to its various programs, in relation to its procedures for priority setting, as well as in relation to some objective economic indicators of the "importance" of different crops and livestock in terms of production, employment, export earnings, etc. In fact, such analysis should consider the whole Chilean NARS and evaluate to what extent there has been some rational division of labor among institutions.

INIA's budgetary and staff resources are discussed in greater detail in Section 2.3.

2.2.2. University Faculties of Agriculture[6]

The schools of agriculture of the university system initiated an active role in scientific and experimental research in the fifties and presently represent a significant element of the Chilean NARS. There are four universities with an established tradition in agricultural research:

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[6]Throughout this paper, the terms faculty and school of agriculture will be used generically to describe the university agricultural research institutions. Universities in Chile have changed the names of these schools over time, or use one or the other terms to mean essentially the same thing.

- The University of Chile, Faculty of Agricultural, Veterinary and Forestry Sciences (UCH)

- The Catholic University of Chile, Faculty of Agronomy (UC)

- The University of Concepción, Faculty of Agricultural, Livestock and Forestry Sciences (UCC)

- The Austral University, Faculty of Agricultural Sciences (UA)

In addition, a little research is conducted by the Catholic University of Valparaíso's Faculty of Agronomy at Quillota (local fruits and horticultural crops); the University of Tarapaca's Agronomic Institute in Arica (crops and problems of the tiny subtropical areas in the north); and by some of the new universities created after the educational reform of 1981.

The bulk of human and physical resources for university agricultural research is concentrated in the first four faculties. All of these, whether state or private institutions, depend on the Ministry of Education. The majority of their regular funding comes from the state, through this Ministry, and they have no formal, permanent linkage with the Ministry of Agriculture. These features influence the nature, scope and continuity of research done by the universities, which to a large extent is designed to complement their training function (particularly at the graduate level since the early 1970) rather than to solve specific production problems of agriculture.

Despite some formal differences, there is a substantial similarity between the university faculties in their basic organizational and functional approach for

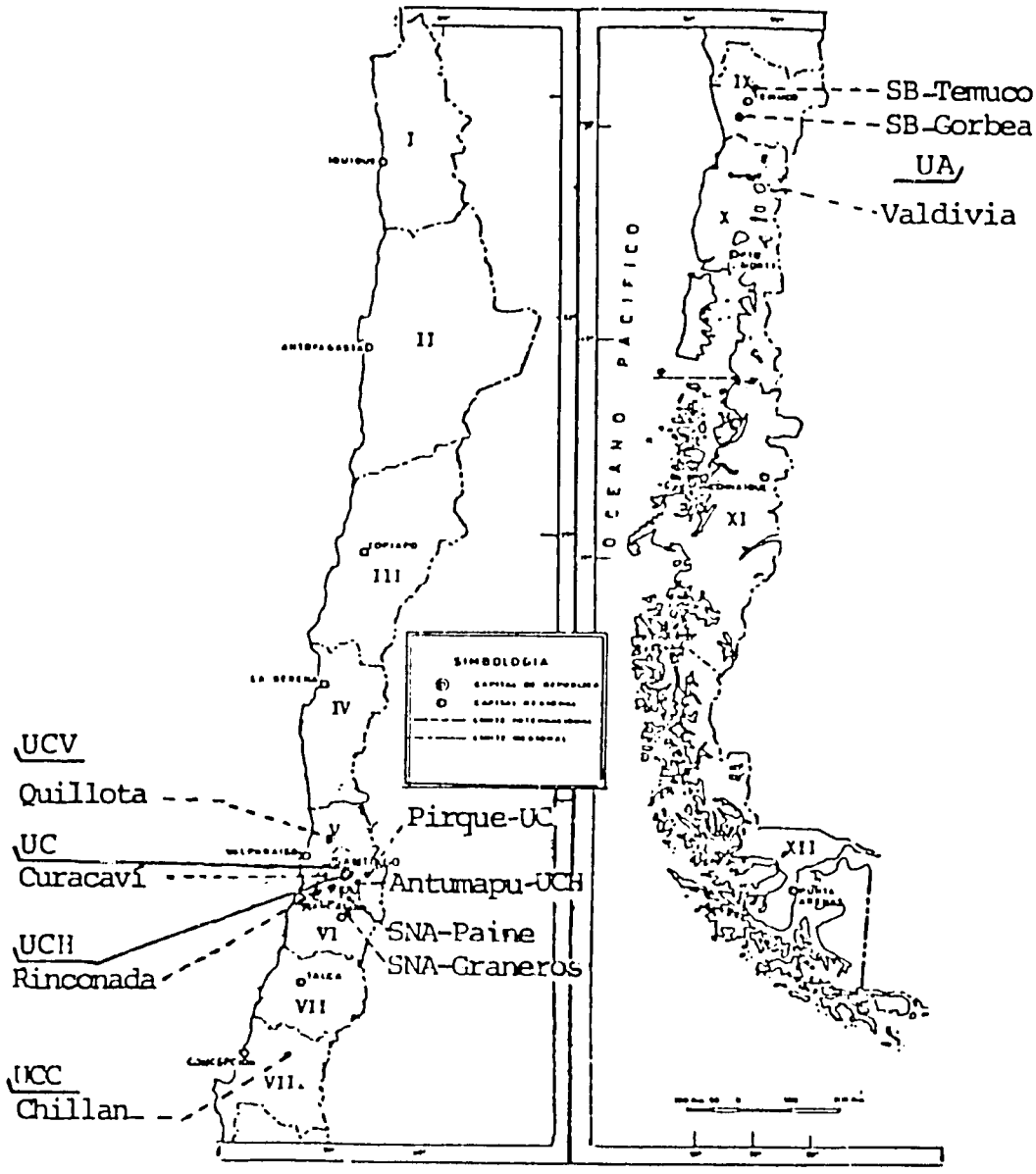
formulation and execution of research programs. These schools define certain themes or lines of research they wish to pursue over time, on the basis of relative staff strength, historical considerations, regional advantage, expected developments, availability of support, etc. Within these lines, the specific research projects stem from the researchers themselves with nearly complete freedom of choice. However, execution of the projects requires operational funds. In the Chilean university scheme, it has become general practice since the mid-1970s for academicians to bid for these funds in research contests at all levels - faculty, university, regional, national, international. While this mechanism ensures supporting good single projects, it has adverse consequences for long-term research activities often resulting in severe fluctuations in research funding, and hindering institutional planning of research. These features of the university research organization distinguish it from that of INIA, and seem among other things, to make it less amenable to cooperation with the IARCs, as shall be discussed later.

The basic characteristics and research programs of the faculties of agriculture are described in the following paragraphs. Their staff and financial resources for research are presented in Sections 2.3 and 2.4.

Faculty of Agricultural Sciences, UCH

This school is located in Santiago, adjoining the La Platina Station of INIA (which is another demonstration of the intention of policy makers in the 1960s to integrate INIA and University research more closely). This faculty was the first to develop research by setting up its experiment station, La Rinconada, in nearby Maipú in 1952, employing full-time staff. It has another experimental field on its Campus Antumapu (see Figure 2.2).

FIGURE 2.2. Location of Faculties and Experimental Stations of Universities and Private Organizations



The big push in UCH research occurred in 1965-75 under the ten year, multi-million dollar Chile-California project. Three areas were selected for special development: crop pests and diseases, fruitculture, and animal production. Eighty percent of the staff with MS and PhD degrees were trained under this program, many visiting professors were brought in, laboratories were modernized and equipped, and the first graduate programs were established.

The research program is broad, as shown in Table 2.3, but heavily concentrated on basic (or general support) disciplines, fruitculture, horticulture, and livestock. The school does little research on the staple food crops of interest to the IARCs, following an early understanding with INIA that the latter would cover them. UCH research on maize refers only to silage corn.

The faculty's research focusses mainly on the central part of the country and on the semi-arid agriculture of the north-central provinces.

Faculty of Agronomy, UC

This school is located in Santiago and has experiment stations in Pirque and Curacaví, within the Metropolitan Region (see Figure 2.2). Research was initiated in the 1960s, as the faculty started developing a full-time staff, but it acquired a significant volume only in the last ten years. Characteristic of this school is the emphasis placed on agricultural economics research, which represents about one third of the total program. Development of this discipline resulted from assistance from AID, IICA and the Ford Foundation over 1960-75.

With respect to agricultural research proper, as shown in Table 2.3, there is strong emphasis placed on cereals

TABLE 2.3. Faculties of Agriculture: Distribution of Research Activities Among Crops and Livestock, 1976-82 (percentages)

SUBJECTS	UNIVERSITIES			
	UCH	UC	UCC	UA
Cereals	5.1	40.0	21.1	7.5
Maize	3.9	3.0		3.1
Wheat	1.2	33.5	21.1	4.4
Oats Barley		3.6		
Legumes	1.7	7.1	5.2	
Beans	0.8	7.1	5.2	
Chickpeas	0.5			
Lentils	0.2			
Peas	0.2			
Oilseeds	0.2			1.3
Rapeseed	0.2			1.3
Potatoes	0.8	2.4	15.8	10.7
Sugar beet		0.6		
Vegetables	7.8	7.8		7.5
Fruit trees	21.7	12.6	31.6	8.1
Vineyards	6.7	3.6		
Livestock	31.8	5.4	26.3	38.4
Pastures	7.7		15.8	2.5
Dairy cattle	7.0	2.4	5.2	18.9
Beef cattle	4.7			9.4
Hogs	4.9		5.2	
Chickens	3.4	3.0		3.8
Sheep	4.1			
General support	23.9	20.4	-	26.4
TOTAL	100.0	100.0	100.0	100.0

SOURCE: Calculated from data in Ortega, (1983) p. 49.

(wheat and triticales, mainly), basic support disciplines, and fruits and vegetables. Research is not restricted in terms of geographic coverage, although a majority of it refers to the intensive type of agriculture of regions V and VI, except for wheat research that reaches farther south.

Faculty of Agronomy, UCC

This school, located in Chillán, was founded in 1955 and has an experiment station nearby (See Figure 2.2). Despite its immediate proximity to INIA's Quilamapu Station, there has seldom been collaboration in research. Although research has been developed in the last fifteen years, it still is not as intensive as in the other universities. The faculty has devoted special attention to agricultural engineering, with UNDP/FAO support, an area in which it offers a graduate program.

Its research program is local in scope and focusses mainly on fruit trees, livestock, wheat and legumes.

Faculty of Agricultural Sciences, UA

Founded in 1954, this school is located in Valdivia where it also has its experiment station (See Figure 2.2). The UA has received considerable assistance from German sources and in agricultural and foresty sciences it maintains cooperative agreements with various German universities. Research was initiated after 1965, with a strong regional focus. This determines a heavy concentration on livestock research, especially on dairy cattle and processing. The faculty created a Dairy Technology Center in 1970, which subsequently became an internationally oriented activity, with support from the Danish Government, FAO and CORFO. In crops, the major emphasis is on potatoes, winter cereals, and fruits and vegetables. A large portion of research is in the supporting disciplines (See Table 2.3).

With respect to extension, or diffusion of research results, none of the faculties has specific programs or staff for it. The principal vehicles for diffusion are seminars, short courses and published articles in journals, bulletins, books, etc. Since the mid-1970s each faculty, except for the University of Concepción, has published its own agricultural journal regularly. Field days are usually held at the experiment stations at which farmers and agricultural leaders are invited, and the schools are fairly open to consultation by interested parties. Under special cooperative agreements, some departments or staff members of the faculties participate in extension activities of INDAP, INIA, SNA, COPAGRO, etc.

2.2.3. The Private Research Institutions

Agricultural research by the private sector is intimately linked to the seed production business. In other areas (fertilizers and chemicals) private enterprises occasionally contract research with INIA and/or the universities, but do not have their own R and D capacity.

The most significant private research institutions are the Experiment Station of the SNA, already referred to earlier, and Semillas Baer. Both are particularly relevant in regard to the food crops of CGIAR concern. In the case of maize there is a peculiar situation, which will be discussed later on, such that several seed companies engage in "research" for testing imported lines and hybrids for introduction and marketing in Chile. This activity has determined that INIA and the universities do virtually no research on (grain) maize improvement. The same companies do a similar testing for other crops too, such as vegetables, beans, sorghum, forages, etc. An important research activity on alfalfa is conducted by A.C. Baldrich, a private seed

producer with links to California research centers. However, only the first two institutions named above represent formal, permanent research centers that deserve explicit inclusion in the analysis of Chile's NARS.

The Experiment Station of the SNA

This old institution has two stations, in Paine and Graneros, in central Chile (See Figure 2.2). Their basic concern has been to produce genetically improved seeds, in which they have had a major role historically in Chilean agriculture. SNA's main efforts on wheat, followed by maize (where it performs in the fashion noted above) and dry legumes, mainly beans. The SNA also works on barley, lentils, chickpeas and horsebeans. As to potatoes, it engages only in seed multiplication. The size and academic level of the SNA's research staff, however, suggests that its research is of the routine seed improvement type (See Table A-2.17). As will be shown later, this institution has maintained significant contacts with the CGIAR centers.

Semillas Baer

This small private company was founded in 1956 by a German agronomist, formerly employed by the SNA Experiment Station, and it is operated as a family business. Its principal field station is in Temuco, with a secondary one in Gorbea (see Figure 2.2).

Its research program consists of genetic seed improvement and covers all species susceptible of cultivation in its area of influence (Regions VIII to X), except potatoes. It also does limited research on crop management practices. The program has a permanent part, devoted to wheat and lupine; and an intermittent one that may attend barley, rye, triticale, rapeseed and forage crops, depending on need and market considerations.

Despite Baer's limited staff and funding, it has had an extraordinary impact on the area's agriculture, through farmer adoption of its wheat varieties and introduction of the lupine as a new alternative crop.

This institution has maintained research links especially with European countries, with little connection to the IARCs. Only lately has it been in more contact with CIMMYT.

Other Private Research Stations

An interesting situation has existed with respect to rice research. Early work on this crop was done by the private Huencuecho Experiment Station, near Talca in Region VII. It was set up in the late 1950s and was terminated under the Land Reform. Its legal rights and patent were acquired by ENDS, the state seed company, which was in turn transferred to the private sector after 1973. After liquidation of this company in 1982/83, the research rights and materials were bought by the INDUS company, a large industrial concern, which is now carrying on rice research at a station near Chillán. Professional assistance is provided by staff of the Faculty of Agriculture, UCC. It will be shown later that most of the rice grown in Chile is in varieties produced by this chain of private stations.

2.2.4. The Transfer of Technology

Agricultural extension services (or technical assistance, or technology transfer as it has been subsequently labelled) have been the responsibility of the Ministry of Agriculture and dependent agencies since the 1930s. Agricultural extension in Chile has gone through many conceptual and institutional changes over time. However, it was not until after the founding of INIA that a superior research-based technology became available for diffusion.

During the mid-1960s, INIA had responsibility for diffusing technology, despite the existence of an extension service under SAG. INIA's experience in a collaborative project with the University of Minnesota, supported by the Ford Foundation, was excellent (Elgueta, 1982, p. 117). The Land Reform Law that came into effect in 1967, however, determined that INIA had to restrict itself to research; extension activities were to be carried out only by INDAP, SAG, CORA and ICIRA, none of which had formal linkages with INIA, or the remainder of the NARS.

INDAP, founded in 1962 and dependent on the Ministry of Agriculture is still very active at present and is particularly responsible for providing assistance to small farmers, including supervised credit services. Since 1979, it has assumed responsibility also for assisting the approximately 40,000 independent farmers resulting from the Land Reform.

CORA was the administering agency for the Land Reform, with all-encompassing responsibilities including technical assistance. ICIRA was a complementary institution, supported by FAO, to train technicians and develop extension materials for the reformed sector. Both agencies were terminated in 1978-80, as the Land Reform program was brought to an end.

SAG also terminated its direct extension work in 1978, when a new, private enterprise-type system known as ATE (entrepreneurial technical assistance) was launched by the government. The ATE consisted of independent private concerns that sold technical assistance services to small farmers, who paid (a high but decreasing percentage of the respective cost) with bonds supplied by the government. The system was supervised and administered first by SAG and then ODEPA. The

idea was to make technical assistance to farmers competitive and efficient, to the point where it could become a normal unsubsidized commercial service. It did not work out well for several reasons, one being that it operated at a time when agricultural business relevant to small farmers was extremely depressed. A contributing factor was certainly the lack of solid technological support from the research institutions to the private extension agents.

The ATE system was revised during 1982 and its administration vested in INDAP. Although several changes in the scheme were introduced, its essential features of operation through private enterprises and official subsidization were maintained. The new system, now labelled ATI (integral technical assistance) has been in effect since 1983. Unfortunately, the absence of formal links to the NARS persists.

INIA re-initiated its technology transfer activities in 1980, when it repatriated an expert on the subject who had been working at CIMMYT for several years. The big push in this direction, however, came only in 1983, when the Ministry of Agriculture determined that INIA would take responsibility for the transfer of technology to medium and large commercial farmers, the rest being INDAP's job. INIA's approach has been to work through numerous, but small groups of farmers throughout the country, in a system similar to the French CETA, which has also been reproduced in other Latin American countries. The system has expanded rapidly. INIA has had to assign about a third of its staff time and resources to it, and current appraisals of it are highly favorable. However, there appears to have been little progress yet in transfering the cost of the program to the farmers, as government policy would require.

INIA also extends its research results through numerous publications, both regional and national in character. It has published a technical journal for many years.

Finally, it should be made clear that technical assistance is also provided by private businesses, either as part of commercial deals (e.g., input suppliers, large industrial monopolies like in malt barley and tobacco, export traders in fruits, etc.) or as a specific paid service. However, this form of assistance is limited to particular crops and to commercial farmers.

2.3. Financial Resources for Agricultural Research[7]

2.3.1. The National Picture

The total level of expenditure on agricultural research, as defined in this study, by all executing agencies is estimated at $1,074.1 million for 1983. In 1960, this expenditure was $157.1 million. Thus, it grew at an average compound rate of 8.7% per year over the period (see Table 2.4). This is well above the growth rate of agricultural GNP, although it is a misleading comparison, since research started from such a low base. The rate of expansion was fastest between 1965 and 1975 with about a fourfold increase in expense, while there has been a contraction in real expenditures since 1981, as a consequence of the economic recession. There are, however, some important differences in the composition of the expenditures between institutions, and according to the source of funds, which are discussed in the next sub-section.

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[7]Throughout this section, all monetary values are in real terms, expressed in pesos of June 1984. Nominal pesos of each year have been converted by the Consumer Price Index shown in Table A-1.5.

TABLE 2.4. Chile: Total Expenditures on Agricultural Research by Institution 1960-1983

(million pesos of 1984)

Institution	1960		1965		1970		1975		1980		1983	
	$	%	$	%	$	%	$	%	$	%	$	%
INIA	148.0	94.2	267.2	94.2	392.4	88.1	703.8	84.8	870.0	76.9	805.8	75.0
UNIVERSITIES	2.9	1.8	9.3	3.3	45.7	10.3	114.0	13.7	249.5	22.0	252.0	23.5
UCH	2.9	1.8	6.6	2.3	32.7	7.3	59.0	7.1	94.9	8.4	91.6	8.6
UC	0.0	0.0	1.4	0.5	3.9	0.9	21.2	2.6	81.8	7.2	89.8	8.4
UCC	0.0	0.0	1.3	0.5	6.2 a/	1.4	17 7	2.1	27.5	2.4	25.1	2.3
UA	0.0	0.0	0.0	0.0	2.9	0.7	16.1	1.9	45.3	4.0	45.5	4.2
PRIVATE ENTITIES	6.2	4.0	7.1	2.5	7.2	1.6	12.7	1.5	12.2	1.1	16.3	1.5
SNA	4.2	2.7	4.4	1.6	4.5	1.0	8.1	1.0	10.3	0.9	12.7	1.2
SB	2.0	1.3	2.7	0.9	2.7	0.6	4.6	0.5	1.9	0.2	3.5	0.3
TOTAL	157.1	100.0	283.6	100.0	445.3	100.0	830.1	100.0	1,131.7	100.0	1,074.1	100.0

a/ Year 1969.

Source: See Appendix Tables.

Relative to agricultural GNP[8], agricultural research expenditures represent 0.78% of it in 1983, up from 0.16% in 1960.

The increase in expenditures on agricultural research prior to 1974 occurred against a background of overall growth of the public sector, and particularly of growing government intervention in agriculture, largely as a consequence of the Land Reform. For instance, current expenditures of the consolidated public sector (central government and decentralized agencies) relative to GDP went from 27.3% in 1968 to 57.3% in 1972 (World Bank, 1975).

A key aspect of government policy after 1973 has been to reverse this trend, and diminish the public sector's role in the economy. This can be appreciated from the figures in Table 2.5 which show a steady reduction in public expenditure relative to GNP until 1980-81, when the recession set in and forced tactical changes in policy. The reduction of public expenditure on agriculture is dramatic; it reflects the phasing-out of the Land Reform program, termination of government direct participation in input and product marketing, the end of subsidized farm credit, etc.

The column on public expenditures for agricultural development and research[9] in Table 2.5 shows that these have been fairly steady since 1975, thus representing a progressively larger share of total expenditures on

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[8]Note that this component of GNP includes forestry production, while agricultural research expenditures exclude forestry.

[9]These figures include many R and D items besides INIA's budget, e.g., SAG, INDAP, CONAF, and other agricultural sector agencies, and especially CORFO and some of its dependent institutes related to agriculture, fisheries and forestry.

TABLE 2.5. Chile: Government Expenditure and Agricultural Share, 1976-83 (pesos of 1984)

Year	Total Public Expenditure		Agricultural Expenditure a/		Expenditure on Develop. and Research	
	Million $	% of GNP	Million $	% of Total	Million $	% of Ag. Exp.
1974	582,053.7	36.2	21,831.2	3.8	8,041.9	36.8
1975	474,484.3	33.8	11,934.9	2.5	5,320.2	44.6
1976	453,659.6	31.2	13,990.0	3.1	5,688.6	40.7
1977	494,477.3	31.0	13,367.9	2.7	6,097.6	45.6
1978	528,460.5	30.6	14,067.1	2.7	5,638.0	40.1
1979	537,670.6	28.8	16,303.2	3.0	6,793.5	41.7
1980	581,285.9	28.8	13,180.8	2.3	6,770.6	51.4
1981	642,978.1	30.2	10,706.2	1.7	5,848.7	54.6
1982	657,655.9	36.0	8,689.2	1.3	5,177.7	59.6
1983	613,330.0	33.9	8,918.0	1.5	5,159.3	57.8

a/ Includes fisheries.

Source: Cheyre, H. y E.Symon "Evolución del Gasto Público...".

agriculture. If one compares exclusively INIA's expenditures (see Table 2.6) with those in this column it can be seen that INIA has maintained its aproximate 15% share.

The source of funds for agricultural research is fundamentally the public sector, through the Ministry of Agriculture. Growth of the universities' role in research, given that they are over 80% directly publicly funded, determines a growing participation by the Ministry of Education. This Ministry however does not exercise any policy influence on agricultural research.

Other significant contributors, through research contracts or agreements, are ODEPLAN and CORFO. The regional agencies of ODEPLAN, known as SERPLAC, as well as the Development Division of CORFO, allocate substantial funds for agricultural research, to be executed by the institutions discussed in the previous section. Although most of these funds are allocated through various bidding schemes, the selection of topics and broad research initiative rests with the funding agencies. Thus, these do influence the nature of the research programs of the executing agencies. Relatively, this influence is stronger on the universities, given their dependence on non-budgetary sources for capital and operating costs of research. However, as shall be seen next, INIA has also been increasingly submitted to this factor in the last four years.

The Ministry of Agriculture, through ODEPA, has also supported research at different institutions on a short-term project basis. This source was systematized by creating a National Agricultural Research Fund in 1981, with a Board composed of distinguished research scientists and producers, with the minister as Chairman and ODEPA as excecutive secretariat. The Fund invites project proposals

TABLE 2.6. INIA[a/]: Research Expenditures, Total and by Selected Crops, 1960-83 (thousand pesos of 1984)

Year	Total	Research Expenditures on					Total Expenditure on Selected Crops	
		Wheat	Rice	Maize	Beans b/	Potatoes	Value	% Total
1960	147,968	11,394		4,983				
1961	163,230	12,569		5,387				
1962	160,930	12,392		5,311				
1963	164,579	12,673		5,431				
1964	164,507	12,667		5,429				
1965	163,307	31,242	2,840	5,680	11,361	8,520	59,643	36.5
1966	267,244	48,995	4,454	8,908	13,362	13,362	89,081	33.3
1967	348,557	55,167	5,015	10,030	15,046	15,046	100,304	28.8
1968	357,163	33,115	4,731	9,461	14,192	18,923	80,422	22.5
1969	360,614	32,572	4,653	9,306	13,959	18,612	79,102	21.9
1970	392,416	56,426	5,130	15,389	20,519	25,648	123,112	37.4
1971	653,677	91,018	8,274	16,549	33,098	41,372	190,311	29.1
1972	649,904	75,473	8,386	16,772	25,158	8,386	134,175	20.6
1973	528,138	61,332	6,815	13,629	27,259	13,629	122,664	23.2
1974	733,670	95,905	9,590	19,181	38,362	19,181	182,219	24.8
1975	703,773	92,601	18,520	27,781	46,301	46,301	231,504	32.9
1976 c/	879,282	109,910	21,982	32,973	43,964	65,946	274,775	31.2
1977 c/	910,754	121,434	22,079	33,118	55,197	99,355	331,183	36.4
1978	843,448	103,088	18,743	18,743	56,230	65,602	262,406	31.1
1979	869,410	98,087	17,843	17,843	35,660	71,336	240,777	27.7
1980	870,006	113,929	10,357	20,714	62,143	62,143	269,286	31.0
1981	982,461	125,663	11,424	22,848	79,968	68,544	308,447	31.4
1982	802,092	103,193	9,381	9,381	65,568	37,525	225,148	28.1
1983	805,778	98,484	17,906	8,953	62,572	35,812	223,827	27.8

a/ Prior to 1965, it refer to the Ministry of Agriculture and Rockefeller Foundation program.
b/ Includes other dry legumes.
c/ Figures reported by INIA were adjusted to correct for one semester overlap.

Source: Total expenditures for 1960-64 and 1971-73: Yrarrázaval, op.cit. [1979]; for 1965-70 and 1974-83: INIA Annual Reports. Elaboration of DEA/UC, based on personal communication with Dr. Sergio Bonilla, deputy director INIA. Expenditures by commodities were estimated on the basis of average expenditures per researcher, times the annual scientist-equivalent (specific and support) involved in each crop program.

once a year, and supports those selected as most worthy. Between 1981 and 1983 it funded twenty-six projects for about two and a half million dollars at nine different institutions, including INIA, universities and agro-industrial technology and forestry centers (Fundación Fondo de Investigaciones Agropecuarias, 1983).

A further source of research support is the Council for Scientific and Technological Research, administered by CONICYT and established in 1982. It is presided over by the Ministers of Education, Finance and ODEPLAN. It also operates on the basis of national research project competitions. The faculties of agriculture received funds through this Council in 1983 and 1984.

Financial resources continue to be obtained from international and foreign aid agencies. This kind of support however has fallen enormously compared to the levels existing in the 1962-70 period, when USAID and the Rockefeller and Ford Foundations were active in Chile. The principal foreign sources of support for agricultural research in recent years are discussed below. Some of the CGIAR international centers have provided important resources, mostly non-monetary, as shall be documented in the following chapter.

Finally, business enterprises provide some funding through service contracts for research on commodities of their interest. This, though, is a rather small and unstable source of research support.

In sum, total expenditures on agricultural research have increased, but public funding has become less dependable, and the complementary sources of funds have become strongly competitive - oriented and economic-minded in their allocation decisions. This results in the generation of many diverse, shorter-term, less-expensive and hopefully more

efficient projects than was the case in former years. The overall effect on the nature of a "program" of national agricultural research is yet to be assessed.

2.3.2. Expenditures by Executing Institutions

The level of expenditures by the various agriculture research institutions over the period 1960-83 are summarized in Table 2.4 and shown in detail in Tables 2.6 to 2.10. It can be appreciated that despite the relative decrease in INIA's participation, its share of expenditures over the last several years has stabilized at about 75% of the total. The big expansion in expenditures has been by the university sector, but this too has tapered off since about 1979-80. The private institutions represent a small percentage of the total expenditures.

INIA

The Institute's financial information is presented in Table 2.6 and Tables A-2.1, A-2.2 and A-2.3. A breakdown of expenses has been estimated for the five food commodities of special interest for the CGIAR study. This group absorbs approximately one-third of INIA's budget, a stable share throughout the period. Wheat has been the most important crop, followed by the dry legumes group and potatoes.

Expenditures on maize have decreased since 1975/76, mostly because of the success of hybrids imported from the United States and the role of private seed companies. Rice, also, has not received priority attention from INIA, partly because it is a less significant commodity and partly because of the role of private research noted earlier.

The regional distribution of INIA's expenditures (Table A-2.3) shows a strong centralization of operations,

with over 70% of expenditures in the head office and La Platina Station in Santiago. However, there appears to be a trend toward expanding the Quilamapu Station, probably in connection with the shift in production of annual crops (wheat, beans, etc.) towards the mid-South and away from the fruit growing central area.

The drastic change in the composition of INIA's income over the last ten years is shown in Appendix Table A-2.1. While in 1960 over 90% of its income was in the form of direct budget allocations, this has decreased to about 50% since 1980. This is the result of the government policy already discussed, which has sought to (a) make the beneficiaries of research pay for some of it, arguing that in a small open economy the producers capture such benefits, and therefore (b) that agricultural research should be conducted more as a private business. It was in order to move in this direction that changes were introduced in INIA's statutes and organization, and in the government's research funding mechanisms. INIA's "guaranteed" public budget was put on a declining scale, with the balance of public research funds offered for bids on a project basis, open to INIA as well as all other research institutions. This scheme operated most severly between 1981-83, but it has been relaxed somewhat since.

The Universities

Estimated research expenditures by the schools of agriculture (Tables 2.7, 2.8, 2.9 and 2.10) show that these institutions have become a significant part of the Chilean

NARS only in the last ten years.[10] Expenses prior to that time include a larger share in capital investment (labs, equipment, etc.) partly funded by foreign grants, corresponding to the formation period of research capacity.

The growth in expenditures has been most spectacular in the case of the Catholic University, which is explained by the greater ability of this legally private institution to raise and manage funds obtained through external contracts and grants. Although the total levels of expenditures reached by the UCH and the UC since the late seventies are similar, the composition of funds is different. Most of the former's funds represent budgeted staff salaries; for the UC, most of the funds are non-budget operational funds. This can be appreciated by the fact that expenditures per full-time staff member are about four times higher at UC than UCH, while salaries are not that far apart. This difference should have important consequences for the nature and efficiency of research; however, there have not been analyses made of this problem at Chilean universities.

The universities devote relatively little effort to the crops of interest to the IARC and CGIAR, as can be seen from the respective figures in the Tables. The exceptions are the wheat and triticale program at the UC, and wheat and potatoes at the UA. As shall be seen later, both schools have

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[10]The universities do not maintain complete, detailed, or even constant financial records that permit precise measurement of research expenditures. Furthermore, information on certain contracts or agreements is treated confidentially and is not released. The figures used in this study are therefore the best estimates that can be made, as is explained in Table 2.7. We are confident that the trends and relative magnitudes of expenditures are reasonably accurate.

TABLE 2.7. University of Chile: Expenditures on Agricultural Research at the Faculty of Agronomy: 1960-1983 (thousand pesos of 1984)

Year	Expenditures on Research	Expenditures a/ on		
		Weat b/	Maize c/	Beans d/
1960	2,880	76	[illegible]	-
1961	4,684	112	[illegible]	-
1962	3,818	91	[illegible]	-
1963	4,669	208	519	311
1964	5,229	109	218	109
1965	6,594	249	498	124
1966	7,480	267	267	267
1967	10,628	-	317	317
1968	14,317	202	1,008	202
1969	19,989	256	513	256
1970	32,698	735	735	-
1971	43,174	419	1,257	-
1972	42,811	372	1,117	-
1973	31,997	233	934	-
1974	42,421	585	585	-
1975	59,037	1,543	1,158	772
1976	80,382	1,997	999	1,498
1977	94,621	1,720	1,147	1,720
1978	88,588	1,563	1,042	2,606
1979	95,607	1,658	1,105	2,763
1980	94,884	1,655	1,655	2,758
1981	90,822	525	2,100	2,100
1982	104,063	605	1,210	1,815
1983	91,615	532	1,598	532

Note: The total expenditures were estimated on the basis of information on staff size and rank distribution; annual gross salaries by rank groups; share of staff time devoted to research; operating Faculty budget for research; research funds allocated by the University Research Division; and approximate external grants and contracts for research. Some of these figures were interpolated for missing years. Data elabored by DEA/UC.

a/ Expenditures by commodities were estimated as in the case of INIA. See Table 2.6. Only the three crops with sustained activity are considered.

b/ Research refers essentially to pest, diseases and weed control studies applied to this crop.

c/ Refers basically to silage corn.

d/ Includes other dry legumes.

TABLE 2.8. Catholic University: Expenditures on Agricultural Research, 1962-84
(thousand pesos of 1984)

Year	Total Research Expenditure a/	Expenditure on wheat Research b/
1962	505	-
1963	938	-
1964	1,205	-
1965	1,419	-
1966	1,393	-
1967	1,535	-
1968	1,179	-
1969	2,426	-
1970	3,867	-
1971	4,720	-
1972	4,997	2,116
1973	10,666	2,301
1974	14,306	3,817
1975	21,179	3,456
1976	18,304	4,304
1977	27,439	5,664
1978	61,401	5,436
1979	65,822	4,935
1980	81,839	3,862
1981	86,673	3,259
1982	103,986	3,945
1983	89,823	4,890
1984	91,975	2,380

a/ Includes the share of staff salaries corresponding to research time, and direct capital and operating costs of research projects.

b/ Includes wheat and triticale.

Source: Faculty of Agronomy, Catholic University of Chile; for wheat, 1972-78: Yrarrázaval, op.cit [1979] and 1979-84: personal communication of Dr. P. Parodi. Data elaborated by DEA-UC.

Table 2.9. University of Concepción: Total Expenditure on Agricultural Research Faculty of Agronomy, 1960-84 (thousand pesos of 1984)

Year	Expenditure
1960	898
1961	972
1962	1,040
1963	1,115
1964	1,186
1965	1,326
1966	2,243
1967	3,055
1968	5,005
1969	6,224
1970	nd
1971	nd
1972	nd
1973	11,104
1974	14,417
1975	17,706
1976	20,681
1977	17,612
1978	19,950
1979	25,121
1980	27,548
1981	25,094
1982	26,669
1983	25,116
1984	24,815

Source: Estimated on the basis of partial information provided by the Directorate of Research Programs, Faculty of Agronomy U.C.C.
See Note to Table 2.7.

TABLE 2.10. Austral University: Expenditure on Agricultural Research by the Faculty of Agricultural Sciences, 1965-84 (thousand pesos of 1984)

Year	Total Expenditure
1965	-
1966	900
1967	1,000
1968	1,000
1969	1,100
1970	2,900
1971	4,075
1972	4,210
1973	4,744
1974	10,522
1975	16,108
1976	24,620
1977	36,934
1978	43,104
1979	39,817
1980	45,317
1981	47,838
1982	48,971
1983	45,548

Source: Estimated on the basis of partial information provided by the Faculty of Agricultural Sciences, and personal comunication Dr. C. Zegers. Elaboration by DEA-UC. See note to Table 2.7.

placed certified wheat varieties in the market which are widely used by farmers.

The Private Research Centers

The SNA and Baer experiment stations show steady levels of expenditures up until 1974, with a rapid expansion between 1974 and 1978 (Tables 2.11 and 2.12). This probably reflects their response to the change in political and economic conditions at the time, and to the national "wheat campaign" of 1974-76. In fact, both institutions devote a major share of their research effort to wheat, and derive much of their income from the sale of certified wheat seed. The smaller and more commercial Semillas Baer concern shows a strong response to the falling wheat acreage and prices that set in after 1978, diminishing its research expenditure. On the other hand, the SNA Station, though private, is more of a "social" enterprise and does not show a similar contraction in its work.

2.4. Staff Resources

2.4.1. Size of Staff, Evolution and Institutional Distribution

The professional staff involved in agricultural research at the institutions considered in this study numbered 488 in 1983. In 1965, the equivalent figure was 214. Thus, the total number more than doubled in the 18 year period, with the fastest growth occurring in 1970 (See Table 2.13). INIA concentrates over 40% of these professionals, with a similar proportion in the Faculty of Agriculture, UCH. Considering however that the university staff, on the average, devote only one third of their time to research, the share of INIA's full-time scientist equivalent is much higher, slightly over 60%, a proportion that has held steady over time.

TABLE 2.11. SNA: Agricultural Research Expenditures, Total and by Commodities, 1960-84

(thousand pesos of 1984)

Year	Total Expenditure	Wheat	Maize	Legumes
1960	4,159	2,337	1,298	524
1961	4,202	2,353	1,324	525
1962	4,244	2,377	1,341	526
1963	4,290	2,402	1,360	528
1964	4,329	2,424	1,379	526
1965	4,372	2,405	1,443	524
1966	4,414	2,428	1,479	507
1967	4,457	2,452	1,515	490
1968	4,499	2,474	1,552	473
1969	4,542	2,498	1,590	454
1970	4,574	2,516	1,600	458
1971	4,627	2,545	1,601	481
1972	4,670	2,569	1,606	495
1973	4,712	2,592	1,611	509
1974	7,824	4,225	2,738	861
1975	8,125	4,380	2,827	918
1976	9,702	5,220	3,357	1,125
1977	10,840	5,821	3,729	1,290
1978	10,500	5,628	3,591	1,281
1979	10,500	5,628	3,591	1,281
1980	10,320	5,521	3,271	1,517
1981	12,502	6,626	4,188	1,688
1982	12,600	6,577	4,385	1,638
1983	12,700	6,630	4,420	1,650
1984	13,500	7,047	4,698	1,755

Source: Total Expenditure, 1960-77: Yrarrázaval, op.cit. [1979]; 1978-84 and expenditures by commodity programs: SNA, Experiment Station Office.

TABLE 2.12. Semillas BAER: Research Expenditure, Total and on Wheat, 1960-84
(thousand pesos of 1984)

Year	Total Research Exp.	Research Exp. on Wheat
1960	2,033	1,872
1961	2,407	1,926
1962	2,474	1,979
1963	2,541	2,033
1964	2,608	2,086
1965	2,675	2,140
1966	2,675	2,140
1967	2,675	2,140
1968	2,675	2,140
1969	2,675	2,140
1970	2,675	2,140
1971	3,057	2,445
1972	3,439	2,751
1973	3,821	3,057
1974	4,203	3,363
1975	4,585	3,668
1976	4,964	3,974
1977	4,280	3,424
1978	4,280	3,424
1979	2,961	2,072
1980	1,911	1,261
1981	1,597	1,054
1982	2,276	1,707
1983	3,321	2,657
1984	3,560	2,848

Source: Elaborated by DEA/UC, based on:
1960-75: Yrarrázaval, et al., op. cit. [1979].
1976-84: Semillas Baer, personal communication Ing. E. von Baer.

TABLE 2.13. Chile: Professional Staff Involved in Agricultural Research, Total and by Institutions, 1965-83

Years	I N I A		U C H		U C		U C C		U A		Private	Total	
	Total	PhD	Total	PhD	Total	PhD	Total	PhD	Total	PhD		Total	PhD
1965	115	4	53	1	14	2	27		5		3	214	7
1966	120	5	56	2	12	1	28		7		3	226	8
1967	139	5	67	4	15	2	31		9		3	264	11
1968	151	9	71	4	13	3	35		11		3	284	16
1969	155	10	78	4	19	4	38		16		3	309	18
1970	153	11	89	5	23	6			19		3		
1971	158	15	103	6	23	7			23		3		
1972			115	8	25	10	33		27		3		
1973			137	9	25	10	36		32		3		
1974	153	13	145	9	24	14	33		38		3	396	36
1975	152	13	153	13	24	12	38		44		3	414	38
1976	160	14	161	12	21	12	38		50		3	433	38
1977	165	14	165	14	21	15	28		55	11	3	437	54
1978			170	14	22	17	29		60	12	3		
1979	195	17	173	15	27	20	29		56	12	3	480	64
1980	168	17	172	15	33	21	31	4	61	13	3	468	70
1981	172	16	173	16	36	23	26	4	50	10	3	460	69
1982	171	18	172	16	36	25	28	4	48	10	3	458	73
1983	180	21	172	16	36	28	27	4	48	10	3	463	79

Source: See Appendix Tables.

2.4.2. Levels of Training

Given the importance of advanced training for research workers, it is interesting to note the proportion of the staff that have advanced degrees. Both INIA and UCH have maintained a PhD proportion of 8 to 10%, with a somewhat higher proportion at UCC and UA. A very different situation exists at the UC, where for several years the PhD staff have comprised over 50% of the total, reaching 70% in recent years. Further details on the level of training of staff at the different institutions are presented in Appendix Tables A-2.5, A-2.11, A-2.14.

Despite difficulties with sending candidates for graduate study abroad in recent years, because of the fall in international fellowship support, some of these institutions endeavor to sustain staff development programs. INIA, for instance, keeps approximately 10% of its staff in advanced training annually, mostly supported by INIA's own resources. This proportion appears to be much lower at the faculties of agriculture, which depend more heavily on eventual outside fellowships.

2.4.3. Turnover of Staff

Staff turnover was a problem in some institutions over the period 1974-80, especially in INIA, although it never reached proportions which endangered the overall, or the major research programs. The following Table 2.14 shows the loss of staff at INIA.

The problem has been serious, especially because many of those leaving have been senior researchers, or MS and PhD level staff (between 7 and 33% in different years). The main reason for resignations after 1975 appears to be the relatively low level of salaries at INIA; the post 1981

TABLE 2.14. Staff Turnover in INIA, 19/0-83

Year	Number of Researchers Resigning	% of the Total Staff
1970	1	0.6
1971	4	2.5
1974	26	17.0
1975	13	8.5
1976	13	8.1
1977	16	9.7
1978 and 79	21	6.5
1980	22	11.2
1981	12	7.1
1982	3	1.7
1983		

Source: INIA, Annual Reports.

recession has decreased the opportunities for employment in the private sector, which probably explains the reduction in staff losses.

The Faculty of Agriculture, UCH is the other institution that has suffered important staff losses (i.e., PhD level professors) over the same period, ranging between 8 and 10% of the total annually. However, in this case, many transferred to other institutions, notably the Catholic University. The main reason for resignations appears to be the unavailability of funds and other facilities for research, rather than salary differentials.

2.4.4. Staff Distribution by Research Areas

The distribution of staff by major subject areas and/or disciplines at the various institutions is shown in Appendix Tables A-2.4, A-2.10, A-2.13, A-2.15. Invariably, the majority are dedicated to crops research (including fruits and vegetables), followed by livestock production research. Soils research also occupies a significant number of staff. Two dissimilar features are the large number of people assigned to technology transfer at INIA and the large size of the agricultural economics staff at UC. Both these points were discussed earlier.

The number of researchers directly concerned with the five IARC-related commodities at the various institutions are presented in Appendix Tables A-2.7 and A-2.12. Wheat research occupies the largest number of scientists -approximately sixteen in total- followed by beans and other legumes, with about nine or ten; and potatoes with six or seven. There are no more than two full-time equivalent scientists in Chile working on each of the crops, maize and rice. Except for wheat, the research groups for the other crops (considering there are four important legumes) appear to

be pretty small for the magnitude of the research task to be accomplished.

2.4.5. Employment of Women Researchers

The employment of female[11] researchers in Chile is conditioned by the size of the supply, more than anything else. Traditionally, the ingeniero agrónomo career did not attract many female students; prior to 1960, female agronomists were trained only at the University of Chile. At present, approximately 35% of the total enrollment of the five agricultural faculties (about 1,500 students) are females. However, it should be noted that some of the female researchers in agriculture have professional degrees in subjects such as biology, chemistry, statistics, etc., which explains the relatively high proportion of women on the staff of some institutions.

Data on female employment at INIA are shown in Appendix Tables A-2.8 and A-2.9. Throughout the years, approximately 11% of the research staff have been women. From 1974 to 1979, the director of La Platina Station was a distinguished female ingeniero agrónomo. Few of the women, however, hold advanced degrees.

At the Faculty of Agriculture, UCH data for 1980 show that 29.2% of the full-time staff were women. One of these had the PhD degree, and seven the MS degree.

On the UC Faculty staff there are only two females (5.4%), one PhD and one MS; there were none prior to 1980,

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[11]There are no legal restrictions to female employment in Chile generally; quite the contrary, there are several legal benefits to protect the employment of pregnant and lactating mothers, to provide nursery attention, etc. In fact, some of these legal measures may sometimes hinder a larger employment of women, because of their higher cost to the employer.

except in teaching administration.

2.4.6. Role of Foreign Researchers

Long-term expatriate scientists in agricultural research never were very numerous in Chile, despite the volume of foreign assistance in effect until the early 1970s. INIA was the principal host institution; it had five visiting researchers each year between 1965 and 1970, supplied by the Rockefeller and Ford Foundations, the West German Technical Mission, FAO, USAID and OAS. (INIA, Memorias Anuales). Data for the period 1971-73 are nebulous, but by 1974 there remained no foreign staff at INIA. Since 1979, INIA has served as home base for CIMMYT staff assigned to its regional wheat program in the Southern Cone. The two CIMMYT staff based at INIA have played an important research support role for the Chilean researchers (see next section).

Among the universities, only the Agriculture Faculty of the UCH received a significant input of visiting staff, under the Chile-California project, from 1966 to 1973. These at times reached 10 professors, but only a maximum of four were in residence for periods of more than one year. These scholars had other responsibilities besides research, however.

2.5. External Influences on the NARS

The Chilean NARS has been deeply influenced by external agencies since its very inception as a modern research system. Reference has already been made to the key role played by the Rockefeller Foundation from 1955 to 1970, and even earlier. The USAID (ex-ICA), Ford Foundation, IICA, and the universities of California and Minnesota are other institutions that have strongly influenced agricultural research, often through their assistance in training

scientists abroad and in setting up graduate programs (MS level) in the Chilean agricultural faculties. In fact most, if not all, of the 100 or more Chilean PhD in the agricultural sciences have been trained under some kind of foreign aid program. Most of them were trained in U.S. universities, thus, the character and methods of agricultural research in Chile are fundamentally shaped after the North American model, even though the institutional organization in Chile may be different.

Other agencies such as FAO, UNDP, World Bank, IDB, OAS, IDRC and some developed country aid agencies have also provided selective, or indirect support to agricultural research in Chile over the past three decades. However, none of these have had a deep influence on the NARS, partly because of the magnitude of the aid involved, and because of the paramount leadership role established by the Rockefeller Foundation from the outset.

Since the mid-1970s, external aid agencies have practically ceased to be of broad significance for agricultural research in Chile. The exception are the IARCs, notably CIMMYT, CIAT and CIP, which are fulfilling an important, sustained technical cooperation role, mostly through INIA. The IARC activities and impact on the NARS are discussed in Section III.

In recent years, the principal external programs that relate to agricultural research operating in Chile include:

(a) FAO's "Networks of Regional Technical Cooperation" in Latin America, in some of which Chile participates, namely: food legumes in the Southern Cone, watershed management, organic recycling and biogas, agricultural marketing.

(b) UNDP-FAO projects on: post-harvest grain storage, with INIA; and development of arid and semi-arid zones, with CONAF (includes some forage research).

(c) The BID/IICA/CONOSUR project, very important for INIA. This will be further discussed in the next section.

(d) IBRD loan for technology transfer to small farmers, operated through INDAP. It may marginally affect agricultural research.

(e) Denmark/FAO and Ministry of Agriculture for Development and Training in Dairy, at the Universidad Austral.

(f) IDRC projects on Triticales and forage crops at the Catholic University.

All of the above, however, do not amount to much in terms of budgetary support, visiting research staff, fellowships, etc. for the Chilean agricultural research institutions, at least not relative to the present size of the NARS. The greatest value of such external assistance lies in facilitating communications and international contacts and exchanges among Chilean scientists and colleagues elsewhere.

2.6. Effectiveness and Problems of the NARS

2.6.1. Assessment of the Productivity of the Agricultural Research Establishment

From the foregoing description of the Chilean NARS, it can be appreciated that agricultural research is an enterprise of considerable magnitude which has developed strongly in the last two and a half decades. It is rather diversified institutionally and in subject matter coverage, and it is quite loosely structured so that it hardly constitutes a system. This NARS is generally considered to

have made a significant contribution to the improvement of agriculture and to the economic and social development of the country. Unfortunately, this assessment is based either on rather broad indicators, of a descriptive nature and characterized by loose correlations of facts, or on rigorous, but very specific economic analyses of a few aspects of research. There has not been made a thorough, sound aggregate evaluation of agricultural research in Chile.

(a) Broad indicators

A number of studies (Elgueta, 1982; Manterola, 1983; Bonilla and del Pozo, 1983; Cortázar, 1973) assert the important contributions made by research through describing examples of domestic research-generated technologies that have been adopted in the country, sometimes providing a rough quantification of the impact of such technologies. For instance, it is noted that crops for which there has been a sustained research effort (wheat, maize, sugar beet) show a rising trend in average national yields, while for those in which research has been lacking or insufficient (rice, potatoes, lentils) yield trends have been stationary or even falling. Also, the extraordinary development of fruit production is associated with the help provided by research on pest and disease control, fertilization, post-harvest technology, etc. Similarly, improved beef and sheep production is associated with the development of local technology in seedgrasses and pasture management, introduction and adaptation of new breeds, etc. The most significant of these and other innovations are further discussed in Section 4.1.

While all these indicators provide a good, convincing argument that research has had a positive effect on some aspects of Chilean agriculture, they are not sufficient

to demonstrate a high productivity of the investment made in research, either generally or in specific programs or at given institutions. The weakness of the research community in arguing its case with strong analytic tools and studies was a major factor in inducing government policy makers since 1977 or so to reduce and/or change the mechanisms for funding agricultural research. The government economists looking at this problem were not persuaded by descriptive arguments of the efficiency of the NARS, and especially of INIA, in generating and getting adopted the technology required by Chilean agriculture. However unfair this appraisal may have been, it has at least forced a much livelier and more professional concern with the evaluation and justification of research programs.

On the part of university research administrators, there have also been efforts at measuring the productivity of research, following the technique most common in these institutions, that is, quantifying the output of publications (Krauskopf, 1980; Cañas, 1981). The study by Cañas refers specifically to agriculture; its results are summarized in Table 2.15.

(b) Economic evaluations of agricultural research

An effort to evaluate more rigorously the economic impact of research in Chile has been made in the case of three crops: wheat and maize (Yrarrázaval, et.al., 1979) and rice (Franco, 1981). For the first two crops the analysis is ex-post and attempts to measure the social payoff to research investments incurred since the 1940s exclusively on genetic variety improvement. For rice, the analysis is ex-ante for the period 1981-2000 and assesses social costs and benefits of improved rice technology, combining varieties, fertilization and other management practices.

TABLE 2.15. Scientific Agricultural Publications in Chile, by Institutions, Biennium 1979-80

Publications and Personnel		INIA	UCH	UC	UCC	UA	Others	Total
Publications	N°	110	139	76	24	70	22	441
	%	24.9	31.5	17.2	5.4	15.9	5.0	100
Researchers[a/]	N°	161	229	34	35	94	77	630
	%	25.5	36.3	5.4	5.5	14.9	12.2	100
Publ/Res.		0.68	0.61	2.22	0.67	0.50	0.29	0.70

a/ Excludes administrators and includes veterinary sciences and forestry. Includes only full-time staff.

Note: The publications considered in the study are all refereed and cover 90% of the total in Chile.

Source: Cañas, 1981.

The study on wheat and maize followed the methodology suggested by Lindner and Jarrett comparing directly costs and benefits. The costs considered both the research and extension expenditures incurred by the Ministry of Agriculture and INIA (including Rockefeller Foundation contributions) the SNA, Caholic University and Semillas Baer. Social benefits were estimated on the basis of supply shifts measured at the experiment station level, comparing improved versus traditional varieties. The diffusion of varieties was estimated from the production and sale of certified seeds[12]. The economic indicators calculated were the net present value using a social rate of discount of 15%, and the internal rate of return. By both measures the two research programs are judged as very good. The IRR obtained for wheat is between 21-28% and that for maize, 31-33% (the alternative values depending on the assumptions made regarding supply shifts and rates of diffusion).

The study on rice refers exclusively to INIA's rice research program, and projects costs and benefits between 1981-2000 on the basis of data for the previous 15 years. The same basic methology is followed as in the previous study. The IRR obtained ranges from 86.8% to 105.2%, depending on alternative assumptions about yield increases and areas seeded to rice.

In sum, these studies would corroborate the high social value of agricultural research in Chile, at least

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[12]The procedure followed by Yrarrázaval et al. most likely underestimates considerably the spread of the new varieties in the case of wheat, because of the retention of seed by the producers even well beyond the time certain varieties cease to be certified. Current estimates of area seeded to wheat varieties, indicate a much larger total area than that used by Yrarrázaval et al.

judging by these three cases investigated in depth. Actually, the wheat and maize evaluation has become a powerful weapon to defend INIA's budget and programs since 1979, given the independence and soundness of the study.

2.6.2. Problems of the NARS

From the foregoing review, and judgements of senior officials and researchers, the main problems affecting the Chilean NARS may be summarized as follows.

(a) National economic policy has generally underestimated the role of technological innovations for agricultural development, and the need to have a strong national capacity to generate, adapt and transfer this technology. Policies have either stressed the distributive aspects of socio-economic activity (land reform, price controls and subsidies) or have assumed that agricultural technology should largely develop in response to an effective demand for it. Under both situations, agricultural research receives low priority in public support and spending.

(b) Because of the above, national planning and coordination for agricultural research have been very weak, and/or short-term, and subject to frequent changes. For an activity with the special characteristics of agricultural research, this lack of guidance and stability surely results in a less effective use of available resources than could be otherwise.

(c) Extension, or technology transfer, has been especially weak, unsteady and largely divorced from the research establishment. This fact most likely has reduced the adoption of research results, the relevance of some of the research carried out at the experiment stations, and hence farmers' and government support for the NARS.

(d) Farm producers have had little direct influence and participation in INIA and the university research institutions over most of the period analyzed. The effect is similar to that in (c).

(e) The loss of highly trained, experienced research staff has been a problem at INIA and the UCH in the 1970s. Salary levels and/or other working conditions are considered the main causes of staff turnover. This is a serious threat to the NARS because of the very limited opportunities now available in Chile for fellowship support to study abroad. The average quality of the agricultural research scientist community could deteriorate in the years ahead.

III. IMPACT OF THE INTERNATIONAL AGRICULTURAL RESEARCH CENTERS ON THE NARS [13]

3.1. Nature and Extent of IARC-NARS Collaboration in Chile

Given that the oldest IARCs in Latin America - CIMMYT and CIAT - originated from the Rockefeller Foundation programs in Mexico and Colombia, and given this Foundation's long-standing involvement in Chile's agricultural research, it can be appreciated that the country's contacts with these centers in a way antecede their founding as IARCs. This is particularly true in the case of wheat and maize research. It is not surprising, then, that the international links of the Chilean NARS are strongest with CIMMYT and CIAT.

Something similar applies to CIP, the other Latin America-based IARC; but its relatively more recent founding and the fact that potatoes are a less significant crop in Chile than the cereals and legumes, determines that CIP's degree of involvement in the Chilean NARS is slightly less pronounced.

The other IARCs with some collaborative activities in Chile are IRRI (though indirectly, through CIAT), ICARDA, ICRISAT and the IBGPR. Very minor contacts have existed with IFPRI and ISNAR, which cannot however be considered as constituting any form of assistance, or collaboration with the NARS.

On the whole, CIMMYT has had the strongest ties and influence in Chile, among other reasons because of the overwhelming importance of wheat as a food crop in Chile and

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[13]This chapter is based mainly on interviews with senior research administrators and scientists of the NARS, and on the response to a written questionnaire by Chilean researchers.

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the consequent large scale of the wheat programs in the Chilean NARS, as was shown earlier. CIMMYT also collaborates in research on maize, triticales and barley. On this last crop, there has been some confusion about ICARDA's eventual role, but in practice so far all collaboration has been with CIMMYT.

The fact that CIMMYT has had staff based at INIA, to serve its Southern Cone wheat program, has reinforced this Center's role in the country. Collaboration has extended beyond crop improvement research, into agronomic practices and production systems research. Finally, an occasional and minor collaboration has existed also in the agricultural economics field.

Additional factors in the close ties between CIMMYT and INIA, in particular, are related to personal staff connections. For instance, the founding director general of INIA was a member of CIMMYT's board for several years; INIA's president since 1978 was previously a senior administrator in CIMMYT for many years; and other senior staff at INIA and CIMMYT have been employees of one or the other institution prior to their current assignments. No similar degree and level of staff interchange has existed between Chilean NARS institutions and other IARCs.

CIAT's active collaboration is more recent than CIMMYT's, in accordance with the expansion of INIA's legume research since the early 1970s. It has centered primarily on beans, and to a lesser extent on rice, corresponding to the relative importance of these two crops in the Chilean NARS. However, CIAT has also had a significant impact on other aspects of INIA's work, namely on pasture research (in relation only to methodology of evaluation, since CIAT's tropical species are not grown in Chile), on techniques for

germplasm collection, on seed production and management (including assistance to SAG) on experiment station management, and on production and use of audio-visual materials for training and extension. In other words, CIAT appears to be playing a broad support role in research techniques, seed management, and training, besides its specific collaboration on beans and rice research.

Since the mid-1970s, CIP's cooperation has been strictly focussed on potato research, but covering a progressively wider spectrum of activities in relation to this crop, from genetic improvement, to storage techniques, economic analysis, research organization, and technology transfer methodology. Of all the IARCs, CIP appears to have paid the most attention to help structure a domestic research and transfer network, based around INIA. In this sense, its impact on the NARS, and not just INIA, may be more significant than the importance of the potato crop may indicate.

Research cooperation for lentils, peas and chickpeas has been established with ICARDA, although this is a relatively recent activity (late 1970s) and still quite incipient. Contacts with ICRISAT on these same crops are minor; most of the support this center may offer is channelled through ICARDA. However, ICRISAT has maintained an interchange of genetic materials for lentils, chickpeas and horsebeans with the SNA Experiment Station.

IFPRI and ISNAR relationships with Chile have been limited to sporadic personal contacts with staff of some of the Chilean NARS institutions; visits and/or attendance by Chileans to international seminars or workshops organized by these IARCs; and publication of studies on policy and research management that, by virtue of including Chilean data, are of interest to the country. These activities, however, have had

no impact on the NARS; therefore, no further significant reference to these IARCs will be made in the remainder of this study.

A basic feature of the IARCs-NARS relations in Chile is the direct and overwhelmingly important connection with INIA. The national institute is the principal conduit for all collaborative IARC activities in the country. The Ministry of Agriculture and ODEPA play virtually no direct role in this collaboration. This is understandable, given what was said earlier about the lack of central organization of the Chilean NARS, the predominance of INIA in the system, and the considerable delegation of public responsibility for agricultural research decisions in INIA's administrators. Notwithstanding, it is important to note that the IARC collaborative activities are carried out at all levels within INIA, with substantial direct research cooperation established in INIA's regional research stations. This is especially so for crops such as potatoes and barley, whose national program leaders are located in regional stations.

On the other hand, the IARC's collaboration with the universities and private research entities is rather casual, of a personal nature, not established on a programmed basis, often operated through INIA, and is largely simply responsive to requests by these institutions. Probably the reason for this situation is the necessity of the IARCs to target their limited resources on a few significant projects, and the disparity, newness, instability, or other unencouraging attributes of the non-INIA portion of the NARS. Nevertheless, this feature of the IARC's collaboration should be examined carefully, for it may have some negative consequences on development of the NARS, while it may mean also missing promising opportunities for productive research and technology adoption in the country.

Finally, another important characteristic of IARC-NARS collaboration in Chile has been the effectiveness and expediency of this collaboration, which is in marked contrast with the typical international organizations' slow and bureaucratic behavior. This easy and efficient form of communication and assistance seems to have become possible, among other reasons, because of the frequent, professional and friendly personal contacts established between a large number of the Chilean researchers and their IARC colleagues. Thus, the importance of the staff exchange mechanisms characterizing the IARC's participation in Chile cannot be overestimated.

The IARC's collaboration with the NARS takes many different forms, which may be conveniently subdivided as follows for subsequent analysis and discussion:

(a) Provision and exchange of biological materials
(b) Staff training, professional contacts, and information
(c) Research ideas, techniques and methods
(d) Research organization, planning and priorities
(e) Financial and material support
(f) General "public" support for NARS

In the following sections, the above topics will be reviewed in terms of the role played by each of the relevant IARCs, by crops and in relation to the various institutions included in the NARS. The relative value of the various activities for strengthening the NARS will be assessed mainly on the basis of judgements by research scientists and administrators of the national institutions, and also on objective measures of the magnitude of the efforts involved.

3.2. Biological Materials

The provision of biological materials by the IARCs to the NARS is considered the most important contribution made

by the centers. This is the basic, key function of the IARCs, around which the other services provided may acquire a greater or lesser meaning; i.e., the latter are seen as complementary to the exchange of germplasm, which has been the main component of the whole crop improvement effort. All the IARCs relevant to Chile have played significant roles in the provision of germplasm. A brief description of their main contributions by crops is presented in the following paragraphs.

It should be noted first, though, that collaboration on breeding materials is a two-way affair, because the Chilean institutions also supply their local materials (sometimes collecting native species) to the IARCs, and because they grow gardens of IARC varieties and do screening for the IARC's worldwide programs. While these activities are largely a contribution of the NARS to the IARCs, the former often benefit too because out of the collecting and/or screening of materials, they obtain valuable lines and information for domestic use.

Wheat. For many years Chile has been receiving a great deal of wheat lines and varieties from many foreign sources. It is estimated that about 10,000 of these per year have been received over the last decade. CIMMYT has become the principal supplier of this material. Such continuous, long-term, massive incorporation of wheat germplasm to the national programs has been of the utmost importance for wheat improvement.

A great advantage of Chile with respect to CIMMYT breeding material is its excellent adaptation to the country. Various estimates indicate that approximately 60-80% of all wheat varieties used in central Chile originate from CIMMYT materials. Thus, Chile probably represents the case of the

highest utilization of CIMMYT germplasm of any country in the world.

Adaptation of CIMMYT lines to Chilean conditions is so good that sometimes these lines are directly adopted as varieties, and distributed for commercial use. Such is the case, for instance, of varieties labelled in Chile as Chasqui, Millaleu, Marianella, SNA1, etc. In most cases, however, the CIMMYT lines are used for crosses and incorporated in locally developed varieties. Besides INIA, the Catholic University and the SNA have been the major institutions benefitting from CIMMYT's collaboration in this area.

An important feature of wheat growing in Chile is the use of winter wheats in the Southern regions, and of crosses of these and spring wheats (known locally as "alternative wheats") in the mid-South. The latter ones allow a longer period for seeding time, which is an important factor affecting yields, given the typical weather instability. CIMMYT's influence has been less marked in the development of these types of wheats, since the basic winter materials are obtained primarily from Europe and North America. In this respect, CIMMYT has helped by serving as bridge between INIA and the Universities of Oregon and Washington State, with both of which there is strong collaboration. On the other hand, this particular characteristic explains why research institutions like Semillas Baer and the Austral University, whose wheat varieties are widely used in Southern Chile, have actually had very limited contacts with CIMMYT. In fact, none of the SB present commercial varieties contain CIMMYT materials, nor does the UA marketed variety either.

The provision of biological materials is particularly important in wheat, because in Chile (a) some 90% of the wheat acreage is seeded to "improved" varieties and

(b) it has been shown that the average "useful life" of a variety is about five years. Therefore, there is a permanent need to produce new varieties to satisfy an effective demand by farmers. This helps explain the strong participation of universities and private institutions in wheat research and seed production.

Triticale. Research on this crop conducted at INIA has been based on CIMMYT materials and has led to registration of two varieties (none in use by farmers yet, however). Triticale research at the Catholic University uses both CIMMYT and Canadian materials; the UC in turn has supplied triticale lines to the Austral University for its program. The SB station has done some research on triticales, based on materials from Hungary, Germany and Canada. None of these three institutions has yet obtained satisfactory varieties for commercial release.

Barley. Exchange of biological materials between CIMMYT and INIA for this crop has become significant only since 1982, and there is incipient collaboration with ICARDA. CIMMYT materials are also used by the SNA. Barley research, however, is very limited in Chile, so that no significant impact can be appreciated on this crop.

Maize. Almost all grain corn grown in Chile is in hybrid varieties originated in the US Midwest. Adaptation of these hybrids has been good enough to justify the near total discontinuation of maize research in Chile. The first hybrids used in Chile, however, were created by the Ministry of Agriculture in the early 1950s; the Ministry and subsequently INIA developed the local agronomic practices for hybrids that facilitated the later penetration of commercial seed companies.

INIA has continued to carry on a small research activity on maize improvement, centered on open-pollinated

flint corn (Camelia) and or corns for fresh consumption. In 1983, it produced again two local maize hybrids. Some of the universities also have conducted limited corn research, focussed on silage corn. In all these cases, biological materials from CIMMYT have been incorporated.

Beans. Research on beans has benefited from good CIAT support since 1975, despite the fact that the bean types grown and the predominant problems of this crop in Chile are not in the mainstream of CIAT's concerns. This divergence of interest determined that initially CIAT sent to Chile biological materials indiscriminately, which made cooperation of little value. As contacts and communications intensifed between INIA and CIAT, local problems became better understood and the nature of collaboration on exchange of biological materials improved significantly. Of particular importance has been the supply of lines resistant to certain diseases that are severe in Chile (e.g. mosaic and root fungi). CIAT has played a crucial intermediary role in obtaining mosaic resistant material from the IVT in Holland, which would not make it available to INIA. Several CIAT international screening essays for beans are also conducted in Chile. On the other hand, CIAT has done specific crosses for INIA's bean program, which are then tested in Chile. All this cooperation on genetic improvement has permitted a much more rapid advance in the country than would have otherwise occurred. Nevertheless, progress on bean improvement is difficult because of the extreme susceptibility of the crop to sudden changes in strains of pathogens, and because of the many different types of beans grown (e.g. for green consumption, soft beans, hard beans, for domestic use and for export).

CIAT bean materials have been supplied not only to INIA, but also to the SNA, the universities and to some private seed companies. In fact, it should be noted that

Chile has had frequent recourse to the importation, or introduction of commercial varieties from abroad, especially the USA in the case of beans for export. Not only private seed companies, but also INIA and the SNA have followed this course in their seed production programs.

Lentils, Chickpeas and Other Legumes. Cooperation with the IARCs on these crops dates only from the late 1970s. The provision of germplasm from ICARDA and ICRISAT has been of great value because of the scarce genetic variability available in the traditional Chilean varieties. Disease-resistant lines are especially important in the case of chickpeas. Direct transfer of varieties in these crops, however, is not feasible because of the different consumption habits of the Middle East and Asian countries, compared to Chile (e.g. small versus large lentils, respectively). While INIA receives biological materials and conducts international screening essays for ICARDA in lentils, it has also supplied materials that are of interest to the IARCs, especially because of the large-size grain.

Besides INIA, ICRISAT materials have been used in the SNA Station (lentils, chickpeas and horsebeans) with good success, and ICARDA lentils have been used in the University of Concepcion's research program.

There is practically no research on peas in Chile; the germplasm available in the country comes from importation of commercial seeds from Europe and the USA.

Research on sweet lupines is conducted by the SB station; the materials originated from Europe, and later from Ecuador, Perú and Bolivia.

Given the rather short period of collaboration, there are no commercial legume seeds produced in Chile that contain IARC biological materials yet.

Rice. The IARCs collaboration on rice research in Chile is restricted to INIA, which has a very small rice program. Nevertheless, since 1977 the assistance provided by the CIAT/IRRI program has been very important, helping develop rice varieties tolerant to cold weather, and of better eating quality (long grains). However, none of these varieties have been released yet for farmers' use. The original rice materials available in Chile, mainly introduced from Italy in the 1930s, offered very little genetic variability; this has been greatly improved upon with the CIAT/IRRI contributions. As in the case of beans, the initial supply of germplasm from the IARCs, suited to tropical conditions, was of little use to Chile; increased understanding of the local problems by the IARCs has led to a more targeted support, so that now over 50% of the CIAT/IRRI lines tested can actually be harvested and used in the Chilean breeding program.

Potatoes. For many years, INIA's strategy for potato improvement was to introduce varieties from abroad, especially from the Netherlands. Over the last ten years, however, emphasis has been placed on breeding, in close collaboration with CIP. Initially, crosses were made at CIP and testing and selection done in Chile; now all work is done at INIA's Remehue and Platina Stations, but using imported parent materials, largely supplied by CIP. However, of INIA's commercial varieties presently used by farmers, none yet originate from the CIP collaborative program.

The Universidad Austral's potato breeding program also uses CIP materials, which it gets via INIA. This university has also received assistance from IBPGR, for which it has collected and evaluated Chilean potato germplasm.

Another useful form of assistance has been the intermediation of CIP to help obtain disease resistant materials from Holland, which were refused to INIA.

3.3. Ideas, Research Techniques and Methods

Given the intensive staff exchange, training and information programs of the IARCs in Chile (see next section), it is difficult to determine to what extent some of the research ideas and techniques observed in the NARS originate locally, or have been picked up at the centers, or brought in by center visiting staff. In some instances this point actually generates conflict because national scientists feel that credit for their work is attributed to, or is appropriated by an IARC, rather than they receiving it. With these caveats, in the following paragraphs some research contributions that appear clearly attributable to IARC collaboration are presented.

Two observations should be made beforehand, though. First, Chile has received a steady, fairly intensive flow of short-term visiting scientists from the Latin American based IARCs for many years, in relation to all the relevant crops on which collaboration has been established. Some projects may be visited two or three times per year by IARC staff; often these visits extend to the regional stations where trials are carried out. Furthermore, on occasions, ad hoc technical assistance has been provided on INIA's request, as for example in 1978/79 when an outbreak of barley yellow dwarf disease threatened the wheat crop. A CIMMYT specialist helped to solve the problem and plan future research work on it. Thus, technical assistance for crop research from the IARCs has been strong in Chile.

Second, the IARC's influence on research methods is limited almost exclusively to INIA and, there, to specific problems or crops; i.e., there has not been a broad impact on approaches or methods of research throughout the institute. On the whole, the universities and private agencies have not had

cooperative projects with the IARCs that might have permitted a significant direct influence on their research projects and methods. One exception is the SNA, which for the last two or three years has received assistance in wheat breeding from one of the resident CIMMYT scientists; this has been of tremendous importance for improving the SNA's breeding program, leading to the incorporation of a large percentage of CIMMYT materials. The other exception is the U.A., that has improved its methods for handling potato germplasm with assistance from CIP.

In wheat, the thorough and long-standing collaboration between CIMMYT and INIA indeed has affected the national breeding program, but it is felt that for many years now there haven't been striking new ideas or methods brought in this area. CIMMYT assistance in research planning design and execution has been important in barley; which becomes more evident because of the small size and weakness of the domestic barley program. In recent years, CIMMYT impact has become significant in the area of agronomic practices and development of research on production systems. This influence is intimately tied to the work of one of CIMMYT's resident staff at INIA, and to ideas and methods suggested by visiting CIMMYT staff. For instance, an innovative project along this line of research has been developed at the Quilamapu Station since 1978/79, focussing on production systems for the coastal drylands of Central Chile, where wheat and dry legumes are the principal crops. Combining "pieces" of known local research results (wheat varieties, legume varieties, fertilization rates, weed control) into a systems approach reportedly has resulted in a three-fold increase in wheat yields at farmer's field level, in addition to improving the legumes and pasture production potential. This approach to research has opened a whole new, very promising field of work at INIA.

CIAT has influenced bean research through continuous review and discussion of approaches and methods, introducing for instance the idea of broadening genetic diversity in the Chilean program. In fact, on occasions it was felt that CIAT may be too overbearing in its assistance on research methods. A very important contribution by CIAT has been in methodology for pastures evaluation, despite the fact that tropical pastures are not usable in Chile. However, the evaluation methods are transferable and are being used by INIA. Similarly, CIAT has helped with techniques for collection of germplasm of native forage species in collaboration with IBPGR and FAO. Finally, the rice program also has been significantly helped in its breeding approaches and methods through CIAT/IRRI assistance; as for barley, the impact is large because INIA's program is so small and weak.

Finally, the impact on research orientation and methods has been most important in potatoes, where CIP's role appears to have been outstanding. The fact that INIA's potato program is based in the minor outlying Remehue Station, and that the Chilean staff responsible for potato research have not had advanced graduate training, help explain the important role that CIP's assistance has had. Besides its overall, albeit subtle, influence on INIA's potato program, some specific contributions are: techniques for accelerated germplasm multiplication (use of vegetative materials); use of botanic seed for potato production; methods for adaptation of genetic materials to day length; methods for inspection and testing of materials for disease and virus resistance; storage techniques using diffuse light; and economic analysis of seed potato production in Chile.

To sum up, there is sufficient evidence of the transfer of research technology from the IARCs to the NARS,

mainly INIA, over the last decade in Chile to conclude that the country has benefited significantly from this form of international collaboration.

3.4. Training and Information

The IARCs have been providing diverse training services to the NARS through a variety of mechanisms over the last twenty years. These, however, have become relatively much more important for Chile in the last decade, because of the radical fall in foreign assistance for formal graduate degree training abroad in this period. While, again, this training has largely focussed on INIA staff, it has extended also to selected university personnel. Information, on the other hand, in the form of published materials by the IARCs is widely distributed to all NARS institutions.

Training activities include those carried out at the IARCs, in the country, and in third countries. The most important ones are the first, which consist of:

(a) Short-term, ad hoc visits to the IARCs to discuss, or look at specific subjects: This corresponds to what is known as the "visiting scientist" program. Practically all INIA program directors, leaders and senior scientists have participated in this form of exchange at CIMMYT, CIAT and CIP many times over the last ten or fifteen years. A few have also occasionally visited ICARDA, ICRISAT and IRRI on similar missions. These visits have served to select materials at the IARCs for the Chilean programs, to review approaches to research, discuss particular problems, plan joint activities, etc. They have been instrumental in increasing the effectiveness of collaboration on biological materials and research methods.

Under this item one should also include the participation of Chilean scientists in review teams for IARC programs; e.g. for beans at CIAT in 1981.

(b) Medium-term courses: This refers to the three to nine month courses, for developing country researchers, that are regularly held by the IARCs. CIAT has played a major role in this type of training, having enrolled in such courses; practically all of INIA's bean researchers, the rice program leader, staff responsible for seed production, researchers in entomology, soil fertility, etc., and some of the transfer of technology staff.

CIMMYT's courses were useful earlier on, but it is now felt that their level is too basic for the Chilean wheat researchers. However, they continue to be used; in particular, three INIA scientists have attended agronomy and production systems courses in the recent past. CIP has enrolled several of the potato staff in its courses. Especially useful have been the courses at ICARDA for researchers on lentils and chickpeas, given the generally backward state of knowledge on improvement of these crops in Chile. Three INIA scientists have attended ICARDA courses since 1980.

(c) Workshops, seminars and special topic short courses: Several INIA and a few university researchers have been invited to this kind of event at CIMMYT, CIAT, CIP on many occasions. The activity is generally considered very valuable for the advancement of national research.

IARC training activities within Chile are limited to participation by center scientists in courses and seminars organized by INIA and others in the country. For instance, CIP has contributed two or three scientists as speakers to the

annual national potato meetings and has supported three international potato courses since 1977. CIAT has done similarly for an international course on beans and legumes held in 1982, now being repeated in 1985. CIMMYT was instrumental in supporting a seminar on the economics and administration of agricultural research in 1979. Although all this may seem a marginal contribution, it is extremely important in raising the level and impact of these activities within the country.

IARC assistance for training of Chileans in third countries has become most valuable since the departure of the traditional foundations and aid agencies. The IARCs' principal role has been in facilitating contacts and admission to regular graduate and/or special courses at foreign universities for Chilean agronomists, often combining this with thesis research at an IARC. For example, people have been trained in crop breeding at Chapingo, Mexico with the thesis done at CIMMYT; a rice entomologist studies at the University of the Phillipines and does research at IRRI; a bean breeder studied in Brazil and did his thesis research at CIAT; and so on. CIP has provided similar assistance both to INIA and the UA.

Another form of third-country training consists of IARC support, or participation in events attended by Chilean researchers. A paramount example is the IICA-Conosur/BID program, that includes workshops, field visits, seminars, etc. conducted in Argentina, Brazil, and other associated countries. Occasionally, an IARC will actually fund the attendance of a Chilean scientist to some such event; for instance, CIMMYT has paid for visits to production systems research activities in Argentina and the USA.

As said earlier, most of the IARC-related training concentrates on INIA, with only marginal participation by the

universities. This limitation reduces the potential impact on the country, especially because of the large multiplier effect the universities have, and it generates some resentment (and hence resistence to the IARCs) by university staff.

Published technical information from the IARCs (reports, newsletters, bulletins, etc.) is usually regularly received by the appropriate research scientists in Chile. There is broad consensus on the good quality and usefulness of the materials for the local research programs.

3.5. Research Organization

In general, the IARCs have had no impact on the NARS organization and very little, if any, on INIA's own organization. An exception to this statement must be made, however, in the case of potatoes and at the local level in south Chile. Here, CIP appears to have played a leading role in bringing together INIA, the UA, former INIA researchers, extensionists, private seed producers, farmers and others concerned with potatoes into an effective collaborative community. Symbolic of this is CIP's founding membership in the Chilean Potato Association (ACHIPA). From a research organization standpoint, the important effect has been to produce a closer contact between INIA and university staff than exists in any other situation in Chile (despite, for instance, the immediate proximity of the UCH and UCC agricultural campuses to major INIA stations).

IARC influence has been somewhat more significant at the level of inter-country regional organizations. Participation in the IICA-Cono Sur/BID activities has helped strengthen that program, which is given much credit by INIA for being a most valuable organization for broadening the contacts and experiences of its staff. CIMMYT's Southern Cone wheat program has played a similar, though more restricted

role. CIP has stimulated and funded PROCIPA, a Southern Cone regional cooperative potato research program (akin to Central America's PRECODEPA), which conducts several projects, two of which are coordinated from the Remehue Station. Finally, a marginal form of collaboration has been provided by ISNAR through supporting the International Federation of Agricultural Research Institutes (IFARD) of which INIA is a member.

However, on this question of regional organization, generally agencies such as FAO and IICA seem to have been more influential than the IARCs.

3.6. Relationships between IARCs and NARS

From the foregoing review of IARC-NARS collaborative activities, it can be concluded that relationships have been generally excellent, at least in regard to INIA. There is a great deal of complementarity in these activities, while very few and minor points of conflict have been detected. Chile has not suffered from competition from the IARCs in research, or for staff - a problem that is more likely to occur in countries that host an IARC. As was shown earlier, the gains from collaboration have been mutual, as the national research institutions have supplied local germplasm, conducted IARC international trials, participated as peers in IARC reviews, etc., thereby providing some services while receiving assistance.

The main limitation to collaboration is the degree to which it can be carried on, given the characteristics and needs of Chilean agriculture and the mandates and priorities of the IARCs. While this problem is virtually non-existent for potato and wheat research, it is marked in other cases. CIMMYT's maize program has been only marginally utilized by Chile for the reasons stated earlier. Of CIAT's (and IRRI)

programs, only the beans and rice research is relevant, but Chile's temperate climate puts the country at the edge of such programs. The ICARDA and ICRISAT programs are even farther away from Chile's main problems on legumes; geographic distance and the smallness of the Chilean legume acreage aggravate the divergence of interest.

Given these conditions, it is actually surprising that exchanges and assistance from the IARCs have been as extensive and fruitful as they have. The IARCs must be given credit for having made special efforts to serve Chile's needs. Although in some cases this has been a slow process and in others it is just getting underway, in the end collaboration has become quite effective. The NARS also has had to accommodate itself to these peculiarities, learning in the process how to communicate its needs and obtain the required help. The dynamics of this international effort are actually extraordinary, considering also the tremendous vicissitudes the Chilean NARS and agriculture have gone through over the period of time analyzed. Probably the key factors explaining the success of this venture are the high quality of the services provided by the IARCs, their efficiency in delivering these services, the relatively good level of the Chilean staff and the solidity of its NARS, and the close personal and highly professional contacts established among the scientists and administrators of both sets of institutions. The latter point, hinting at the lack of bureaucratic obstacles on both sides, was repeatedly stressed by all Chilean staff interviewed as a most positive feature of the IARC-NARS relationship.

The only negative note on this relationship is, again, the relatively little attention paid by the IARCs to the non-INIA part of the Chilean NARS. As was shown in the previous chapter, the universities and private research

entities represent at least 25% of the system, and in many respects their impact on agricultural production is proportionately much higher. Furthermore, under conditions of a national policy that stresses institutional diversification and competition in the research field, the IARCs would be well advised to spread some of their collaborative efforts more widely within the NARS. Such strategy would most likely help strengthen both the NARS as a whole, as well as INIA within it.

IV. RESEARCH IMPACTS ON AGRICULTURAL PRODUCTION

4.1. Important Innovations and Their Adoption

The performance of agriculture and the policy environment surrounding it, reviewed in Chapter I, have not been favorable in Chile for most of the 1960-84 period. Institutional instability first, and economic policies later on kept the sector under severe strain, which demanded drastic resource adjustments largely beyond the capacity of an overall weak economy. These conditions were not conducive to focussing priority attention on technological change, which implies a long-term, sustained effort at generating, diffusing and adopting innovations suited to a country's resource endowments and market conditions. In a way, it is paradoxical that the NARS developed so strongly under so adverse an environment for it.

This situation must be kept in mind when assessing the output of the NARS and the impact of research on agricultural development. The absence of clear, long-term objectives for agricultural research, and of sustained producers' demand for technological innovations, have certainly diminished the production of useful results from the NARS, as well as adoption of such results. Nevertheless, there have been some important innovations introduced in Chilean agriculture over the past two decades, as are described below. These innovations are discussed by sub-sectors of agricultural production (crops, fruit trees, livestock, etc.) and by single practices, where relevant, indicating insofar as there is information, the extent of their adoption by farmers.

First, however, it should be highlighted that the overall most important technological innovations in Chilean agriculture post-1960 have been the expansion of fruit culture

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with overall new technology, the widespread use of improved crop varieties especially in wheat and maize, the great increase in fertilizers and pesticide consumption, the eradication of foot-and-mouth disease, the transformation of the poultry industry into a large-scale, vertically integrated modern operation, and the introduction of new forage species and related management, especially for rainfed areas. While the NARS has been involved to varying degrees with all these innovations, it is fair to say that they originate mainly abroad. There seem to be no really important innovations as yet, representing research-based domestic solutions to autochthonous problems of Chilean agriculture. An exception may be INIA's efforts at developing production systems for specific areas (e.g. the central coastal dry lands) or for specific farmer groups (e.g. "parceleros" of the land reform) but on the whole these have produced minor results at best.

Chile is quite privileged in its agro-climatic characteristics (though not by its socio-economic ones) which enable it to transfer much of its agricultural technology from the developed countries of the northern hemisphere and Oceania; hence the NARS is wise to concentrate on adaptive research rather than trying to be original. The following review tends to confirm this observation.

(a) Annual crops

The most significant area of technical innovation on annual crops has been variety improvement, aimed at increasing yield potential and disease resistance. Advances in seed certification, production, and distribution are closely tied to the research effort on varietal improvement. Innovations in agronomic practices for crops have generally been of less significance, per se, although they are necessary to realize the yield potential of the new varieties. That is,

research on dates of planting, seeding rates, fertilization rates, chemical applications, etc. has been of the adaptive, or fine tuning type; except for maize, the resulting changes in technology have been gradual and do not represent a radical break from previous practices.

A brief description of these innovations and their degree of adoption for the major crops is presented in the following paragraphs.

Wheat. The introduction of high-yielding dwarf and semi-dwarf wheat varieties and associated management practices has been a major innovation since 1960. Though its CIMMYT origin is well known, the local adaptation was due to INIA, soon followed by the SNA and the rest of the NARS. As said earlier, wheat varieties need to be changed periodically because of loss of disease-resistance; the NARS has been quite effective at maintaining an appropriate rate of innovation in this area.

Farmer response in the adoption of these varieties also has been exceptional; it is estimated that over 90% of the wheat area has been seeded to improved varieties since at least the late 1960s. Table 4.1 shows the principal certified wheat varieties used by farmers in three selected crop years. It can be seen how rapidly these have been substituted over the years, while a broad range from which to select has been maintained. Also noteworthy is the large share of the market captured by the small SB private research station.

Seed certification is well developed and protected by a sophisticated law and procedures. A National Registry of Varieties is maintained by ANPROS, the national association of seed producers, which also administers a "certification program" under agreement with SAG. Patents are registered at

TABLE 4.1. Estimated Area Seeded With Improved Wheat Varieties, Selected Years (thousand hectares)

1971/72			1977/78			1983/84		
Variety	Source	Area	Variety	Source	Area	Variety	Source	Area
VILMORIN 29	SAG	13	VILMORIN	SAG	15	QUILAFEN	INIA	20
C. DEPREZ	"	116	MANELLA	"	20	AURIFEN	"	90
E. DE CHOISY	"	18	QUILAFEN	INIA	20	ANDIFEN	"	40
HESBIGNON	"	1	TOQUIFEN	"	5	NAOFEN	"	50
HEINES KOGA	"	2	MEXIFEN	"	3	LUCERO	"	5
QUILAFEN	INIA	45	AURIFEN	"	95	MALLALEU	"	5
CANDEALFEN	"	22	ANDIFEN	"	8	CHASQUI	"	5
TOQUIFEN	"	69	ANTUFEN	"	5	MAITEN	"	4
VILUFEN	"	10	HUENUFEN	"	35	TALAFEN	"	15
LILIFEN	"	5	MECIFEN	"	3	RANCOFEN	"	12
PANGUIFEN	"	8	NAOFEN	"	25	LABRIDGO	"	5
PUMAFEN	"	30	LIKAY	"	5	SNA-1	SNA	20
HUELQUEN	SNA	117	LUCERO	"	5	SNA-2	"	20
MENFLO	"	14	SONKA	"	20	SNA-3	"	10
INTERMEDIO	SB	127	YECORA	"	4	SNA-12	"	7
FLECHA	"	8	MANQUEFEN	"	18	SNA-24	"	7
			SNA-1	SNA	30	AS BAER	SB	35
			SNA-2	"	30	EXPORT B	"	20
			ESTRELLA B	SB	5	INTER B	"	15
			EXPRESS	"	13	PENECA B	"	6
			EXPORT B	"	12	EXITO B	"	15
			EXITO B	"	20	MARIANELA	U.C.	4
			IMPACT B	"	12	CAROLINA	"	6
			INTER B	"	20	VICTORIA	"	4
			PATRIOTA	"	10	AUSTRAL	U.A.	5
			PANADERO B	"	5			
			PERLA	"	5			
			MARIANELA	U.C.	20			
TOTAL		605			453			425

Source: For 1971/72, adapted from Hacke, EE [1974]. His estimated areas by variety were adjusted to add up to 85% of the total seeded area that year. For 1977/78 and 1983/84, estimates provided by the Seed Production Section, INIA.

the Ministry of Economy. Although presently about 15% of the annual wheat seed consumption is in certified seed (which experts consider an appropiate proportion), a few years ago this share reached 50%. The reason for such a high proportion was the requirement by the government farm credit programs that farmers purchase certified seed in order to receive production loans for wheat growing. Further information on wheat varieties, and seed production and certification is provided in Appendix Tables A-4.1 and A-4.2.

Maize. As mentioned earlier, maize varieties used in Chile are almost wholly imported from the U.S. It is estimated that over 90% of the planted area is in hybrid, or improved varieties. The important innovation contributed by INIA on this crop refers to the package of techniques required for high yields. Early INIA research showed that the new hybrid corns produced by the Ministry of Agriculture responded well to fertilizers, provided plant density was increased from 30,000 to 70,000 per hectare and weeds were properly controlled. The specification and refinement of this technology revolutionized maize production in Chile, permitting a 100% increase in the national average yield over a 20-year period. The excellent adaptation of imported hybrids has reduced the need for crop breeding research on maize by the NARS.

Rice. Up until 1977/78, a single rice variety known as Oro, originated in the private Huencuecho Station, occupied almost the whole area seeded to this crop in Chile. Although of poor milling quality, its high yielding capacity made it dominate in farmers' preference. At present, it is estimated that over 80% of the rice acreage still uses the Oro variety. The remainder is seeded to Quella, an early-maturing variety originated at INIA. Over the last year, another new INIA variety, Diamante, of semi-long grain, has been

introduced. The demand for long-grain rice has expanded in Chile lately, denoting a change in consumer preference, resulting from the 1977-82 period of heavy food imports.

Management practices in rice have changed very little; it is all direct seeded and flood irrigated. Research has helped to improve fertilizer applications and weed control.

Beans. INIA did not produce the first new domestic bean varieties until the mid-1970s; previously improved varieties were obtained by mass selection of the native types. For the most part, however, bean varieties (especially those for the export market) have been and continue to be imported.

This crop is among the most traditional in the country in terms of farmer self-consumption of seed. Only 15-20% of the area planted to beans for internal consumption uses seed marketed through established commercial channels. It is estimated that barely 3-4% of the bean seed is certified annually. Approximately 60% of total seed consumption is in more or less recognized commercial varieties, the remainder being "old" seeds. There is a great diversity of varieties used in the country; the main suppliers of the improved ones are INIA, the SNA and the V. Alamos private company (FAO, 1982; INIA, Seminario Leguminosas de Grano, 1983).

The traditional technology prevailing in bean production for the domestic market is considered likely to change very slowly, because of the predominance of small farmers in their cultivation. Notwithstanding, average national yields are relatively high, given that beans are grown under irrigation and that 50% of the volume produced is for the export market, which is attended by larger commercial farmers.

Lentils and Chickpeas. These crops are grown under dryland conditions, mostly by small farmers and hence with very traditional technology. New varieties, however, have become available, principally through imports by private companies (ANASAC) and more recently from INIA's research program. INIA has certified two varieties of lentils, Araucana and Tacna. The vast majority of seed used, however, is from farmers' retention from harvest. Although there are no estimates of the proportion of cultivated area that is under some form of improved varieties, it is known that the imported Laird variety of lentils is the predominant one in use.

In chickpeas, practically the total area planted is in unimproved domestic varieties; not until 1983 did INIA launch its first variety, California-INIA, result of research initiated in 1976.

Potatoes. The principal technological innovation for this crop has been the change in varieties. In the early 1960s, the principal potatoes grown were Corahila (a native variety), and Ackerzegen and Pimpernel (imported from Germany). As these became severly vulnerable to late blight disease and other attacks, INIA proceeded to import and test other varieties, of which two that originated from Holland -Desiree and Ultimus- adapted so well in Chile that they almost completely replaced the former. It is estimated that for the last several years these two varieties have occupied 80% of the potato acreage in the country. These varieties have been imported since 1968 by ENDS and some private companies, on occasion associated with the SNA and/or INIA, and are multiplied in Chile, paying royalties to the foreign owners of the patent. The remainder of the potato acreage also is planted to improved varieties (Cardinal, Spartan, Yagana, Fueguina, etc.) with traces still of Corahila. The

Yagana and Fueguina are the first products of INIA's research program.

No significant innovations have been introduced in management practices; changes in fertilization, pest and weed control have spread slowly over time as knowledge has been gained through domestic research and imported techniques (e.g., use of chemicals). An important aspect, however, refers to potato seed certification and control of production, aimed at obtaining nematode and disease-free material for farmers' use. The significance of this problem in Chile explains the sustained high volume of production of certified potato seed, compared to the drastic fall experienced by other crops (See Appendix Table A-4.2).

(b) Fruit trees

Many innovations have accompanied the nearly three-fold increase in area planted to fruit trees since 1960 (see Appendix Table A-1). These include the introduction of new species and varieties (e.g. kiwi fruit, dwarf apple trees), methods of planting (e.g., grapevines on trellises, planting density), pruning, fertilization, pest control, irrigation methods (e.g., drip irrigation), harvest and post-harvest technology, etc. All these innovations were mainly directly imported by producers from the United States and elsewhere; but the NARS contributed significant complementary knowledge in the area of soils and fertilization, disease, pest and weed control, and overall orchard management that made possible the fast expansion of fruit culture (Manterola, 1983). Of particular interest appear to have been INIA's biological control techniques for over 40 insect pests, and methods of chemical control of the Venturia disease in apple and pear trees (Bonilla, 1983).

The adoption of advanced technology in fruit production has been quite thorough across the country,

especially since the mid-1970s, prompted by the demand for high-quality products imposed by the export market.

(c) Horticulture

Innovations in this fast-growing sub-sector refer principally to the introduction of new species and varieties, and related cultivation practices and pest and disease control. Cultivation under plastic has also expanded in the last few years. While, again, direct importation has been paramount, the NARS has played a role in screening and adapting varieties and cultivation methods. As in the case of fruits, opening of the export market has been a basic factor in inducing rapid adoption of the new technology.

(d) Livestock Production

Cattle numbers have expanded at a rapid rate (approx. 4.0% per annum) since 1970, with a simultaneous improvement in the qualitative composition of herds and in productivity (Zegers, 1982). This is attributed to the reduction in draft animals, the introduction of better feeding techniques, sanitation practices, and overall cattle management. Of particular significance has been the eradication of foot and mouth disease in 1970-73. The NARS (and the Schools of Veterinary Medicine not included in the NARS) and SAG have been responsible for generating, or adapting and diffusing most of the innovations relevant to the livestock sector. These include particularly the introduction of the Hereford breed, the improvement in cultivation and processing of irrigated forage crops (e.g., clovers, silage corn), the introduction of grasses and legumes for dryland areas (e.g. sub-clover, phalaris, sudan grass, etc.) and development of appropriate management practices, nutrition alternatives and methods, and sanitary practices like vaccinations, parasite control, etc. (Manterola, 1983; INIA, Memorias Anuales; INIA, 1971).

Poultry production has been the most drastically transformed activity in terms of technological innovations. However, in this case, the whole organizational and productive technology has been imported. The NARS has only contributed marginal knowledge, mainly on nutrition aspects. Presently, 90% of the national commercial egg and broiler production is concentrated in three large-scale enterprises that utilize the most modern international technology for this industry.

The adoption of cost-reducing technology in poultry production has resulted in a better than three-fold increase in per capita consumption of poultry meat in Chile since 1965 (Aldunate, 1982). This development has been a basic factor inducing the expansion of maize production, given that 80% of all maize consumed in Chile is used as poultry feed.

Hog production technology is clearly dualistic in Chile. Traditional small-farmer technology has been untouched by research advances. Commercial production, on the other hand, has evolved in a fashion very similar to poultry, resorting essentially bo importation of breeds and technology from abroad. The NARS has had little participation in this evolution.

Sheep raising is a stationary, or even declining industry in Chile. The only significant innovation pertaining to it refers to the introduction of new forage species and range management techniques, partly imported from Australia and New Zealand. Adoption of these has been modest in terms of number of ranchers and scale of use. Recognizing the cost factors involved, INIA has evolved new recommended practices that imply seeding no more than 10% of the rangeland to improved pastures.

Some important innovations relate to the introduction and adaptation of alfalfa varieties tolerant to

cold weather and acid soils. This work has been led by a private company, in association with the University of California and the NARS. This set of innovations has permitted growing alfalfa south of Region VII, thus improving conditions for dairy production which is predominant in that part of the country.

(e) Other practices and inputs

Mechanization of agriculture has advanced steadily in Chile over the years. Innovations are embodied in farm machinery, all of which is imported. The NARS has had virtually no influence at all in this matter.

Irrigation methods have changed little since ancestral times. The exception is the limited introduction of drip irrigation and the use of plastics, mainly in relation to the development of fruit culture. These techniques are wholly imported.

The use of chemical fertilizers and pesticides, though already widespread in 1960, has expanded substantially since then. Technological innovations linked to the use of these inputs are also imported. The NARS however have contributed to improved use, in terms of better defining the dates, rates and forms of applications.

4.2. Factors Affecting the Adoption of Innovations

Aside from the study by Muchnik (1983) reviewed below, there has been no research carried out in Chile specifically analyzing the question of farmers' adoption of technology. A protracted debate over the causes of agricultural "stagnation" extended over the 1950s and 1960s, with one "school" advancing the argument that the old-fashioned, latifundia-dominated land tenure system was to

blame; and the other arguing that government policies to promote industrialization determined relative prices adverse to agriculture, thus discouraging its development. An extensive literature grew out of this debate (see for instance, CIDA, 1966; and Mamalakis, 1965) and a drastic land reform was implemented as the first viewpoint predominated. Yet, amazingly there was not a single piece of sound research done to test alternative hypotheses about factors affecting the adoption of technology in agriculture[14]. The liberal open market economic policy implemented since 1974 has in turn assumed rational farmer behavior in relation to the adoption of innovations, without regard for particular factors (such as size of farm, access to information, education, etc.) that might determine differential rates of response. Again, however, no research has been conducted to substantiate, or qualify this assumption.

In this vacuum of sound information, one has to resort to partial evidence obtained from raw data and judgements of knowledgeable individuals, in order to assess the main elements conditioning the adoption of innovations in agriculture.

In the first place, from the review in the previous section it can be concluded that appropriate. technological innovations and recommendations have been generally available to Chilean farmers, stemming either from foreign sources, or from the NARS. Also, risk associated with weather is minor in Chile, given the predominance of irrigated farming.

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[14]A few macroeconomic studies have been done on supply response in agriculture, but they do not throw much light on the particular question of adoption of new technologies. See Hurtado, 1980.

The rate, degree and spread of adoption, however, look rather disparate as among crops and subsectors of agriculture, and over time. Several factors account for this: direct government intervention in production, price relationships, land tenure problems, capital and credit restrictions, effectiveness of the extension services, management ability of farmers, and overall political and economic instability. As often these factors interact in different combinations and degrees, it is not possible to establish direct associations among any of them and particular cases of adoption of innovations. With this caveat in mind, the various arguments explaining observed changes in technologies in different cases run as follows.

In general, the land reform process of 1967-73 generated such insecurity and instability in agriculture that it was a strong detrimental factor for technological innovations and investment. Its effects lasted beyond 1973, because of the severe disorganization and loss of capital it caused in the sector. On the positive side, however, the elimination of latifundia, shaking of traditional practices, and impoverishment of big farmers seems to have induced a new dynamism in agriculture which has favored the introduction of innovations in recent years.

The expansion and improvement of fruit culture up to 1973 resulted mainly from a specific government (CORFO) program, supported by credit and other incentives, including direct action during the land reform period. After 1973, the free market policies determined an extremely high payoff to investment in fruit production, often yielding IRR of 20-40% per year and NPV above US$10,000 per hectare (DEA, 1979). This, coupled to renewed tenure security and ample availability of credit (albeit at high interest rates) induced farmers and other entrepreneurs to move strongly into fruit production.

The widespread adoption of wheat varieties is not reflected in wheat yield increases over time[15]. The national average yield of 1.7 tons/ha masks of course important differences existing among regions and types of farmers. Under irrigation, normal yields are above 3.0 tons and reach as high as 8.0 tons/ha among the better farmers. However, with superior alternative opportunities in these lands, such as fruits, truck crops, or maize, wheat is displaced. A similar situation occurs in the humid south, where higher returns to livestock may displace wheat. Such has been the situation since 1975, explaining in part the reduction in wheat acreage. Furthermore if input/output price ratios are adverse, as over 1977/81, the use of complementary inputs like fertilizers and weedkillers is contracted. Wheat production is thus pushed into the marginal lands (with fewer alternatives) where the incidence of smaller farmers is also larger. The weakness of extension services and small-farmer credit programs becomes more significant for technological improvement. The combined effect of all these forces explains why, despite the wide adoption of new wheat varieties, average yields have been stagnant.

Similar lines of reasoning apply to other food crops. In beans and other legumes, for instance, the small farmer effect and/or dryland nature of cultivation, in addition to the extreme price variability shown by these crops are important factors hindering adoption of new technology.

The problem of adoption of innovations by small-farmers was analyzed by Muchnik (1983), on the basis of farm survey data for the VII region of the country. It was found that demand for technological change, defined as the

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[15]It is considered however that the new varieties have prevented a falling trend in yields.

growing adoption of "modern" inputs, was very restricted. The most significant variables explaining such low demand were found to be: degree of technical assistance (extension) contacts, access to credit, and educational level of the farmer. Therefore, this study confirms the generally held position, particularly by INIA researchers, that the historical deficiency of extension services has been a factor retarding the adoption of research results from the NARS, given the large incidence of small farmers in Chilean agriculture.

Cattle-raising has been shown to be highly responsive to price and interest rate changes (Zegers, 1982; DEA, 1981), as would be expected given its usual large-scale, commercial nature especially in the south. This also helps explain the continuous introduction of technological innovations in this activity. However, government sanitary controls and intervention have played a major role, particularly in the eradication of foot and mouth disease. This has been most important over the past ten years, since declaring the country free from this disease has meant placing a non-tariff protection on the livestock sub-sector, hence making it much more profitable than it would have been under the prevailing free market policy.

In sum, the above illustrations show that there does not seem to be a single "model" of adoption of new technologies in Chilean agriculture. It is not surprising then that the rather dogmatic economic policies implemented over different periods since 1960 have failed to generate a uniform and steady progress in this sector.

4.3. Production Effects.

The evolution of area utilized, production and yields for the main commodities since 1960 were presented in

Chapter I. Additional information is shown in the Appendix. The aggregate studies on technical change in Chilean agriculture (see Section 1.2.2), while coinciding in their measurement of the positive effect of the adoption of innovations since 1960, do not give the same interpretation as to what specific factors have been at play (e.g., improvements in labor productivity, changes in the composition of production). On the other hand, aside from evaluation studies by Yrarrázaval (1979) and Franco (1982), already reviewed, there are no studies that have analyzed rigorously, in a disaggregate fashion, the evolution of agricultural production, looking at shifts in its physical and value composition, in factor use, in yields, and in regional patterns of production[16]. Without information of this nature, and because of the complex elements involved in the adoption of innovations, it is virtually impossible to establish a specific accurate connection between agricultural research and agricultural production.

Notwithstanding, from the presentation in previous sections of this report some broad conclusions can be put forward, which are generally agreed upon by knowledgeable observers and appear reasonably supported by facts. Research by the NARS (including, where appropriate also the IARC's contribution) has had an appreciable influence on production in the following cases:

(a) Wheat. The study by Yrarrázaval et al. (1979) is conclusive with respect to this crop. The fact that average yields and total production have not increased significantly is attributable to other causes, such as

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[16]Lack of adequate statistics in Chile, e.g., on input use by regions and/or commodities, on capital investment, etc. have prevented doing quantitative research on these subjects.

price policies and availability of extension services. It is estimated that, should these factors be corrected, as has been occurring starting in 1983/84, average wheat yields may rapidly reach 2.5 ton/ha or higher, given Chile's good soil and moisture conditions for wheat, and the stock of superior technology available.

(b) Maize. The study by Yrarrázaval et.al. is also conclusive in regard to maize. The fast rate of growth in maize yield and acreage is attributable to the extraordinarily high marginal productivity of the new technological input package, which has more than compensated, for the adverse effects of changing price relationships.

(c) Potatoes. The modest increase in potato yields would not have been possible in the absence of local research; in fact, due to disease and nematode problems, the lack of research indeed would have resulted in a reduction in yields. The typical violent potato price fluctuations have been an adverse factor for a faster expansion of production.

(d) Rice. The relatively high average yields and positive growth trend must be attributed in good part to domestic research, as the total seeded area and the region where rice is grown are quite stable, while price relationships have not been any more favorable for this crop than the rest.

(e) Beans, lentils and other legumes. Research seems to have been significant in preventing a falling trend in yields of these crops, given their vulnerability to disease attack. However, the case appears much weaker than for the former crops, given that research results are much more recent and limited.

(f) Fruit production. Domestic research can only claim a marginal contribution in this area. A fast expansion in fruit culture most certainly would have occurred even in the absence of supportive research by the NARS, given the high profitability of fruit-growing and the feasibility of importing biological materials and technical advice.

(g) Livestock production. Research on pastures, and on animal nutrition and health, given its relative location specificity must be considered a significant factor in the observed improvement of cattle production. The remainder of the livestock sector owes little to the NARS.

4.4. Gender Issues

There is no information in Chile on any eventual impact that agricultural research may have had on female employment, or on women's roles in the rural sector. Only very recently is there starting to be some attention paid to women's roles in agriculture (Revista del Ing. Agr., 1984). There are many more urgent issues than agricultural research that must receive priority attention in regard to women. At any rate, given the general lack of striking impacts of research on Chilean agriculture, it is quite doubtful that research could have had much effect on women's activities.

What has had a significant impact on employment of rural females is the expansion of fruit culture. The numerous packing houses and other agro-industries that have been established throughout the fruit growing areas in the last ten years, employ a very large proportion of females in their work force.

4.5. Welfare and Other Effects of Research

Significant changes[17] in the structure of agricultural production and resource use that have occurred in Chile in the last fifty years include the introduction of rice in the 1930s; the introduction of sugar beet and rapeseed in the 1950s and their demise in the 1970s; the expansion of fruit trees since the mid-1960s; the reduction in wheat acreage since 1975; and the more recent expansion in horticultural production. Actually, none of these changes can be attributed to a research effect, as was discussed earlier. Furthermore, there are not even other less significant shifts in the structure of Chilean agriculture attributable to the adoption of research-generated innovations. Such shifts that may be identified would respond to investments in irrigation schemes, effects of the land reform, changes in economic policies (prices, tariffs, wages, credit, etc.), or developments outside of agriculture.

In this situation, it would be superfluous to try to identify possible effects of research on income, welfare, nutrition and distribution. This surely explains why there hasn't been any discussion of these subjects in Chile, let alone research done on them.

4.6. Innovations with Potential Impact[18]

The Chilean NARS shows a good level of development and stability, which is reflected in ongoing programs at the various institutions, with fairly predictable research output

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[17]That is, those implying a permanent change in use of more that 15,000 hectares of cropland, or about 1% of the total cropland area.

[18]This section is based on interviews with senior staff of the NARS.

in the immediate and near future. By the same token, however, most of this expected output denotes a limited capacity for really innovative ideas, or for applying the most advanced scientific knowledge and methods. In fact, the NARS researchers often felt that a shortcoming of the IARC's assistance was precisely the centers' disregard for, or little interest in, tackling the more basic research problems, which national researchers feel unable to handle by themselves. Also, among INIA personnel, it was strongly felt that the universities should be concerned with moving to the forefront of scientific research, rather than competing in the purely short-term, applied area.

Following is a list of prospective results from research at the NARS, with observations on their potential impact on agriculture:

(a) Creation of new varieties. The principal expected innovations at all NARS institutions relate to production of new varieties of the crops they work on. The aim is to achieve one or more of: higher yielding capacity, disease resistance, eating or milling quality, shorter vegetative period.

Among the expected new varieties, those with greater innovative impact are early maturing beans (85 days) because of (c) below; long-grain rices, because of Chile's export potential in this crop; and phosphorus efficient wheats, because of the problem represented by the trumao soils in the principal wheat growing areas of the country.

(b) Introduction and adaptation of new species and varieties. Important work is being done on soybeans, forage sorghum, grasses, and vegetables. Introduction of early maturing soybeans may have significant impact

because of (c) below and because of Chile's large deficit in oilseed production. Diversification and improvement of vegetable production (e.g., asparagus, artichokes, garlic, melons, brussel sprouts, etc.) can revolutionize irrigated farming in central Chile if the export market develops as hoped. The impact on labor demand would be quite significant (DEA, 1984).

(c) Double-croppping and new rotation systems. Chilean agriculture typically involves one crop harvest per year. However, in most irrigated areas it is possible to double-crop, although presently this is little practiced because the prevailing crops and varieties and cultivating mehods are not well suited to this practice. The creation of early maturing beans, and the introduction of soybeans and sorghums, for instance, are aimed at developing double-cropping systems. The introduction of soybeans is also being tested in rotation systems with rice and sub-clover, to improve soil management in the rice-growing area (which is projected to expand considerably as a result of a large irrigation scheme under construction). Successful adoption of double-cropping by farmers in irrigated lands would have an enormous impact on total agricultural production.

(d) Location-specific and small farmer production systems. INIA has already developed some systems of this kind, especially for the coastal and pre-Andean drylands, and for land-reform farmers. This research is being continued and new systems are expected to be recommended in the coming years. While their impact on total production may not be too significant, they would be important for certain groups of farmers and at the local-economy level.

(e) Production of homogeneous disease-free plant material. Genetic heterogeneity and disease-infected fruit tree plants represent a serious problem, the consequences of which are often discovered years after an orchard is planted. INIA is establishing a nursery of indexed plants, to serve as a foundation from which to supply commercial nurseries. Though research is only indirectly involved, this effort can have a strong economic impact on fruit culture.

Similar efforts for producing disease-free potato seed are also expected to yield good results in the coming years.

(f) New agronomic practices. The most important of these is the adaptation of zero or minimum-tillage to Chilean conditions, which has already been tested at farmers' level. If this practice takes hold, it could have important cost-saving and energy-saving consequences for farmers, but it should not affect production.

In rice, trials with "muddying" and transplanting show some potential for introduction of these practices.

(g) Livestock breeding. Embryo transplants are being tried in dairy cattle, with excellent prospects of rapid farmer adoption of this technique. Research on it is incipient, but various institutions, especially the Schools of Veterinary Medicine are moving into this line of work. The impact on dairy production could be substantial.

4.7. The Contribution of the IARCs

The IARCs' impacts on agricultural production in Chile must be considered as an indirect effect, operating

through the NARS, particularly through INIA. The IARCs have not had autonomous projects or activities in the country that could have reached producers directly. To this extent, the detailed analyses made of IARCs-NARS collaboration and of the NARS impact on production, suggest the areas and extent to which the IARCs may have had an influence on production. It does not appear worthwhile to recapitulate this point here.

There are, however, two further aspects in which the IARCs presence has been important for agriculture in Chile. One refers to the added stability that collaboration with an IARC gives to domestic research programs, and hence the increased likelihood that these will generate useful results. The reason for this is that the government cannot easily pull out of international commitments established through some of its agencies, such as INIA. Furthermore, it is often obliged to increase its support for projects receiving IARC collaboration. This has been the general experience at INIA, rather than the contrary possiblity, i.e., that local support be reduced because of external assistance.

The second aspect refers to the high level, political influence that the IARCs have been able to excercise in defence of national research, and more generally of the importance of national production of basic food commodities. The visits, admonitions and declarations of highly prestigious IARC scientists, and the promotion of activities such as the international seminar on the economics of agricultural research, have been crucial for obtaining greater public understanding and support for research and agriculture generally.

With respect to these points, it is to be lamented that the IARCs specifically responsible for policy and administration affairs, have been so notoriously absent from

Chile. They could be playing a significant role, too, by helping raise public concern and appreciation for domestic food policies and research organization.

V. SUMMARY AND CONCLUSIONS

Chile's agricultural sector has expanded at a moderate rate, 2.2% per annum, over the period 1960-83. This is slightly above the average rate of population growth of 1.9%. There are marked differences however, over sub-periods that correspond to three fundamentally different sets of policies applied to the sector. During the traditional pre-land reform period, 1960-67, the average growth rate of agricultural GNP was 2.6%; during the active land reform stage, 1968-73, this rate was -2.7%; and in the 1974-83 period, corresponding to the liberal, open market policy of the present administration, the average growth rate was 4.3%.

As a consequence of the various policies applied, significant changes occurred in the pattern of resource use, the structure of production, and the institutional organization of the sector. Notably, the land area devoted to "traditional" food and industrial crops decreased by approximately 25%; as did the labor force employed in agriculture, by about 14%. The principal expanding activity has been fruit culture, followed by beef and dairy cattle.

The food crops of concern to the CGIAR system have generally not been favored by the policy environment. Either due to price controls, institutional instability, or external competition, production of these crops has not been stimulated, and in some cases it has actually been discouraged. The volume of wheat production has shrunk by some 50% since 1969/70. Over the entire twenty-four year period, potatoes have stayed almost stationary; and rice and beans have increased modestly. The exception has been maize, with about a three-fold increase in volume of production.

Average national yields of these crops, except maize, have improved only slightly, at annual rates varying

from zero to 1%. Maize yields have increased at nearly 4% per annum. Several factors account for this performance, among which research and extension play a role. However, the vagaries of policies for agriculture, land tenure uncertainty, capital restrictions, and price relationships have generally been a more significant factor in discouraging the rapid and widespread adoption of new technology.

Chile has developed a fairly strong set of agricultural research institutions, loosely organized into a NARS. Its center piece is INIA, which concentrates about 75% of the resources for agricultural research, complemented by four major university schools of agronomy and a few private research entities. The NARS has expanded very rapidly in the last 15 years, especially in terms of numbers of scientists with advanced training. Total research expenditures increased from 0.16% to about 0.8% of agricultural GNP from 1960 to the present.

The NARS covers a broad range of subjects, crops, and livestock research problems. Traditionally, major attention has been devoted to food crops, especially wheat, and to cattle production and pastures. More recently, greater emphasis is being placed on fruit trees and vegetable crops. Overall research planning and priority setting appear weak; in general, individual researchers have a great deal of participation in program decisions, and autonomy in their execution.

The NARS has produced a fair output of research results and recommendations; the principal of which consist of a continuous flow of improved crop varieties, of higher yield potential and disease resistance.

Agricultural extension, or technology transfer mechanisms, have generally been detached from the NARS and

have performed poorly. This weakness is considered to have been a serious obstacle to farmers' adoption of research generated innovations.

The IARCs have collaborated extensively with the Chilean NARS, mainly with INIA, in a variety of ways. The longest and strongest collaboration has been established by CIMMYT, CIAT and CIP, the three Latin America based IARCs. IRRI assistance has been mostly channelled through CIAT. Since the late 1970s, collaboration has developed also with ICARDA, and somewhat less with ICRISAT. IBPGR has had some participation in Chile, often in association with one of the other IARCs. Very minor contacts have existed with ISNAR and IFPRI. Collaboration has centered primarily on wheat, beans and potatoes; but other crops covered include maize, triticale, barley, rice, lentils and chickpeas. Some assistance has been provided also on production systems research, collection of plant materials, seed production, technology transfer, and research on supporting disciplines.

The most important forms of collaboration, from the standpoint of the NARS, have been: provision of biological materials, training of staff through a variety of schemes, facilitating staff exchanges and international contacts, and assistance in research techniques.

The effectiveness of the IARCs' support has increased overtime, as more intimate knowledge of the country's research needs, gained through center scientists' visits and staff exchanges, has resulted in the provision of better adapted germplasm and more sharply targeted training and advice. Communications with IARC scientists has been direct and expeditious and IARCs' responsiveness to requests, rapid and effective.

On the whole, very minor criticisms were expressed by some national researchers about relationships with the

IARCs. These pertain essentially to the wish that assistance be broadened to work more on basic research issues, on agronomic practices, and on certain problems characteristic of Chile's temperate climate. The principal limitation of the IARCs' collaboration encountered, however, is the scarce contact with university research groups. These institutions are significant in the Chilean NARS, and stronger association with the IARCs could be of significant mutual benefit.

IARCs-NARS collaboration entails some contributions from the national institutions to the centers, too. These refer mainly to conducting international trials in Chile, collecting and/or providing local biological materials to the NARS, and occasionally participating in center program reviews. These activities have not normally represented conflicts for the NARS, although at times have caused some localized budgetary strain.

Although there are very few, partial studies assessing the effect of research on agricultural production in Chile, the cumulus of diverse evidence suggests a definite positive impact. The fact that this impact is not strongly reflected in national average statistics, is not sufficient to deny the contribution of research for the improvement of agricultural technology. It appears, however, that the principal source of innovations in Chilean agriculture has been the importation of technology from abroad. This is most evident in fruit, vegetable and poultry production, and in technologies embodied in inputs such as machines, pesticides, irrigation equipment, etc. In food crops, much of this importation has come through the IARCs. Nevertheless, it is felt that the effective adoption of foreign technologies has been possible because of (a) the accumulated local research knowledge on aspects such as soils, insects, diseases, fertilizer response, etc. and (b) the ability of the NARS to

help adapt the foreign technology to national conditions, evolving appropiate management practices.

To the extent that the IARCs have contributed significantly to strengthen and improve the NARS' performance, there is no doubt that their impact is being indirectly felt on production, too. This should become more evident in the coming years, given the recent changes in pricing and foreign trade policies that are strongly stimulating domestic food production, most notably wheat. If under these new conditions the known research-generated technologies for food crops are effectively adopted by farmers, national average yields and total production are expected to increase significantly in the years ahead.

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APPENDIXES

Annex Tables to Chapter I: A-1.1 through A-1.25

Annex Tables to Chapter II: A-2.1 through A-2.17

Annex Tables to Chapter IV: A-4.1 through A-4.2

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Annex Tables to Chapter I

TABLE A - 1.1 Sectoral Contribution to GNP, 1960 - 81

(percentages)

Year	Agriculture [a]	Mining	Manufacturing	Trade	Services
1960	10.2	8.0	21.8	22.1	24.7
1961	9.6	7.1	22.2	22.2	25.1
1962	8.7	6.8	23.6	21.5	24.7
1963	8.7	8.2	23.7	21.6	24.6
1964	8.5	8.2	24.2	20.7	24.6
1965	8.4	7.7	23.8	19.2	26.3
1966	9.3	8.7	22.8	19.2	25.5
1967	9.3	8.9	23.6	18.5	26.1
1968	9.4	8.7	25.4	18.7	26.0
1969	8.0	10.8	25.0	18.7	25.6
1970	8.2	8.8	25.4	18.6	26.7
1971	7.4	5.8	24.4	18.0	29.4
1972	6.9	6.8	23.4	19.2	28.3
1973	6.6	9.1	27.1	20.9	24.7
1974	8.2	12.0	29.5	14.1	24.6
1975	9.9	10.4	20.3	17.3	31.5
1976	9.3	10.2	23.3	15.1	30.2
1977	9.3	8.1	21.7	15.6	31.4
1978	8.0	9.8	21.2	16.7	32.0
1980 [b]	7.7	8.7	21.5	16.1	33.7
1981 [b]	7.6	7.1	21.0	17.5	29.6
1982 [b]	8.6	6.1	19.6	16.5	40.5
1983 [b]	8.5				

Source : Hurtado, H. 1984 and Table 1.2.

a/ Includes Fisheries

b/ Provisional figures.

TABLE A - 1.2 Labor Employment and Wages, 1965 - 82

Year	General Wage Index	Agricultural wage Index [a]	National unemployment rate %	Agricultural unemployment rate %
1965	100	100	n d	n d
1966	113	112	5.9	2.2
1967	130	117	4.8	2.0
1968	130	110	4.8	1.8
1969	141	103	4.4	1.6
1970	156	121	3.4	1.7
1971	181	171	3.8	1.5
1972	146	150	3.2	1.0
1973	78	121	n d	n d
1974	95	81	n d	n d
1975	93	67	13.5	4.0
1976	125	72	16.3	5.0
1977	141	89	14.0	5.7
1978	161	109	13.9	7.1
1979	179	108	13.6	7.3
1980	194	108	9.4	5.0
1981	211	124	9.6	6.3
1982	211	113	23.2	9.4

Source : Hurtado, 1984 (See the original sources in that study).

a/ This Index has been deflated by "corrected" IPC calculated by the University of Chile, Dept. of Economics.

TABLE A - 1.3 Summary Balance of Payments, Selected Years
(million current US dollars)

ITEM	1960	1965	1970	1975	1980	1982[c]
1. Trade Balance	- 85.7	68.7	155.9	- 118.3	- 1,055.0	218.0
Exports F O B	469.7	684.2	1,111.9	1,589.5	4,722.0	3,798.0
Copper	321.5	428.5	839.4	868.2	2,136.0	——
Agriculture a/	—	54.9	103.7	313.1	956.4[b]	——
Import CIF	-555.4	-615.5	- 956.0	1,707.8	- 5,777.0	-3,580.0
Food	109.3	137.3	135.5	361.0	754.0	——
2. Services & Transfer	- 62.4	-125.3	- 237.0	- 373.0	1,086.0	-2,600.0
3. Current Account Balance	-148.1	-56.6	- 81.1	- 491.3	- 1,597	- 2,382.0
4. Capital Movements	76.3	65.8	267.5	298.7	2,343.0	2,469.0
5. B of P Balance	- 28.4	46.7	113.5	- 285.0	776.0	-1,165.0

Source : Banco Central, 1983.

a/ These figures come from different sources. See Ministerio de Agricultura, 1981.

b/ Year 1979.

c/ Provisional figures.

TABLE A-1.4 Total Goverment Expenditures, by Functions, Selected Years
(percentages)

Functional sector	1965	1970	1975	1980	1983
General Services	4.9	8.5	8.8	8.3	8.9
Defense	13.5	16.4	13.5	11.9	10.7
Education	14.8	17.4	12.3	13.1	13.1
Health	9.0	7.7	8.7	8.2	8.6
Social Security	11.9	11.1	23.4	29.4	26.7
Housing	9.3	5.2	8.5	5.4	3.0
Agriculture & Fish	5.8	5.0	2.5	2.3	1.5
Transport and Comm.	16.7	14.8	7.6	5.0	4.3
Total	100	100	100	100	100

Source : 1965 and 1970, World Bank, 1980.
Other years, Cheyre and Symons, 1984.

TABLE A - 1.5 Consumer Price Index (IPC) and Inflation: 1960-1984

Year	Price Index (Dec.1978=100)	Annual Average Rate of Inflation (Percent)
1960	0.0036291596	5.5
1961	0.0039080395	9.6
1962	0.0044514671	27.7
1963	0.006420677	45.3
1964	0.009372921	38.5
1965	0.012076471	25.8
1966	0.014838418	17.0
1967	0.01753029	21.9
1968	0.02219878	27.9
1969	0.02900254	29.3
1970	0.03843172	34.9
1971	0.04614072	22.1
1972	0.0820405	163.4
1973	0.3715024	508.1
1974	2.246601	375.9
1975	10.665410	340.7
1976	33.268013	174.3
1977	63.859329	63.5
1978	89.458759	30.3
1979	119.33	38.9
1980	161.26	31.2
1981	193.01	9.5
1982	212.19	20.7
1983	270.03	23.1
1984 a/	316.22	19.3

a/ January-June, 1984.

Source: Banco Central de Chile.

TABLE A-1.6 Area Planted to Principal Crops and Annual Changes, 1960-1984

Year	Cereal Crops a/		Legumes and Potatoes b/		Industrial Crops c/		Total	
	Thous Has	% Var.	Thous Has	% Var.	Thous Has	% Var.	Thous Has	% Var.
1960	1,098.3	-	224.0	-	100.2	-	1,422.5	-
1961	1,042.4	-6.7	223.1	-0.4	62.9	-37.2	1,310.4	-7.9
1962	1,013.3	-1.1	209.1	-6.3	74.2	18.0	1,296.6	-1.1
1963	991.7	-2.1	202.4	-3.2	89.6	20.8	1,283.7	-1.0
1964	987.5	-0.4	187.0	-7.6	110.9	23.8	1,285.4	0.2
1965	957.9	-3.0	189.4	1.3	107.5	-3.1	1,254.8	-2.4
1966	1,009.3	5.4	171.0	-9.7	124.9	16.2	1,305.2	4.0
1967	968.9	-4.0	170.1	-0.5	96.2	-23.0	1,235.2	-5.4
1968	1,003.3	3.6	173.2	1.8	96.6	0.4	1,273.1	3.1
1969	951.3	-5.2	156.7	-9.5	100.7	4.2	1,208.7	-5.1
1970	967.7	1.7	168.2	7.3	115.6	14.8	1,251.5	3.5
1971	968.4	0.1	194.2	15.5	99.8	-13.7	1,262.4	0.9
1972	982.1	1.4	210.4	8.3	102.3	2.5	1,294.8	2.6
1973	784.6	-20.1	177.5	-15.6	65.7	-35.8	1,207.8	-20.6
1974	898.6	14.5	215.9	21.6	60.9	-7.3	1,175.4	14.4
1975	970.1	8.0	176.5	-18.3	101.3	66.3	1,247.9	6.2
1975	969.2	-0.1	188.1	6.6	144.9	43.0	1,302.2	4.4
1977	928.6	-4.2	238.0	26.5	120.2	-17.1	1,286.8	-1.2
1978	856.0	-7.8	262.6	10.3	76.8	-36.1	1,195.4	-7.1
1979	883.8	3.3	274.8	4.8	91.8	19.5	1,250.4	4.6
1980	852.0	-3.6	291.2	6.0	93.9	2.3	1,237.1	-1.1
1981	723.9	-15.0	289.1	-0.7	65.8	-29.9	1,078.8	-12.8
1982	649.2	-10.8	260.0	-10.1	35.7	-45.7	994.9	-12.4
1983	635.0	-2.2	194.0	-25.4	42.0	17.6	871.0	-12.5
1984 d/	782.0	23.1	212.0	9.3	57.0	35.7	1,051.0	20.7

a/ Wheat, Oats, Barley, Rye, Rice and Maize.
b/ Beans, Lentils, Peas, Chickpeas and Potatoes.
c/ Sugar beet, Sunflower and Rapeseed.
d/ Preliminary estimate.
Source: Banco Central de Chile.

TABLE A-1.7 **Area Allocated to Fruit Trees** [a/b/] **and Annual Rate of Change**

Year	Area (hectares)	Annual Rate of Change (%)
1960	35,939	-
1965	48,775	35.8[c]
1970	[illegible]52	7.8[c]
1972	59,060	-
1973	63,950	8.3
1974	63,885	-0.1
1975	65,775	3.0
1976	67,590	2.8
1977	69,365	2.6
1978	72,972	5.2
1979	77,486	6.2
1980	82,310	6.2
1981	86,113	4.6
1982	89,708	4.2
1983	93,034	3.7

a/ 1960, 1965 and 1970, correspond to surface of 15 principal fruits.

b/ 1972 to 1983, correspond to total surface in the country.

c/ Rate over 5 years.

Source: 1960, 1965 and 1970: González, G. y A. Gálmez [1980] Estadísticas Frutales en Chile.
1972-1979 : Banco Central de Chile [1983] "Indicadores Económicos y Sociales 1960-1982".
1980-1983 : Banco Central de Chile [1984] "Boletín Mensual N°680"

TABLE A-1.8 Agricultural Work Force[a/], 1960-1984

Year	Persons (thousands)	Agricultural Share of Total Work Force (%)
1960	695.5	30.0
1961	674.9	28.9
1962	671.5	28.2
1963	675.0	27.7
1964	674.2	27.1
1965	675.5	26.5
1966	654.6	25.2
1967	638.8	23.8
1968	623.9	23.0
1969	625.1	23.0
1970	608.0	22.0
1971	557.5	19.9
1972	511.5	17.6
1973	480.3	16.6
1974	488.5	17.5
1975	497.5	18.7
1976	499.8	18.0
1977	502.1	17,6
1978	504.4	17.1
1979	506.7	16.6
1980	509.1	16.2
1981	511.4	15.8
1982	633.5	20.0
1983	578.5	18.6
1984	604.1	18.1

a/ Figures show the "employed" work force.

Source: 1960-1981: Banco Central de Chile [1983]

1982-1984: Universidad de Chile [1984].
Revista de Economía N°25, Julio 1984.

TABLE A-1.9 Wholesale Prices of Selected Crops, 1960-84
(pesos of 1984 per metric ton)

Year	Wheat	Rice	Maize	Beans	Potatoes
1960	6,709.36	7,232.17	7,145.03	23,613.46	8,190.65
1961	6,311.45	7,039.70	7,767.94	23,789.32	5,987.79
1962	6,393.45	6,322.41	6,393.45	16,054.66	6,180.33
1963	6,008.61	4,925.08	6,550.36	14,479.75	7,633.88
1964	6,072.78	6,376.42	7,759.67	14,844.58	6,949.96
1965	6,808.09	6,284.39	6,808.09	23,304.61	6,232.02
1966	7,245.71	7,885.04	7,245.71	22,376.47	5,860.50
1967	7,035.05	7,774.63	7,197.40	19,211.09	5,159.04
1968	6,951.55	7,692.29	7,079.75	14,102.53	4,629.62
1969	7,283.34	7,741.27	8,286.43	27,558.09	4,088.70
1970	7,240.73	7,866.07	7,635.68	37,108.75	3,702.65
1971	7,264.59	8,224.06	8,086.99	34,609.60	5,208.57
1972	5,087.86	5,820.20	13,028.00	30,642.78	20,158.71
1973	4,085.72	5,788.11	24,258.98	20,939.33	20,939.33
1974	17,467.68	19,142.66	16,975.03	25,166.97	8,093.40
1975	23,158.93	21,222.84	15,571.72	93,682.32	19,153.33
1976	21,290.76	23,350.54	15,735.90	83,329.47	19,557.95
1977	18,613.90	19,393.81	12,768.27	36,746.48	10,435.96
1978	17,539.74	19,532.32	15,665.94	24,670.17	8,625.30
1979	17,484.19	16,268.65	15,007.00	45,963.86	13,645.45
1980	16,106.90	13,511.22	14,392.66	94,236.54	13,454.15
1981	14,933.33	16,165.05	11,766.38	73,181.15	10,285.30
1982	14,327.88	13,162.05	11,931.53	32,628.53	13,663.23
1983	19,441.86	13,515.85	16,209.27	42,206.70	16,918.23
1984 a/	19,050.00	15,833.30	15,583.30	51,167.70	10,286.50

a/ January - June 1984.

Source: Instituto Nacional de Estadísticas (INE).

TABLE A-1.10 Real Prices of Selected Agricultural Inputs 1960-83 (pesos of 1984)

Year	Minimum Legal Farm Wage ($/Month)	Diesel Oil ($/M^3)	Index of Farm Implements ($/Unit.) a/
1960	5,240	4,225.91	-
1961	6,357	3,924.43	-
1962	6,139	3,573.23	-
1963	6,096	3,531.29	-
1964	6,350	3,151.10	-
1965	7,202	2,932.69	-
1966	8,042	2,838.61	-
1967	8,428	2,969.13	-
1968	7,896	3,103.98	-
1969	7,380	3,173.92	736.84
1970	8,699	3,383.40	707.95
1971	12,294	3,055.92	678.62
1972	10,845	2,136.51	836.41
1973	8,721	4,953.94	897.33
1974	5,864	11,256.17	1,759.97
1975	4,835	17,325.76	1,029.28
1976	5,204	14,125.91	882.48
1977	6,419	11,511.95	1,085.34
1978	7,186	12,376.02	1,081.90
1979	7,126	21,180.19	1,009.51
1980	7,138	22,620.18	1,094.65
1981	7,073	19,692.65	1,063.64
1982	6,930	20,898.52	964.94
1983	5,446	24,831.50	873.78

a/ A "basket" of spades, shovels, plows, harrows and tillers was defined and used to weight the respective prices.

Source: Instituto Nacional de Estadísticas (INE), elaboration of DEA/UC.

TABLE A-1.11 Domestic Price of Certified Seeds, Selected Crops, 1965-84
(pesos of 1984 per metric tons)

Year	Wheat	Rice	Maize	Beans	Potatoes
1965	11,125	-	75,935	53,940	3,141
1966	12,253	-	63,293	51,785	3,409
1967	11,383	-	63,134	59,526	4,174
1968	11,110	-	63,397	52,955	4,230
1969	12,005	-	61,057	43,176	4,372
1970	12,541	13,164	64,179	66,647	5,286
1971	12,278	14,392	64,216	78,128	5,981
1972	8,638	14,158	48,373	64,144	7,107
1973	12,318	8,852	34,047	47,539	17,047
1974	21,069	nd	nd	nd	nd
1975	35,845	63,449	nd	nd	nd
1976	44,084	60,389	177,025	171,094	16,596
1977	34,480	37,138	178,265	108,940	15,504
1978	27,657	53,002	187,345	169,671	12,677
1979	28,385	37,099	211,996	127,198	19,700
1980	26,629	32,355	174,581	146,873	25,650
1981	28,280	40,631	182,215	154,005	19,620
1982	30,881	53,327	179,640	220,305	20,393
1983	40,873	nd	292,295	168,632	27,217
1984	38,561	nd	324,240	192,000	29,167

Source: 1965-1973= ODEPA. Boletín Agroestadístico N°20
1974-1979= ODEPA. Chile: Estadísticas Agropecuarias 1975-1979
1980-1981= ODEPA. Chile: Estadísticas Agropecuarias 1980-1981
1982-1984= Estimated by Departamento de Economía Agraria, U.C. based on ODEPA information.

TABLE A-1.12 Domestic Prices of Fertilizers: 1960-1984
(pesos of 1984 per metric ton)

Year	Sodium Nitrate a/b/	K Nitrate a/b/	Urea b/	Ammonium Phosphate b/	Trisuper Phosphate b/
1960	5,394.91	6,055.68	-	-	-
1961	3,803.06	4,288.55	-	-	-
1962	3,338.80	3,765.03	-	-	-
1963	3,807.03	4,452.21	-	-	-
1964	3,896.70	4,510.73	-	-	4,858.20
1965	4,162.38	4,869.20	-	-	4,973.84
1966	4,603.12	5,519.54	-	-	7,309.66
1967	4,499.33	5,493.12	10,118.93	9,486.60	6,794.23
1968	4,686.34	5,840.08	10,825.43	7,848.54	5,512.51
1969	5,114.08	6,117.24	9,181.30	9,323.03	6,673.39
1970	5,327.95	7,114.98	8,564.31	9,363.09	6,760.87
1971	4,438.05	5,926.61	7,386.92	8,162.68	6,173.51
1972	2,992.55	3,999.02	6,208.67	5,738.21	4,338.42
1973	13,933.07	17,439.25	14,591.94	14,283.21	13,842.71
1974	17,750.94	22,319.96	39,818.99	41,688.29	37,021.98
1975	16,079.85	23,041.49	42,916.30	46,622.17	47,940.44
1976	11,419.62	16,916.46	23,399.64	26,516.34	22,828.79
1977	9,601.15	12,390.81	19,241.09	19,535.20	14,595.67
1978	11,331.28	13,864.55	22,695.91	19,672.45	17,988.04
1979	12,640.59	15,956.77	25,039.19	26,496.20	22,276.59
1980	9,101.17	15,533.30	23,863.26	28,813.26	22,866.62
1981	9,794.45	14,886.47	22,314.53	22,715.73	18,723.42
1982	7,213.12	11,992.38	23,872.88	27,195.45	22,564.31
1983	9,230.64	16,475.19	25,345.66	30,031.89	25,195.62

Source: a/ Instituto Nacional de Estadísticas (INE): 1960-1964.
b/ Oficina de Planificación Agrícola (ODEPA): 1965-1984.

TABLE A-1.13 Nominal Import Tariffs, Ad-valorem, in the Agricultural Sector, 1974-80

(percentages)

ITEMS	1974	1976	1978	1980
Cereal & other crops				
Wheat	36	20	28.7	10
Barley	43	20	10	10
Maize	62	20	10	10
Rice	43	21	10	10
Potatoes	52	20	10	10
Legumes	52	20	10	10
Meats				
Beef	43	21	10	10
Mutton	64	21	10	10
Pork	44	22	10	10
Dairy products				
Fluid milk	64	21	13.4	*
Powder milk	109	24	13.4	*
Cheese	84	33	11	10
Fruits	36	21	10	10
Eggs	43	21	10	10
Wine	153	35	13.8	10
Wool	43	18	10	10

Source : Hurtado, 1984.

*) Milk is subject to variable specific tariffs to compensate for dumping practices of exporting countries. Nominal protection may reach the 35 % permitted by GATT.

TABLE A - 1.14 Estimates of Effective Protection[1/] for Various Economic Sectors, Selected Years

(percentages)

Economic Activity	1961	1967	1974	1977
Agriculture	50	- 52	- 65	1
Food Products	2,884	20	178	28
Tobacco	141	55	-	5
Textiles	672	56	-	-
Chemicals	89	- 20	-	-
Electric equipment	111	62	-	17
Transport equipment	101	11	-	-

Source : Hurtado, 1984. See detailed sources in that report

1/ Tariffs adjusted by the undervaluation of the exchange rate.

TABLE A-1.15 Chile: Nominal and Real Interest Rates[1/], 1960-83.

Year	Nominal Interest	Rate of Inflation	Real Interest Rates
	--- Percentages ---		
1960	19.0	5.5	-10.8
1961	19.6	9.6	9.3
1962	17.9	27.7	-8.3
1963	17.0	45.3	-19.8
1964	17.4	38.5	-16.4
1965	18.2	25.8	-7.1
1966	19.0	17.0	0.9
1967	19.0	21.9	-2.4
1968	19.9	27.9	-6.3
1969	23.2	29.3	-4.7
1970	24.0	34.9	-8.1
1971	18.0	22.1	-3.4
1972	21.0	163.4	-57.0
1973	48.0	508.1	-80.9
1974	91.2	375.9	-64.8
1975	411.3	340.7	13.7
1976	350.7	174.3	64.2
1977	156.2	63.5	57.2
1978	85.2	30.9	42.3
1979	62.0	38.9	16.4
1980	52.0	31.2	15.9
1981	51.9	9.5	38.7
1982	63.1	20.7	35.1
1983	42.7	23.1	15.9

Source: Muchnik (1983) and Banco O'Higgins (1984)

1/ Short-term (30 days) bank lending rates, annualized.

TABLE A-1.16 Chile: Volume of Agricultural Credit, 1965-81 (million pesos of 1984)

Year	Total Agr.Credit	Operational Loans	Capital Loans
1965	8,459	7,660	799
1966	13,942	11,323	2,619
1967	15,381	12,652	2,729
1968	16,481	10,390	6,091
1969	17,241	14,069	3,172
1970	18,027	10,010	8,017
1971	24,686	12,348	12,338
1972	26,995	9,173	17,822
1973	20,574	9,414	11,160
1974	12,639	10,686	1,953
1975	10,788	8,092	2,696
1976	23,044	16,824	6,220
1977	19,400	10,051	9,349
1978	29,246	17,146	12,099
1979	37,607	20,845	16,762
1980	83,217	68,513	14,704
1981	149,964	123,947	26,017

Source: 1965 - 73 : PPEA (1976) "El sector Agrícola Chileno 1964 1974 "

1974 - 81 : ODEPA (1980) " Chile: Estadísticas Agropecuarias 1975 - 1979" y Actualizaciones posteriores.

TABLE A-1.17 Gross Value Product of Selected Commodities, 1960-84
(million pesos of 1984)

Year	Wheat	Rice	Maize	Beans	Potatoes
1960	7,002.49	774.71	1,150.71	1,743.38	6,470.61
1961	6,504.33	737.20	1,264.70	1,788.72	5,047.11
1962	6,200.05	496.18	1,155.68	1,192.70	4,729.56
1963	6,823.44	390.41	1,152.99	928.59	6,470.63
1964	7,037.62	512.92	1,874.12	952.13	5,618.42
1965	7,596.67	505.20	1,769.22	1,372.64	4,382.54
1966	9,755.70	604.78	2,067.42	1,539.50	4,705.98
1967	8,466.33	654.24	2,607.04	1,724.39	3,996.71
1968	8,452.32	719.15	2,271.54	917.51	3,352.26
1969	8,843.50	284.26	1,274.37	1,288.34	2,463.40
1970	9,462.98	599.63	1,825.31	2,433.59	2,531.87
1971	9,937.31	551.59	2,089.11	2,498.12	4,353.48
1972	6,080.71	502.17	3,686.79	2,540.29	14,777.34
1973	3,050.73	318.06	7,132.63	1,360.43	13,057.35
1974	16,417.96	657.55	6,218.32	1,883.50	8,190.44
1975	23,230.03	1,621.00	5,121.54	6,937.16	14,133.82
1976	18,447.80	2,280.18	3,901.72	5,859.73	10,540.17
1977	22,696.30	2,327.45	4,563.82	4,129.57	9,688.64
1978	15,726.48	2,046.79	4,024.27	2,764.54	8,459.18
1979	17,399.22	2,947.39	7,342.47	5,345.14	10,513.68
1980	15,559.27	1,289.51	5,831.76	7,938.49	12,150.85
1981	10,243.82	1,612.30	6,096.75	10,116.56	10,356.97
1982	9,319.57	1,726.60	5,775.46	5,300.83	11,498.29
1983	11,391.96	1,561.89	8,291.85	3,562.25	11,565.64
1984	18,827.11	2,612.49	11,241.79	4,814.88	10,658.87

Source: DEA-UC.

TABLE A-1.18 Area Planted of Selected Crops, 1960-84
(thousand hectares)

Crop Year	Wheat	Rice	Maize	Beans	Potatoes
1959-60	833.00	38.79	82.60	80.98	89.52
1960-61	769.20	38.49	83.33	77.53	96.18
1961-62	763.80	27.69	84.56	75.01	91.41
1962-63	751.00	30.95	84.35	70.78	88.85
1963-64	748.20	30.55	88.16	64.06	84.73
1964-65	727.08	27.53	87.64	58.45	91.07
1965-66	779.97	36.88	80.70	64.74	76.27
1966-67	718.50	33.00	92.20	68.40	77.10
1967-68	698.35	32.48	88.61	53.38	79.25
1968-69	743.05	16.19	58.44	47.16	76.22
1969-70	740.29	25.22	73.86	57.23	71.55
1970-71	727.42	27.26	77.00	69.91	80.03
1971-72	711.82	25.70	84.48	79.47	79.20
1972-73	533.79	18.54	86.39	67.55	66.69
1973-74	591.01	13.17	107.39	73.89	93.27
1974-75	686.19	22.88	91.55	68.02	71.53
1975-76	697.57	28.59	96.15	81.55	68.44
1976-77	628.01	35.46	115.56	97.30	85.86
1977-78	579.59	32.64	93.88	111.74	90.82
1978-79	560.47	47.07	130.41	109.99	80.93
1979-80	545.74	40.84	116.19	110.70	88.76
1980-81	432.16	31.40	125.53	117.74	89.92
1981-82	373.80	36.96	107.13	121.52	77.41
1982-83	359.18	30.43	117.95	86.41	67.16
1983-84 a/	471.32	39.88	138.37	84.54	81.37

a/ Preliminary estimate.

Source: Instituto Nacional de Estadísticas, INE.

TABLE A-1.19 Volume of Production of Selected Crops, 1960-1984
(metric tons)

Crop Year a/	Wheat	Rice	Maize	Beans	Potatoes
1959-60	1,043,690	107,120	161,050	73,330	790,000
1960-61	1,030,560	104,720	162,810	75,190	842,900
1961-62	969,750	78,480	180,760	74,290	765,260
1962-63	1,135,610	79,270	176,020	64,130	847,620
1963-64	1,158,880	80,440	241,520	64,140	808,410
1964-65	1,115,830	80,390	259,870	58,900	703,230
1965-66	1,346,410	76,700	285,330	68,800	803,000
1966-67	1,203,450	84,150	362,220	89,760	716,550
1967-68	1,215,890	93,490	320,850	65,060	724,090
1968-69	1,214,210	36,720	153,790	46,750	602,490
1969-70	1,306,910	76,230	239,050	65,580	683,800
1970-71	1,367,910	67,070	258,330	72,180	835,830
1971-72	1,195,140	86,280	282,990	82,900	733,050
1972-73	746,680	54,950	294,020	64,970	623,580
1973-74	939,905	34,350	366,300	74,840	1,011,990
1974-75	1,003,070	76,380	328,900	74,050	737,930
1975-76	866,470	97,650	247,950	70,320	538,920
1976-77	1,219,320	120,010	355,320	112,380	928,390
1977-78	892,620	104,790	256,880	112,060	980,740
1978-79	995,140	181,170	489,270	116,290	770,490
1979-80	966,000	95,440	405,190	84,240	903,130
1980-81	685,970	99,740	518,150	138,240	1,007,260
1981-82	650,450	131,180	484,050	162,460	841,550
1982-83	585,950	115,560	511,550	84,400	683,620
1983-84 b/	988,300	165,000	721,400	94,100	1,036,200

a/ The crop year covers the period May-April.

b/ Preliminary.

Source: 1960-1980: Instituto Nacional de Estadísticas, INE [1981] "Chile: Series Estadísticas."
1981-1984: INE. Encuesta Nacional Agropecuaria.

TABLE A-1.20 Yields of Selected Crops, 1960-1984
(metric tons per hectare)

Crops Year	Wheat	Rice	Maize	Beans	Potatoes
1959-60	1.25	2.76	1.95	0.91	7.81
1960-61	1.34	2.72	1.95	0.97	8.76
1961-62	1.26	2.83	2.14	0.99	8.37
1962-63	1.51	2.57	2.09	0.91	9.54
1963-64	1.55	2.63	2.74	1.00	9.54
1964-65	1.53	2.92	2.97	1.01	7.72
1965-66	1.73	2.08	3.54	1.06	10.53
1966-67	1.67	2.55	3.93	1.31	9.29
1967-68	1.74	2.88	3.62	1.22	9.14
1968-69	1.63	2.27	2.63	0.99	7.90
1969-70	1.77	3.02	3.24	1.15	9.54
1970-71	1.88	2.46	3.35	1.03	10.44
1971-72	1.68	3.36	3.35	1.04	9.26
1972-73	1.40	2.96	3.40	0.96	9.35
1973-74	1.59	2.63	3.43	1.01	10.85
1974-75	1.46	3.34	3.59	1.09	10.32
1975-76	1.24	3.42	2.58	0.86	7.88
1976-77	1.94	3.38	3.07	1.15	10.81
1977-78	1.54	3.21	2.74	1.00	10.80
1978-79	1.78	3.85	3.75	1.06	9.52
1979-80	1.77	2.34	3.49	0.76	10.18
1980-81	1.59	3.18	4.13	1.17	11.20
1981-82	1.74	3.55	4.52	1.34	10.87
1982-83	1.63	3.80	4.34	0.98	10.18
1983-84 a/	2.10	4.14	5.21	1.11	12.73

a/ Preliminary.

Source: Instituto Nacional de Estadísticas, INE.

TABLE A-1.21 Chile: Livestock Numbers by Species 1965-81
(number of heads)

Year	Cattle	Sheep	Hogs
1965	2,870,190	6,690,280	1,021,594
1966	2,869,378	6,630,400	1,022,331
1967	2,883,518	6,732,600	1,023,068
1968	2,910,708	6,834,700	1,003,805
1969	2,916,468	6,506,500	1,026,157
1970	2,998,675	6,131,200	1,027,436
1971	3,051,495	5,906,700	1,029,757
1972	3,124,965	5,676,063	1,032,960
1973	3,276,960	5,353,300	967,761
1974	3,456,725	5,543,700	866,148
1975	3,606,210	5,574,305	734,410
1976	3,380,373	5,674,339	895,055
1977	3,406,874	5,649,663	923,766
1978	3,440,879	6,216,069	979,192
1979	3,487,503	5,928,010	1,036,756
1980	3,602,176	6,014,000	1,070,000
1981	3,768,202	6,185,000	1,100,000

Source: Hurtado,H. 1984 (See the various original sources of data in that report).

TABLE A-1.22 Value of Exports, Total and Agricultural, 1960-84
(million US dollars)

Year	Total National Exports	Farms Sector Exports			
		Agricultural Products a/	Livestock Products b/	Total	
				US$	%
1960	469.7	16.3	7.2	23.5	5.0
1961	465.4	16.5	10.0	26.5	5.7
1962	500.7	18.3	7.7	26.0	5.2
1963	504.0	16.0	9.6	25.0	5.0
1964	592.1	16.9	9.0	25.9	4.4
1965	684.0	15.0	6.8	21.8	3.2
1966	866.5	11.6	8.1	19.7	2.3
1967	873.2	12.3	6.5	18.8	2.2
1968	910.9	16.4	7.6	24.0	2.6
1969	1,170.9	14.8	9.8	24.6	2.1
1970	1,111.7	22.4	7.7	30.1	2.7
1971	962.2	22.7	4.3	27.0	2.8
1972	836.2	15.5	0.8	16.3	1.9
1973	1,247.5	20.8	1.2	22.0	1.8
1974	2,152.5	42.9	4.4	47.3	2.2
1975	1,552.1	59.7	16.7	76.4	4.9
1976	2,082.6	86.2	24.8	111.0	5.3
1977	2,190.3	126.6	23.2	149.8	6.8
1978	2,407.8	157.7	27.8	185.5	7.7
1979	3,894.2	183.8	37.5	221.3	5.7
1980	4,670.7	244.3	36.9	281.2	6.0
1981	3,906.3	268.0	29.1	291.1	7.4
1982	3,709.5	278.1	33.5	311.6	8.4
1983	3,835.5	253.7	26.4	280.1	7.3

a/ Includes principally apples, grapes and other fruits, and dry legumes.
b/ Includes principally mutton and wool.

Source: 1960-1982: "Indicadores Económicos y Sociales". Banco Central de Chile.
1982-1984: "Indicadores de Comercio Exterior, Junio 1984". Banco Central de Chile.

TABLE A-1.23 Volume of Imports (M) and Exports (X) of Selected Crops, 1964-83
(metric tons)

Year	Wheat		Rice		Maize		Beans		Other Legumes[a/]		Potatoes	
	M	X	M	X	M	X	M	X	M	X	M	X
1964	203,554	-	22,234	-	-	-	-	22,142	-	15,921	249	-
1965	240,266	-	10,708	-	12,150	-	496	11,939	-	5,086	-	-
1966	265,399	-	39,729	-	28,536	-	791	6,351	-	2,581	3,989	-
1967	213,857	-	10,180	-	37,209	-	-	13,111	-	3,084	9,540	-
1968	363,557	-	14,000	-	72,750	-	-	12,835	-	6,467	40	-
1969	267,941	-	50,069	-	254,599	-	-	6,075	-	2,147	13,114	-
1970	200,371	-	36,757	-	163,580	-	164	11,655	-	6,608	21,459	-
1971	367,090	-	19,795	-	76,841	-	-	13,059	-	5,375	6,965	-
1972	352,446	-	15,836	-	93,902	-	-	11,718	-	1,152	3,499	-
1973	549,825	-	6,756	-	35,366	-	-	7,716	-	1,357	350	-
1974	729,678	-	72,051	-	142,184	103	1	27,567	-	11,627	9,675	42
1975	599,119	-	22,473	-	86,844	113	9	21,735	-	11,738	13,389	380
1976	1 131,242	504	5,039	1	15,334	324	277	14,705	30	8,098	4,774	851
1977	460,314	-	32,311	15,678	83,954	411	5	35,061	9	18,287	4	24
1978	918,213	-	11,252	22,922	253,310	123	11	55,363	21	19,712	133	280
1979	728,113	-	9,000	18,371	197,559	384	-	48,795	-	26,483	5,006	-
1980	1,027,140	-	45,014	1,015	433,660	167	-	49,653	332	17,202	-	-
1981	1,036,381	-	14,892	-	314,954	138	-	59,975	771	10,087	-	-
1982	992,034	-	21,431	-	397,181	-	-	47,652	-	5,881	-	-
1983	1,158,283	-	31,127	-	143,624	-	-	44,585	-	5,281	-	-

a/ Lentils, chickpeas and greenpeas.

Source: 1964-1974 : PPEA-UC [1975] "El Sector Agrícola Chileno: 1964-1974".
1975-1979 : PPEA-UC [1981] "El Sector Agrícola Chileno: 1974-1980".
1980-1981 : ODEPA [1982] "Chile: Estadísticas Agropecuarias 1981-1982".
1982-1983 : Banco Central de Chile [1984] "Indicadores de Comercio Exterior".

TABLE A-1.24 Value of Imports (M) and Exports (X) of Selected Crops, 1964-83[a/]
(thousand US dollars)

Years	Wheat		Rice		Maize		Beans		Other Legumes		Potatoes	
	M	X	M	X	M	X	M	X	M	X	M	X
1964	16,751	-	3,589	-	-	-	-	3,728	-	3,460	26	-
1965	16,139	-	1,805	-	799	-	-	2,250	-	1,027	-	-
1966	28,442	-	6,732	-	2,027	-	-	1,356	-	703	247	-
1967	17,515	-	2,168	-	2,480	-	-	2,237	-	733	677	-
1968	27,475	-	3,176	-	4,323	-	-	2,143	-	1,290	2	-
1969	20,441	-	8,700	-	15,649	-	-	1,664	-	503	872	-
1970	13,357	-	7,598	-	10,826	-	-	2,635	-	1,990	1,757	-
1971	25,860	-	3,166	-	6,778	-	-	6,795	-	1,961	501	-
1972	24,653	-	2,690	-	6,857	-	-	3,560	-	537	297	-
1973	81,709	-	1,271	-	3,448	-	-	2,884	-	700	64	-
1974	253,398	-	21,170	-	27,085	81	1	14,160	-	6,409	1,108	6
1975	114,034	-	9,734	-	15,251	53	8	7,486	-	5,002	3,940	71
1976	253,982	101	3,207	-	1,994	154	67	4,822	25	4,268	1,333	101
1977	53,265	-	9,492	2,066	10,034	1,837	3	12,688	14	9,944	4	23
1978	129,261	-	4,223	4,000	29,208	35	-	19,029	24	12,155	105	14
1979	137,335	-	4,150	4,324	27,692	75	175	19,890	-	17,470	1,177	-
1980	209,204	-	25,661	225	69,761	101	-	31,490	189	16,194	-	-
1981	212,306	-	8,492	-	49,107	76	-	39,342	393	7,734	-	-
1982	175,800	-	10,900	-	50,800	-	-	12,200	-	3,800	-	-
1983	198,300	-	10,700	-	22,400	-	-	13,000	-	3,100	-	-

a/ Values are CIF and FOB, respectively.

Source: 1964-1973 : PPEA-UC [1974] "El Sector Agropecuario Chileno: 1964-1974".
1974-1979 : PPEA-UC [1981] "El Sector Agropecuario Chileno: 1974-1980".
1980-1981 : ODEPA [1982] "Chile: Estadísticas Agropecuarias 1980-1981".
1982-1983 : Banco Central de Chile [1984] "Indicadores de Comercio Exterior".

TABLE A-1.25 Fertilizer Consumption: 1960-1984
(metric tons of nutrient elements)

Year	Nutrient Elements		
	Nitrogen	Phosphate	Potash
1960	13,872	37,610	1,070
1961	15,536	52,914	3,760
1962	22,572	53,726	3,716
1963	26,528	73,967	3,802
1964	31,872	72,000	3,096
1965	32,432	71,246	2,852
1966	37,226	83,105	6,084
1967	38,229	75,104	12,463
1968	33,939	96,885	9,836
1969	45,104	98,876	13,645
1970	44,428	98,564	15,066
1971	49,681	103,693	16,697
1972	54,726	84,660	18,853
1973	60,733	121,151	15,582
1974	52,967	103,480	16,176
1975	37,100	62,000	9,010
1976	49,928	64,298	14,794
1977	38,117	59,323	9,952
1978	50,032	65,950	13,463
1979	56,374	73,465	13,609
1980	52,369	70,954	14,417
1981	49,253	56,458	13,170
1982	48,760	48,500	12,477
1983	65,230	62,037	11,935
1984	73,000	84,000	13,000

Source: 1960-1977: Servicio Agrícola y Ganadero (SAG)
1978-1983: Oficina de Planificación Agrícola (ODEPA)
1984 : Estimación Departamento Economía Agraria, Universidad Católica de Chile (DEA-UC).

Annex Tables to Chapter II

TABLE A-2.1 INIA: Source of Income, 1965-83
(percentages)

Year	Public Budget Allocation a/	Income from Sales b/	Other Income c/
1965	93.0	7.0	0.0
1966	93.7	6.3	0,0
1967	93.9	6.1	0,0
1968 (*)	91.0	9.0	0.0
1969 (*)	90.0	10.0	0.0
1970	88.8	11.2	0.0
1971	91.2	8.8	0.0
1972 (*)	88.0	12.0	0.0
1973 (*)	78.0	22.0	0.0
1974	80.0	20.0	0.0
1975	73.3	26.7	0.0
1976	77.6	22.0	0,4
1977	77.0	20.9	2.1
1978	80.5	19.2	0.3
1979	78.9	20.3	0.8
1980	57.5	28.1	14.4
1981	49.3	24.9	25.8
1982	58.3	22.5	19.2
1983	44.4	37.3	18.3

a/ Includes funds allocated for current and investment expenses.

b/ Includes sale of seeds, farm produce, and professional and other services.

c/ Includes research grants and contracts; and sale of propertry in years 1977 and following.

Source: Calculated from figures in INIA Annual Reports; except for years marked (*) which are taken from Muchnik, 1983.

TABLE A-2.2 INIA: Research Expenditure, by Type of Expense, 1965-83 (thousand pesos of 1984)

	Operating Expenses	Capital Expenses	Total
1965	152,374	10,933	163,307
1966	219,396	47,848	267,244
1967	283,401	65,156	348,557
1968	316,516	40,647	357,163
1969	349,422	11,192	360,614
1970	375,759	16,657	392,416
1971	nd	nd	653,677
1972	nd	nd	649,904
1973	nd	nd	528,138
1974	675,633	58,037	733,670
1975	556,120	147,653	703,773
1976 a/	728,554	150,728	879,282
1977 a/	766,608	144,146	910,754
1978	761,462	81,986	843,448
1979	787,017	82,393	869,410
1980	779,646	90,350	870,006
1981	884,151	98,310	982,461
1982	784,706	17,386	802,092
1983	777,726	28,052	805,778

a/ Adjusted. See Table 2.6.

Source: INIA. Annual Reports and Table 2.6.

TABLE A-2.3 INIA: Current Operating Expenses[a/] of Regional Research Centers, 1965-83 (million pesos of 1984)

Year	Platina	Quilamapu	Carillanca	Remehue	Kampenaike
1965	50.78	20.20	14.14	4.31	-
1966	50.24	28.42	17.24	4.31	-
1967	61.82	36.37	23.30	4.85	-
1968	59.00	39.47	26.94	6.06	-
1969	65.60	45.26	30.85	8.90	0.67
1970	71.12	52.80	36.10	10.24	3.77
1971	103.45	67.89	44.72	16.97	6.33
1972	99.00	66.54	40.27	18.32	10.64
1973	91.19	63.17	37.44	18.86	10.78
1974	118.53	77.32	51.18	30.04	11.18
1975	108.16	67.21	45.26	26.94	8.22
1976	152.48	100.89	66.14	39.20	13.60
1977	193.96	123.38	86.21	51.59	17.24
1978	192.56	124.12	86.21	51.30	15.71
1979	208.11	143.18	100.48	56.03	17.38
1980	174.43	122.98	68.83	51.59	12.66
1981	191.81	138.20	71.25	55.63	13.47
1982	142.89	114.79	60.28	43.43	15.00
1983	155.68	105.62	56.27	47.23	7.48

a/ The annual totals would differ from the operating expenses reported in Table A-2.2 by the amount expended by the central office.

Source: 1965-77: Muchnik [1983].
1978-83: INIA, Memorias Anuales.

TABLE A-2.4 INIA: Total Professional Staff, by Areas of Assignment, 1965-83

Year	Head Office	Exp. Sta. Admin.	Techn. Transfer	Crop Production	Animal Production	Environment Resources a/	Total
1965	5	9	8	49	32	12	115
1966	6	9	12	52	32	9	120
1967	6	10	15	53	36	19	139
1968	7	8	15	57	40	24	151
1969	7	12	12	56	43	25	155
1970	7	13	12	53	44	24	153
1971	8	9	6	78	42	15	158
1972	nd	nd	nd	nd	nd	nd	nd
1973	nd	nd	nd	nd	nd	nd	nd
1974	7	13	7	66	39	21	153
1975	10	10	6	66	38	22	152
1976	9	13	8	65	37	28	160
1977	5	15	12	72	33	28	165
1978	nd	nd	nd	nd	nd	nd	nd
1979	8	18	25	76	36	32	195
1980	11	14	26	64	29	24	168
1981	10	13	30	68	25	26	172
1982	10	11	30	67	24	29	171
1983	11	13	32	69	25	30	180

a/ This section includes scientists in soils, irrigation and drainage, ecology and management, and biometrics.

Source: INIA. Annual Reports.

TABLE A-2.5 INIA: Professional Staff, by Academic Degree, 1965-83

Year	Ing. Agr.	D.V.M.	M.S.	Ph.D.	Others a/	Total
1965	88	3	17	4	3	115
1966	93	3	16	5	3	120
1967	105	4	21	5	4	139
1968	111	6	19	9	6	151
1969	107	6	26	10	6	155
1970	97	11	28	11	6	153
1971	95	8	31	15	9	158
1972	nd	nd	nd	nd	nd	nd
1973	nd	nd	nd	nd	nd	nd
1974	103	9	26	13	2	153
1975	106	9	24	13	2	152
1976	107	11	26	14	2	160
1977	112	8	29	14	2	165
1978	nd	nd	nd	nd	nd	nd
1979	126	7	41	17	4	195
1980	106	5	36	17	4	168
1981	111	3	39	16	3	172
1982	102	3	44	18	4	171
1983	108	2	44	21	5	180

a/ Includes economists, chemists, statisticians, etc.

Source: INIA. Annual Reports.

TABLE A-2.6 INIA: Distribution of Researchers by Regional Research Centers, 1965-83

Year	Platina			Quilamapu			Carillanca			Remehue			Kampenaike		
	Total Invest.	M.S.	PhD.	Total Invest.	M.S.	PhD.	Total Invest.	M.S.	PhD.	Total Invest.	M.S.	PhD.	Total Inves.	M.S.	PhD.
1965	62	11	1	16	-	-	19	4	-	4	-	-	-	-	-
1966	66	11	1	17	1	-	22	4	1	4	-	-	-	-	-
1967	70	12	1	20	2	-	28	5	1	5	-	-	-	-	-
1968	82	10	4	20	2	-	29	5	1	5	-	-	-	-	-
1969	80	11	7	21	6	-	30	6	1	5	-	-	-	-	-
1970	79	13	6	20	5	-	28	6	2	5	-	-	1	-	-
1971	86	15	9	24	7	-	29	5	2	2	-	-	-	-	-
1972															
1973															
1974	72	15	5	23	3	-	30	5	2	5	1	-	3	-	-
1975	75	14	4	25	2	-	23	4	2	6	1	-	3	-	-
1976	73	14	7	25	3	-	25	5	2	9	1	-	6	-	-
1977	75	16	8	31	3	-	23	5	2	9	2	-	7	1	-
1978															
1979	83	18	10	35	8	1	32	9	2	14	3	-	5	1	-
1980	88	21	10	30	7	1	21	4	1	13	3	-	3	-	-
1981	77	20	11	30	9	1	27	6	1	14	3	-	1	-	-
1982	78	24	12	30	10	1	27	5	1	14	3	-	1	-	-
1983	81	22	12	33	11	1	27	6	1	15	3	1	-	-	-

Source : INIA. Annual Reports.

TABLE A-2.7 INIA: Total Number of Researchers Assigned to Specific Crop Programs, 1965-83

Year	Wheat	Rice	Maize	Beans a/	Potatoes
1965	11	1	2	4	3
1966	11	1	2	3	3
1967	11	1	2	3	3
1968	7	1	2	3	4
1969	7	1	2	3	4
1970	11	1	3	4	5
1971	11	1	2	4	5
1972	9	1	2	3	1
1973	9	1	2	4	2
1974	10	1	2	4	2
1975	10	2	3	5	5
1976	10	2	3	4	6
1977	11	2	3	5	9
1978	11	2	2	6	7
1979	11	2	2	4	8
1980	11	1	2	6	6
1981	11	1	2	7	6
1982	11	1	1	7	4
1983	11	2	1	7	4

a/ Includes other dry legumes.

Source: INIA. Annual Reports, and personal communication with Dr. Sergio Bonilla, Research Director of INIA.

TABLE A-2.8 INIA: Number of Women Professional Researchers, by Program Area, 1965-83

Year	Administr. of Exp. Sta.	Extension and Trans. Tech.	Crop Production	Animal Production	Environment Researchers	Women Researchers	As % of INIA Researchers
1965	-	-	10	1	3	14	12.2
1966	-	-	9	2	3	14	11.0
1967	-	-	9	2	3	14	10.1
1968	-	-	9	2	3	14	9.3
1969	-	-	6	2	1	9	5.9
1970	-	-	6	2	2	10	6.5
1971	-	-	6	2	1	9	5.7
1972	nd	nd	nd	nd	nd	nd	nd
1973	nd	nd	nd	nd	nd	nd	nd
1974	1	-	10	8	3	22	14.4
1975	1	-	10	5	3	19	12.5
1976	1	1	10	5	3	20	12.5
1977	1	2	10	3	3	19	11.5
1978	nd	nd	nd	nd	nd	nd	nd
1979	1	1	12	4	3	21	10.8
1980	-	2	11	3	4	20	11.9
1981	-	2	11	3	2	18	10.5
1982	-	2	11	3	2	18	10.5
1983	-	2	11	3	3	19	10.6

Source: INIA. Annual Reports.

Table A-2.9 INIA: Women Researchers, by Professional Degree, 1965-83

Year	Ing. Agr.	M.S.	Other	Total
1965	13	1	-	14
1966	13	1	-	14
1967	13	1	-	14
1968	13	1	-	14
1969	8	1	-	9
1970	9	1	-	10
1971	8	1	-	9
1972	nd	nd	nd	nd
1973	nd	nd	nd	nd
1974	19 a/	2	1	22
1975	16	2	1	19
1976	17	2	1	20
1977	16	2	1	19
1978	nd	nd	nd	nd
1979	18	3	-	21
1980	17	3	-	20
1981	15	3	-	18
1982	15	3	-	18
1983	14	3	2	19

a/ Includes 3 Doctors of Veterinary Medicine.

Source: INIA. Annual Reports.

TABLE A-2.10 University of Chile: Professional Staff of the Faculty of Agriculture by Departments, 1960-84 a/ b/

Year	Agric. Prod. c/	Animal Prod.	Soils	Rural Development	Total
1960	26	7	5	-	38
1961	28	7	7	-	42
1962	28	7	7	-	42
1963	31	7	7	-	45
1964	33	7	8	-	48
1965	37	8	8	-	53
1966	40	8	8	-	56
1967	46	10	11	-	67
1968	50	10	11	-	71
1969	54	11	13	-	78
1970	58	12	17	2	89
1971	64	15	20	4	103
1972	72	17	22	4	115
1973	80	21	26	10	137
1974	80	22	28	15	145
1975	86	22	30	15	153
1976	88	26	29	18	161
1977	88	26	30	21	165
1978	90	27	31	22	170
1979	90	28	32	23	173
1980	88	30	32	22	172
1981	86	30	33	22	173
1982	85	29	36	22	172
1983	84	28	37	23	172
1984	86	28	39	23	176

a/ Refers to staff of the "School of Agronomy" proper, excluding forestry and vet. medicine.

b/ The figures refer only to full-time staff and include those on study leave.

c/ Includes the departments of Crops, Fruit culture, and Phytopathology.

Source: Planning Office, Faculty of Agriculture, University of Chile.

TABLE A-2.11 University of Chile: Agricultural Staff, by Academic Degree, 1960-84

Year	Ing.Agr.	DVM	M.S.	Ph.D.	Other	On Study Leave	Total
1960	22	2	4	1	9	-	38
1961	25	2	5	1	9	-	42
1962	25	2	5	1	9	-	42
1963	26	2	5	1	9	2	45
1964	27	2	6	1	10	2	48
1965	29	2	7	1	10	4	53
1966	29	2	7	2	13	3	56
1967	32	2	10	4	13	6	67
1968	32	2	14	4	15	4	71
1969	36	2	15	4	16	5	78
1970	37	2	17	5	23	5	89
1971	47	2	18	6	24	6	103
1972	53	2	21	8	26	5	115
1973	60	5	23	9	33	7	137
1974	60	7	24	9	36	9	145
1975	64	7	25	13	37	7	153
1976	66	7	30	12	37	9	161
1977	69	8	30	14	39	5	165
1978	70	8	34	14	39	5	170
1979	70	8	35	15	40	5	173
1980	68	8	35	15	40	6	172
1981	67	8	37	16	42	3	173
1982	66	8	37	16	42	3	172
1983	65	8	36	16	44	3	172
1984	67	8	37	17	44	3	176

TABLE A-2.12 University of Chile: Number of Researchers Working on Selected Commodity Projects, 1960-1984 a/

Year	Wheat	Rice	Maize	Beans	Potatoes	Total
1960	1	-	1	-	1	3
1961	1	-	1	-	1	3
1962	1	2	3	-	1	7
1963	2	-	5	3	-	10
1964	1	-	2	1	-	4
1965	2	1	4	1	1	9
1966	2	1	2	2	3	8
1967	-	-	2	2	2	7
1968	1	-	5	1	1	8
1969	1	-	2	1	-	4
1970	2	-	2	-	1	5
1971	1	-	3	-	-	4
1972	1	-	3	-	-	4
1973	1	-	4	-	-	5
1974	2	-	2	-	1	5
1975	4	-	3	2	-	9
1976	4	-	2	3	1	10
1977	3	-	2	3	-	8
1978	3	2	2	5	-	12
1979	3	-	2	5	1	11
1980	3	-	3	5	-	11
1981	1	-	4	4	2	11
1982	1	1	2	3	-	7
1983	-	-	2	3	-	5
1984	1	-	3	1	-	5

a/ This distribution is based on an analysis of staff research publication and advising of student theses, and on Faculty administrators estimates. The figures include research in support disciplines, applied to these crops.

TABLE A-2.13 Catholic University: Full-Time Staff, by Departments of the Faculty of Agronomy, 1960-1984

Year	Crop Prod.	Fruits Crops	Soils	Animal Prod.	Agric. Economics	Total
1960	1	-	-	-	-	1
1961	-	-	-	-	-	-
1962	1	-	1	1	1	4
1963	1	-	2	2	3	8
1964	2	-	4	3	4	13
1965	2	1	4	3	4	14
1966	2	1	3	3	3	12
1967	1	1	5	3	5	15
1968	2	1	4	2	4	13
1969	5	2	3	4	5	19
1970	4	3	4	4	8	23
1971	5	4	4	4	6	23
1972	4	4	6	3	8	25
1973	5	3	6	4	7	25
1974	4	2	6	5	7	24
1975	4	3	5	5	7	24
1976	5	3	4	3	6	21
1977	3	2	4	3	9	21
1978	4	1	5	4	8	22
1979	4	3	5	6	9	27
1980	5	5	5	9	9	33
1981	8	7	5	8	8	36
1982	8	5	5	8	10	36
1983	9	5	6	7	9	36
1984	9	6	6	7	9	37

TABLE A-2.14 Catholic University: Number of Full-Time Staff in the Faculty of Agronomy, by Academic Degree, 1960-84

Year	Ing. Agr.	M.S.	Ph.D.	Other	Total
1960	-	1	-	-	1
1961	-	-	-	-	-
1962	1	3	-	-	4
1963	3	3	2	-	8
1964	5	6	2	-	13
1965	5	7	2	-	14
1966	4	7	1	-	12
1967	5	7	2	-	14
1968	5	5	3	-	13
1969	5	9	4	1	19
1970	7	9	6	1	23
1971	7	8	7	1	23
1972	6	9	10	-	25
1973	4	11	10	-	25
1974	2	8	14	-	24
1975	4	8	12	-	24
1976	3	6	12	-	21
1977	1	5	15	-	21
1978	-	5	17	-	22
1979	1	6	20	-	27
1980	3	8	21	1	33
1981	3	9	23	1	36
1982	2	8	25	1	36
1983	-	7	28	1	36
1984	-	8	28	1	37

Source: Faculty of Agronomy, U.C.
Figures exclude the staff on study leave, sabbaticals, or other forms of leave.

TABLE A-2.15 University of Concepción: Agricultural Staff, a/ by Fields, 1960-84

Years	Total	Crops	Soils	Animal	Ag. Ec.	Ag. Eng.
1960	19	8	4	2	2	3
1961	22	10	5	2	2	3
1962	24	10	5	3	2	4
1963	26	10	7	4	2	3
1964	28	9	7	5	3	4
1965	27	9	7	4	3	4
1966	28	9	7	5	3	4
1967	31	10	8	5	3	5
1968	35	11	8	6	4	6
1969	38	13	8	7	4	6
1970	n.d.	-	-	-	-	-
1971	n.d.	-	-	-	-	-
1972	33	11	8	4	5	5
1973	36	11	8	6	4	7
1974	33	12	5	6	3	7
1975	38	13	7	7	4	7
1976	38	13	7	7	4	7
1977	28	12	5	7	4	*
1978	29	14	4	7	4	-
1979	29	14	4	7	4	
1980	31	14	4	8	4	-
1981	26	13	4	5	4	
1982	28	14	4	6	4	
1983	27	14	4	6	3	-
1984	27	14	4	6	3	-

a/ Data refer to full-time staff of the Faculty of Agronomy (1960-80), renamed Department of Agronomy (1981-84). * Agricultural engineering was separated from Agronomy in 1977. The breakdown by fields for 1967-69 is an estimation.

Source: Dirección Programas de Investigación, Facultad de Ciencias Agropecuarias y Forestales, U. de Concepción.

TABLE A - 2.16 Austral University: Number of Full-time Staff in the Faculty of Agricultural Sciences, by Fields and Academic Degree, 1965-1983

Year	TOTAL				Crops	Plant Pathol.	Ag.Eng. Soils	Animal Prod.	Dairy Tech.	Ag. Econ.
	Total	PhD	MS	IA a/						
1965	5									
1966	7									
1967	9									
1968	11									
1969	16									
1970	19									
1971	23									
1972	27									
1973	32									
1974	38									
1975	44									
1976	50									
1977	55	11	10	34	11	5	5	9	20	5
1978	60	12	11	37	14	6	5	9	20	6
1979	56	12	12	32	14	6	5	8	16	7
1980	61	13	11	37	16	6	6	9	18	6
1981	50	10	12	28	11	4	6	8	15	6
1982	48	10	13	25	12	4	5	7	15	5
1983	48	10	9	29	12	3	5	7	15	6

Source: 1977-83, Office of the Dean, FA, UA.
1965-69, Personal communication, Dr. C. Zegers
Missing years were interpolated on basis of partial info.

a/ Includes university degrees other than I.A.

TABLE A- 2.17 Research Staff[a/] of the Private Agricultural Experimental Stations, 1960-84

Year	Semillas Baer	S.N.A.
	(Number of Researchers)	
1960	1	3
1961	1	3
1962	1	3
1963	1	2
1964	1	2
1965	1	2
1966	1	2
1967	1	2
1968	1	2
1969	1	2
1970	1	2
1971	1	2
1972	1	2
1973	1	2
1974	1	2
1975	1	2
1976	1	2
1977	1	2
1978	1	2
1979	1	2
1980	1	2
1981	1	2
1982	1	2
1983	1	2
1984	1,5	2

Source: Semillas BAER and SNA Experiment Station Office.

a/ All are Ingenieros Agrónomos.

Annex Tables to Chapter IV

TABLE: A - 4.1. Certified Wheat Varieties, According to Ownership, 1984

INIA	S. A. G.	BAER	S.N.A.	U.AUSTRAL	U.C.
Primafen	Artois Desprez	Gorbea 1	SNA 14	Austral	Carolina
Novafen	Nord Desprez	BT - 6/72	SNA 4		Victoria
Alifen	Moisson	BT - 31/76	SNA 24		Marianella
Q - 3/76	Capelli	BT - 30/75	SNA 12		
Ancoa	Castaño Alemán	Malleco	Challay	1 variedad	
Maipofen	Gral.von Stocken	BT - 23/75	Raco	0,83%	3 variedades
Manifen	Ministre	Impacto	SNA 3		2,48 %
Alifen	Capeiti	Peneca	Baflo		
Yafen	Caren	Gorbeano	SNA 1		
Andalien	Paine	Línea 503	SNA 2		
Chasqui	Vilmorin 27	BT - 18/74	Huelquen		
Lancera	Druchamp	BT - 22/75	Menflo		
Maiten	Kerne Desprez	As Baer			
Millaleu	Heine 60	BT - 29/75	11 variedades		
Onda	Hesbignon	Primo	9,09 %		
Rancofen	Manitoba	Export Baer			
Talafen	Vilmorin 53	Estrella			
Candealfen 6	Manella	Panadero			
Labriego	Carsten	Express			
Yacora 70	Castaño Colorado	Pionero			
Platifen	Heine 4	Exito			
Likay INIA	Heine's koga	Perla			
Loncofen	Etoile du Choisy	Invicto			
Budifen	Capelle Desprez	Flecha			
Trisa	Vilmorin 29	Patriota			
Candealfen 1		Intermedio			
Rulofen		Inter 74			
orofen 60					
Lilifen	25 variedades	28 variedades			
Melifen	20,66 %	23,14 %			
Orofen					
Collafen					
Panguifen					
Huenufen					
Manquefen					
Andifen					
Sonka INIA					
Lucero					
Candealfen 4					
Kenymfen					
Llocofen					
Chifen					
Antufen					
Punafen					
Mexifen					
Centrifen					
Cabildofen					
Toquifen					
Naofen					
Aurifen					
Quilafen					
Vilufen					
Candealfen 5					
53 variedades					
43,80 %					

Source: Silva, R. and J. Castillo, 1984.

TABLE A - 4.2 National Production of Certified Seeds, Selected Crops, 1960-84 (metric tons)

Year	Wheat	Rice	Maize	Beans	Potatoes
1960	21,222	-	114	115	910
1961	28,421	-	980	285	1,094
1962	32,975	457	1,004	430	2,168
1963	41,423	551	544	495	2,292
1964	42,086	-	1,343	1,002	2,590
1965	44,337	-	1,554	909	2,891
1966	42,250	316	1,322	-	2,964
1967	43,314	-	1,808	-	3,070
1968	47,328	1,091	1,148	42	3,451
1969	39,182	1,183	412	136	2,318
1970	36,452	1,475	1,439	413	4,206
1971	39,608	1,016	1,079	329	6,983
1972	45,036	2,494	1,285	55	7,980
1973	42,032	1,221	1,275	199	6,970
1974	44,335	1,894	2,247	426	8,504
1975	34,646	3,576	235	58	4,486
1976	27,452	2,568	503	301	2,665
1977	34,623	13	448	581	4,807
1978	13,156	634	639	653	2,536
1979	15,138	624	594	255	3,778
1980	8,988	130	9	219	7,083
1981	4,200	768	16	344	6,873
1982	7,283	1,422	8	278	5,128
1983	6,553	1,188	55	80	7,305
1984	15,114	1,201	385	48	8,224

Source: ODEPA.