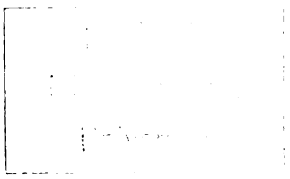

146
271
THS

THESIS
141
S10
THS



PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.
MAY BE RECALLED with earlier due date if requested.

DATE DUE	DATE DUE	DATE DUE

5/08 K:/Proj/Acc&Pres/CIRC/DateDue.indd

EVALUATION AND PROPOSAL FOR AGRICULTURAL MECHANIZATION RESEARCH IN CHILE

By

Omar Ulloa

An AE 811

TECHNICAL PROBLEM REPORT

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Engineering

Summer 1969

LD 2490 .T4

ACKNOWLEDGMENTS

The author wishes to express sincere thanks to Dr. Chester J. Mackson for his guidance and suggestions which made this report possible. He also wishes to thank Professor Howard F. McColly for suggesting the subject and his initial guidance.

Special thanks are expressed to my friend and colleague Edgardo Ossandon (Agricultural Research Institute) for the sending of valuable information.

The author is indebted to the Agricultural Research Institute,Chile and to The Rockefeller Foundation which provided for my stay in this country.

To all those who have contributed to the mechanization of Chilean agriculture, to whom is this report dedicated.

Approved C. J. Mackson
Major Professor

Approved Carl W. Hall
Department Chairman

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Statement of the Problem

In the Latin American panorama, Chile is one of the countries that have most mechanized their agriculture (15).

But Chile is far below the mechanization level of more developed countries. In 1965 there were 22,307 tractors, 274,450 horses and 291,930 oxen, to work 2,317,800 hectares. If all the work were done exclusively with tractors, each tractor working 28.3 hectares, which is the average rate for nine developed countries*, and working to the full capacity of Chile's arable land a total of 140,000 tractors would be required (15). This theoretical figure is impractical, because of socio-economic reasons, but shows a mechanization goal for the future.

Like most Latin American countries, Chile depends on importations for tractors and machinery. Importers have seldom considered the needs of agriculture, and the main

---

*These countries are: Germany, Belgium, Canada, Denmark, France, Holland, Italy, United States and England. They have an average of 28.3 cultivated hectares per each tractor.

criteria has been the initiative of dealers and distributors. The results have been inadequate equipment and proliferation of makes and models (15). To counteract this confusion the National Commission on Agricultural Mechanization was established in October, 1967. This Commission has responsibility of supervising the orderly importation of suitable machinery.

Research in agricultural conditions of Chile is essential to decide which type of machinery to import or manufacture in Chile and how to use it. The research in agricultural mechanization has been meager. The Chilean Development Corporation (CORFO) (5) reports that prior to 1963 not more than 10 significant experiments related to agricultural machinery were done. In recent years CORFO has carried out testing of equipment and some survey studies.

The study presented here makes an evaluation and proposal for agricultural mechanization research in Chile, as essential for the success of the process of mechanizing Chilean agriculture.

Objectives of the Study

1. To review the situation of the agricultural mechanization in Chile;
2. To analyze the research in agricultural mechanization, and to discuss the main problems to be solved;

3. To analyze existing coordination between the institutions doing research in agricultural mechanization;
4. To prepare a proposal for agricultural mechanization research. Goals of this proposal are:
   a. To further coordinate research between the different institutions;
   b. To present guidelines for types of necessary research to be done;
   c. To prepare guidelines for the experimental procedure for the research in agricultural mechanization;
   d. To establish short- and long-term goals according to government plans.

Importance of the Research Project

The organization of a research project in agricultural mechanization is very important for Chilean agriculture for the following reasons:

1. The Government is putting very much emphasis on programs for the development of agriculture;
2. The governmental agencies, cooperatives and farmers in general share great interest for the use of machinery;
3. Most of the machinery is imported; for this reason the selection of machinery must avoid

waste of money; research is essential to decide which equipment to import;

4. The research done so far in agricultural mechanization is very limited; no exact information is available about the most suitable type of machinery for Chilean conditions and its use and maintenance;
5. Good possibilities exist for manufacturing most of the machinery in Chile; therefore studies to encourage such activities should be developed.

I. GENERAL CONDITIONS

1.1 Location and Topography

Chile is located on the Pacific coast of South America. It is a narrow, ribbonlike country, averaging 110 miles in width, and extending 2,650 miles in length, from 17° 30' S to 55° 59' S. (Figure 1.1.)

The total area of Chile is 292,257 sq. miles (756,946 sq. kilometers).

In northern and middle Chile the country is composed of three parallel strips: The Andes on the east, the coast range on the west and a series of lowlands between. South of 42° S there is no central lowland but only a discontinuous island chain standing guard before a fiorded, mountainous coast. Northern Chile is desert, notable for the production of copper and nitrates; southern Chile is a wet and cold region of limited economical potential. Central Chile has an agreeable climate and is the center of agriculture, livestock ranching and industry. (Figure 1.1.)

1.2 Climate

The climate of Chile is characterized by little or no rainfall in the extreme northern part and an increasing

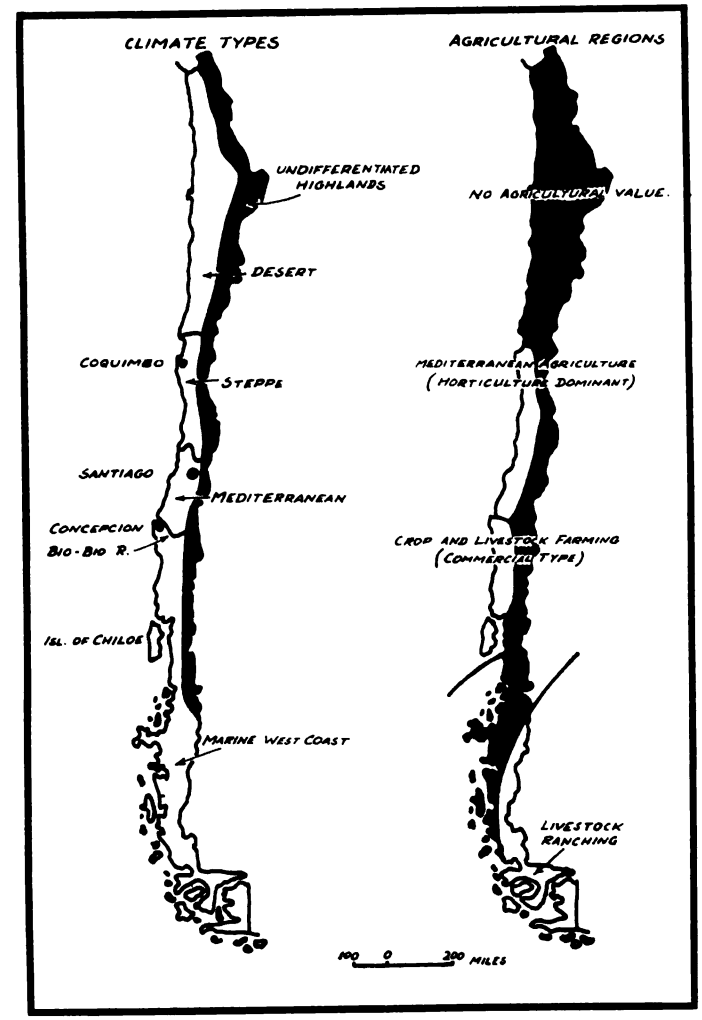


Figure 1.1--Climatic and agricultural maps of Chile.

amount to the south, with 85 to 200 inches per annum south of Puerto Montt. See Table 1.1.

TABLE 1.1.--Annual Rainfall in Selected Stations in Chile.

Station	Latitude South	Altitude in feet	Annual precipitation in inches
	North Chile		
Arica	18° 28'	84	0.08
Iquique	20° 12'	20	0.04
Antofagasta	23° 39'	305	0.24
Copiapo	27° 21'	975	0.96
	North-Central Chile		
Vallenar	28° 34'	1,112	2.4
La Serena	29° 54'	104	5.5
Ovalle	30° 27'	715	6.9
	Central Chile		
Quillota	32° 53'	422	17.6
Santiago	33° 27'	1,690	14.4
	South-Central Chile		
Talca	35° 26'	315	30.1
Chillan	36° 36'	370	42.0
Concepcion	36° 50'	32	52.0
Osorno	40° 55'	88	58.0
	Southern Chile		
Puerto Octay	40° 59'	130	68.0
Puerto Montt	41° 22'	29	87.2

Source: Storie, R. E. & C. Mathews (19)

For all practical purposes, northern Chile can be considered to have no rainfall. There is no vegetation outside of the few river valleys.

North-Central Chile has an arid or semi-arid climate with slight rainfall in winter and a warm, dry summer. A few desert-like shrubs grow in this zone.

Central Chile has a Mediterranean-like climate, with mild rains in the cool winter and with dry summers, very much like the coastal area of Southern California.

South-Central Chile has a subhumid climate with wet, mild, rainy winters; and cool, dry summers. Forests are the dominant vegetation, although there are some prairie-like areas where the dominant vegetation is grass.

Southern Chile is a humid region of high rainfall, chiefly forested. Winters are mild and summers cool. There is no dry season.

1.3 Human Resources

The total population in 1965 was 8.6 million inhabitants. In 1970 it is expected to be 9.6 million persons. The increase of the population between 1960-1964 was 2.8 per cent annually. With this rate of increase, it is estimated that the present (1969) population could be doubled in 25 years (4).

The origin of the people is mostly European. The indigenous population of the country is very small (2.4

per cent in 1952) and concentrated primarily in the provinces of Cautin and Valdivia. (Figure 1.2.)

About 90 per cent of the people live in Central Chile from 30° S to 42° S, where Santiago, the capital of Chile, is located. The population for Santiago in 1966 was 2,346,781 inhabitants.

The composition of the population by age makes Chile a young country. More than 75 per cent of the population is less than 40 years. See Table 1.2.

TABLE 1.2.--Structure of the Population by Age, 1960.

Group of Age	Population (thousands)	Percentage of Total
0- 4	1,167	15.1
5- 9	1,035	13.4
10-12	371	4.8
12-14	502	6.5
15-19	750	9.7
20-54	3,160	40.9
55-59	224	2.9
60-64	193	2.5
over 65	325	4.2
Total	7,727	100.0

Source: Economic Geography of Chile (4)

The literacy level was 88 per cent in 1968 and it is expected to rise to 91 per cent at the end of 1970 (7).

In religion, 90 per cent of the population is Catholic.

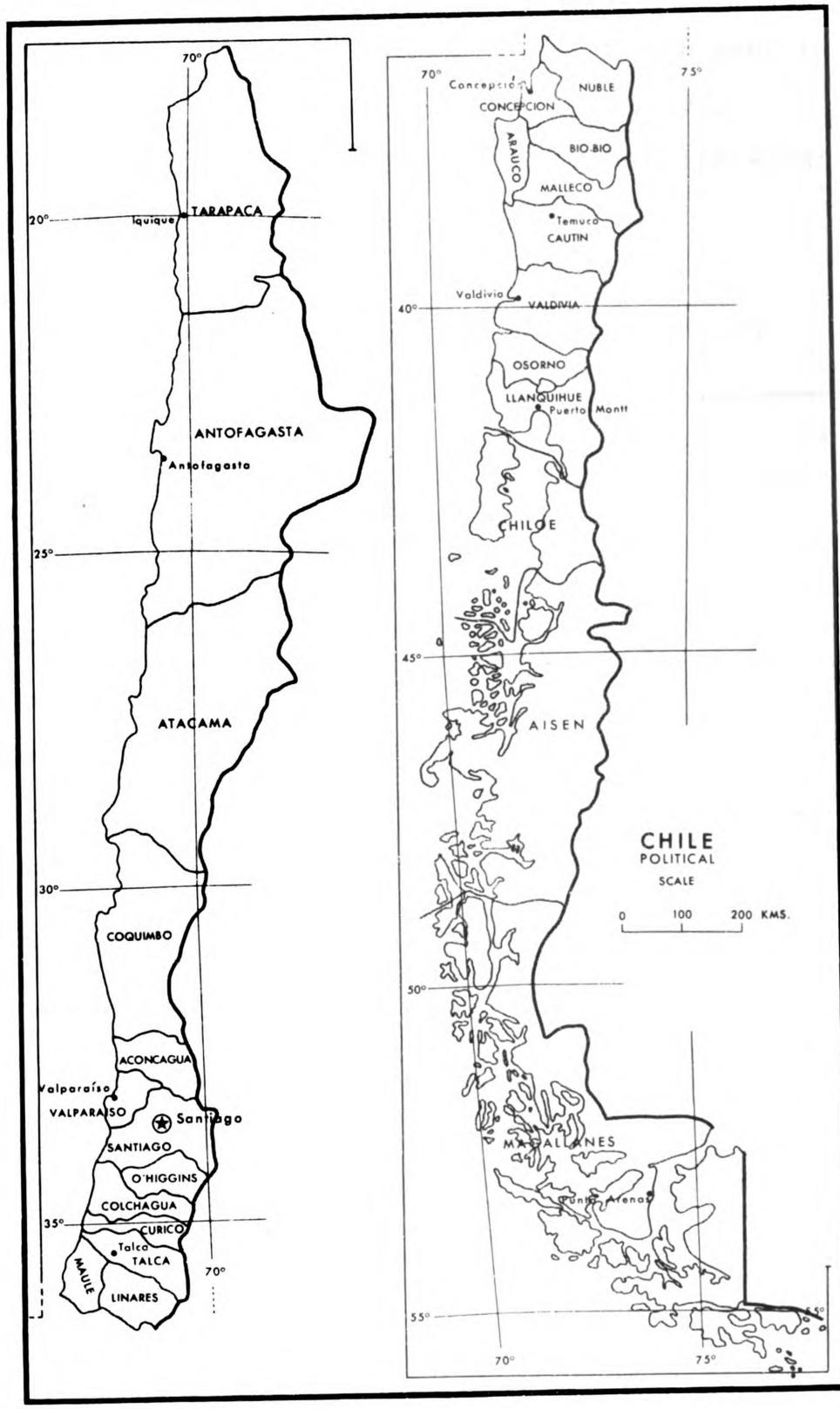


Figure 1.2.--Political map of Chile.

The urban population has risen from 60 per cent in 1952 to approximately 73 per cent in recent years.

Table 1.3. shows the main occupations of the working population in 1952 and 1960.

TABLE 1.3.--Composition of the Working Population by Occupation (in thousands).

Occupation	1952	%	1960	%
Agriculture	648.0	30.1	648.0	27.0
Mining	101.4	4.7	97.3	4.1
Industry	408.7	19.0	406.0	17.2
Construction	102.3	4.7	164.5	7.0
Services	499.4	23.2	568.4	24.1
Commerce	222.9	10.3	225.3	9.6
Transport	95.3	4.4	120.2	5.1
Miscellaneous	77.3	3.6	126.3	5.4
Total	2,155.3	100.0	2,356.0	100.0

Source: Economic Geography of Chile (4).

1.4 Economy

> Chile has reached the point in its history where it is beginning to shed the image of a tradition bound preindustrialized society with a restricted participatory democracy. The country is on the threshold of becoming an industrialized society with a truly popular democracy, as evidenced by its level of income and the complexion of its social structure and economic capacity.
>
> President Eduardo Frei in his annual address to the nation, May 21, 1969.

In the same address President Frei indicated that the Gross National Product was 5.3 per cent between 1964 to

1968, and the increase in population was 2.3 per cent in the same period. This means per-capita growth in national production of approximately 3.0 per cent, the highest rate Chile has attained in many years (7).

II. AGRICULTURE IN CHILE

2.1 Agricultural Zones

The agricultural physiognomy of Chile varies greatly from north to south. A number of classifications based on physiography, climatic and ecological conditions must supplement classifications based on production.

The country has been divided in nine forage areas, according to differences in climate and ecological conditions.

For the CORFO 1961-1970 Agricultural Development Project, the country has been divided in six zones, based primarily on the rainfall and climate (13). These are:

Zone I. Tarapacá to Atacama: annual precipitation from 0 to 50 mm. of rainfall. Desert climate.

Zone II. Coquimbo and Aconcagua: 50 to 300 mm. of rainfall. Arid temperate climate.

Zone III. Valparaíso to Talca: 300 to 1000 mm. in the Central Valley; 500 to 1000 mm. in the coastal region; and between 400 to 2000 mm. in the Andean foothills. Semi-arid temperate climate.

Zone IV. Maule to Malleco: 1000 to 1500 mm. in the Central Valley; 1500 to 3000 mm. in the Andean

foothills; and 1000 to 3000 mm. in the coastal region. Temperate climate.

Zone V. Cautín to Chiloé: 1200 to 1400 mm. on the coast; 1500 to 2500 in the Central Valley; and 2500 to 4000 mm. in the Andean foothills. Humid temperate climate.

Zone VI. Aisén and Magallanes: 3000 to 8000 mm. in the insular cordillera; 300 to 800 mm. in Chilean Patagonia. Cold temperate climate. (Figure 1.1 and 1.2.)

2.2 Land Capability

The total area of Chile is 74,176,000 hectares. Of this total 28 per cent has no agricultural value (see Figure 1.1). The arable land is 6,196,000 hectares or 8.3 per cent of the total.

Table 2.1 gives a complete picture of the land capability.

Figure 2.1 shows the distribution of the land. More than 80 per cent of the farms are located in the Central Valley, which has most of the arable land in the country.

Table 2.2 indicates the distribution of the arable land per crops.

TABLE 2.1.--Use Capacity of the Land in Chile.

Classification	Area in thousand hectares	Percentage of total
Arable land without serious limitations Class I and II	6,196	8.3
Arable land with limitations Class III and IV	5,728	7.7
Non-arable land, but perennial pastures. Permanent livestock raising. Class V	4,365	5.9
Non-arable land, but annual grasses for temporary use. Class VI	16,737	22.6
Non-arable land, woodlands. Class VII	10,395	14.0
Non-agricultural land. Desert, mountains, lakes, dunes Class VIII	20,707	27.9
Total	74,176	100.0

Source: Economic Geography of Chile (4).

TABLE 2.2.--Distribution of the Arable Land in 1955.

Crop	Area in thousand hectares	Percentage
Cereals	1,044.5	18.8
Legumes	106.4	1.9
Tubers and roots	69.7	1.3
Vegetables	42.3	0.8
Industrials	37.8	0.7
Total annual crops	1,300.7	23.5
Vineyards	99.4	1.8
Fruits	80.6	1.4
Total fruits and vineyards	180.0	3.2
Forages, artificial	487.4	8.8
Forages, natural	2,909.9	52.5
Total forage production	3,397.3	61.3
Fallowing	665.4	12.0
Total arable land	5,543.4	100.0

Source: Economic Geography of Chile (4).

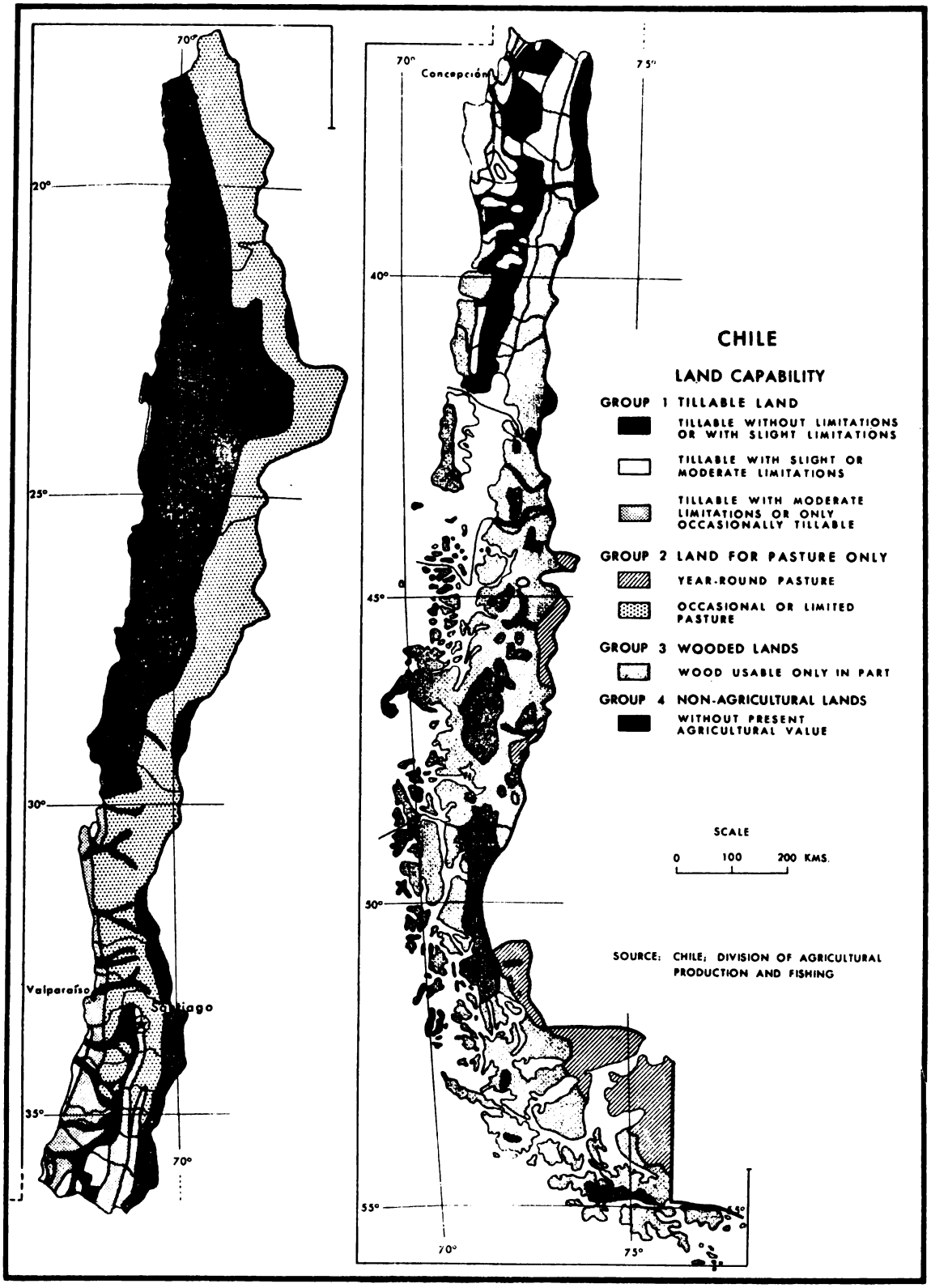


Figure 2.1.--Map of land capability. Chile.

2.3 Land Distribution

Poor distribution of land is one of the main problems of Chilean agriculture. The presence of great latifundia greatly affects the utilization of the land. In 1955, less than 3 per cent of the proprietors (owning farms of more than 1000 hectares) owned 41 per cent of the arable land and 80 per cent of the land used for agricultural purposes (13). The minifundia or dwarf holdings is another important factor; in 1955 more than 50 per cent of the farm had less than 10 hectares each. Table 2.3 gives the distribution of the holdings by size.

The overall goal of the Agrarian Reform Law, passed in November, 1962 (Law 12,020), is to give access to the land to 200,000 to 300,000 rural families composed of landless workers and owners of farm too small to support a family. Besides, the Agrarian Reform must make efforts to increase the productivity and income of 60,000 families owning farms of sizes that can support families (3).

The current government has "strongly emphasized agrarian reform" (7). From 1965 to March 1969, more than two million hectares were expropriated. A total of 404 workers settlements, incorporating 14,594 families, were created.

2.4 Rural People

The rural population has decreased from 73 per cent of the total population in 1875 to 39.8 per cent in 1952.

TABLE 2.3.--Distribution of Agricultural Property by Size of Holding.

Size of Holding (Hectares)	Number of Holdings	%	Agricultural Surface thousand of Has	%	Arable Land (thousand Has)	%	Irrigated Area (thousand Has)	%
Less than 9.9	75,627	50.1	192.5	0.9	153.5	2.8	43.8	4.0
10.0 to 49.9	41,420	27.4	876.5	4.0	573.1	10.3	86.7	7.8
50.0 to 199.9	20,820	13.8	1,838.9	8.5	1,018.9	18.4	154.2	14.1
200 to 999.9	9,842	6.5	3,846.3	17.8	1,735.4	31.3	411.6	37.5
1000.0 to 4999.9	2,554	1.7	4,523.7	20.9	1,378.4	24.9	268.5	24.5
5,000 and more	696	0.5	10,359.2	47.9	684.1	12.3	133.2	12.1
Total	150,959	100.0	21,637.1	100.0	5,543.4	100.00	1,098.0	100.0

Source: Economic Geography of Chile (4).

At the present time it is estimated at about 27 per cent.

According to the 1955 census the total wage-earning population engaged in agriculture was 664,240 persons, classified by occupation as follows:

Farmers and members of family	49.6 %
Permanent workers	23.3 %
Temporary workers	27.1 %
	100.0

Interamerican Committee for the Agricultural Development (CIDA) (3), indicates that the use of the human resources in the agricultural sector is as poor as the use of the land. The work force required in 1955 to obtain needed agricultural production was 363,250 persons. This figure indicates a surplus of labor of about 1/3 of the total, and shows the low level of job opportunities and wages of the agricultural workers and the low standard of living in the rural areas.

The illiteracy level is higher in the rural areas as compared with the whole country. In 1961, national illiteracy was 17 per cent compared with 34 per cent in the rural areas.

2.5 Agricultural Production

The increase in agriculture has not matched industrialization and growing urbanization, and has led to greater imports of food and inflationary pressure.

Information from CIDA (3) shows that the agricultural production in recent years was increasing at a lower rate than population. Between 1945 to 1959 the per-capita production decreased by 5 per cent. The cumulative annual rate of production growth of agricultural sector was 1.8 per cent while the population in Chile had a growth of 2.2 per cent.

Consequently, there is an increasing gap between demand and internal supply of agricultural products. Agriculture has not shown an export surplus since 1939. The annual net deficit averaged $82.9 million (U. S.) between 1958 to 1963. The increase in imports has been in products that Chile could produce in sufficient quantities like wheat, meat and milk products.

Although the solution of agriculture problems is a very difficult and complex task, nearly every commentator on the Chilean scene has felt that the amount of farm land is great enough to support agriculture at a higher level than the present static level.

One of the most important projects of the present administration is the Agricultural and Livestock Development Plan for 1965-1980. The program is aimed at tripling the historical agricultural growth rate. As President Frei told the nation in May, 1969, this goal is achievable, since production between 1964 to 1968 progressed at a rate of 4.1 per cent against a previous 1.8 per cent. Recently, a credit for 23.5 million dollars was granted by the Inter-American

Development Bank to implement this program. Of this amount, 8.5 million is allocated to double rural electrical power use in the next five years.

III. AGRICULTURAL MECHANIZATION IN CHILE

3.1 Historical Development

Most of Chile's modern machinery has been imported. The importation of tractors was initiated more than 30 years ago, but only in the 1950's did it reach a significant point as seen in Table 3.1.

TABLE 3.1.--Agricultural Tractors in Chile.

Year	Number
1930	660
1936	1,557
1940	2.750
1944	3,882
1948	5,400
1955	14,177
1965	22,307

Source: United Nations CEPAL/FAO Study (15).

The Mechanized Agricultural Equipment Service (SEAM) has done an excellent job of promoting farmers interest in the use of machinery.

Before the establishment of the Plan Chillan to develop agriculture in the South-Central part of Chile in 1954 with the assistance of the U. S. Point 4 Program, no governmental institution had carried on any investigations or extension work in the use of machinery.

The teaching of agricultural machinery use was started in 1958 when a course was included in the curriculum for agronomist engineers at the College of Agronomy, University of Concepción. At the present time there are five universities which have agronomy faculties where a course is given in agricultural machinery. Courses in irrigation and drainage, engines, hydraulics and farm structures are included in some institutions. Courses in electrification and processing are not yet available.

A curriculum in agricultural engineering is not available in Chile, but the University of Concepción has a project to open this career. Until now, aspects related to agricultural engineering have been mainly in hands of agronomists (Ingeniero Agrónomo).

3.2 Extent of Machinery

Table 3.2 shows the number of tractors, horses, oxen and equipment in Chile.

3.3 Importation

As already indicated, the agricultural machinery is largely of foreign origin. This has represented about 2 to

TABLE 3.2.--Machinery and Power Sources in Chile.

Classification	Number of Units
Tractors	22,307
Horses (work)	274,450
Oxen	291,930
Tractor plows (disc and moldboard)	13,035
Disc harrows	14,290
Combines	2,636
Balers (mobile)	1,433
Drills and planters	10,257
Mowers (tractor and horse traction)	6,130

Source: CORFO, 1963

3 per cent of the total value of all imports into the country. In the last 12 years, the total value of the importation in machinery has fluctuated from a maximum of $15 to $17 million to a minimum of $5 million. From 40 to 63 per cent has been tractors.

Table 3.3 shows a complete picture of the importations of agricultural machinery since 1953.

Table 3.4 shows the source of the importations and the shifts in the relative importance since 1940.

3.4 National Production

The national production of machinery has been small, representing about 5 to 7 per cent of all machinery purchased (15).

TABLE 3.3.--Importation of Farm Machinery, 1953-1967.

Year	All Machinery (thousand U. S. $)	Number of tractors	Tractors value in Thousands of dollars	Tractors Percentage of total value
1953	9,776	1,597	5,022	51.4
1954	14,028	2,523	7,337	52.3
1955	17,020	3,577	10,743	63.2
1956	9,365	1,017	4,042	43.2
1957	11,924	1,728	5,610	47.0
1958	7,113	1,379	4,014	56.4
1959	5,519	488	2,605	47.2
1960	11,219	1,295	6,073	54.1
1961	15,609	1,999	7,325	46.9
1962	13,196	1,483	5,225	39.6
1963	12,721	1,904	5,959	41.0
1964	9,536	1,334	4,495	47.1
1965	11,673	1,571	5,212	44.7
1966	12,397*	2,393*	n/a	n/a
1967	n/a	2,434*	n/a	n/a

n/a Not available

Source: The use of Agricultural Machinery in Chile. CEPAL/FAO (15).

* CORFO

TABLE 3.4.--Source of Imported Machinery (Percentage of total per country of origin).

Country	Year					
	1940	1945	1950	1955	1960	1966
Argentina	0.37	1.74	0.01	0.02	0.35	6.3
Australia	--	--	--	--	--	3.7
Belgium	--	--	--	0.06	1.23	2.3
Canada	--	9.77	0.61	3.31	2.18	0.3
England	0.23	0.31	17.06	6.20	25.57	34.3
France	--	--	0.48	0.12	1.04	0.7
Germany	0.67	--	3.80	28.03	11.34	1.7
Italy	0.14	--	--	2.39	1.97	3.8
U.S.A.	98.47	88.18	76.17	57.75	53.50	41.7
Others	--	--	--	--	--	5.2

Source: CORFO

Equipment manufactured in small quantities in Chile includes: plows, harrows, tool-bars, sprayers, mowers, ditchers, rakes, lime applicators, manure spreaders, dryers, corn shellers, hammer mills and land-leveling equipment. The engines, gear boxes, bearings and retainers used for this machinery are imported. The electric motors are produced in Chile.

CORFO estimates that with adequate production facilities half of all machinery bought, excluding the tractors, could be produced in Chile. The main obstacles facing these industries are:

1. Lack of information about types and amounts of equipment required;

2. Lack of credit to buy Chilean machinery as compared with credit facilities to purchase imported machinery;
3. Poor distribution systems and lack of mechanical attention for this equipment;
4. Limited market, which raises the cost of production.

CORFO has devised a program to increase national production. Some important steps already taken are:

1. The creation of the National Register of Producers of Agricultural Machinery;
2. Surveys related to the markets for plows, harrows, mowers and sprayers;
3. Credit for farmers to purchase equipment from those producers registered in the National Register.

3.5 Mechanization Level and Projections

The National Planning Office (ODEPLAN) indicates that the total investment in agricultural machinery was $120 million in 1959, and $150 million in 1965. These figures include an investment in machinery of $20 to $30 per arable hectare, and of $150 to $200 per agricultural worker.

Compared with these figures, France in 1958 had an investment of $3200 million or $150 per arable hectare, and $900 per agricultural worker. Holland in 1952 had an

investment of $200 per hectare of useable agricultural land.

Those figures show the low level of mechanization for Chile as compared with European countries.

Among the Latin American countries, Chile is a country with high mechanization level. Considering that there is a close relation between number of tractors and the general degree of mechanization of a particular country it is possible to compare the mechanization level of different countries (15).

Table 3.5 shows a comparison of nine Latin American countries. Chile is in third place in active population in agriculture, and in second place in the number of tractors per 1000 hectares of useable agricultural land.

In relation to the estimated requirements of machinery, Stenstrom (12), 1959, in his very complete report to the Chilean Government indicated that one tractor for each 100 hectares under cultivation is an adequate ratio when used mainly for the heavy farm work. Increasing the mechanization level to include the rest of the work--on the farm one tractor could work 50 hectares.

According to the last figure a total of 58,000 tractors were required for Chilean agriculture.

The same author indicated that 55,000 planters, 34,000 mowers, 34,000 rakes, 2,700 balers and 5,200 combines were required.

TABLE 3.5.--Number of Tractors and Their Relation to Active Agricultural Populations and Useable Areas in Nine Latin American Countries.

Country	Number of tractors (thousands)	Active agric. population x1000	Useable agric. area x1000 Ha's.	Number of tractors per: 1000 active persons	Number of tractors per: 1000 Ha's. useable agr. area
Argentina	104	1,450	33,450	72	3.1
Brazil	107	9,900	43,000	11	2.5
Colombia	21	2,500	5,047	8	4.2
Chile	22	675	4,511	33	4.9
Ecuador	2	830	2,081	2	1.0
México	55	6,100	23,817	9	2.3
Perú	8	1,340	2,735	6	2.9
Uruguay	25	185	2,252	135	11.1
Venezuela	10	775	5,219	13	1.9
Total	354	23,755	122,112	15	2.9

Source: CEPAL/FAO Commission (15).

A study prepared by Economic Commission for Latin America (CEPAL) and FAO in 1968 indicates that:

a. To work all the land presently under cultivation, replacing all work animals by tractors, a total of 39,000 tractors will be required;
b. If, at the same time, the total potential arable land is to be worked with tractors only, a total of 66,500 tractors will be necessary;
c. To achieve the mechanization level of nine developed countries, the useable land will require 140,000 units, which is six times the present number.

3.6 Institutions Related to Agricultural Mechanization

The main institutions through which agricultural mechanization has to be implemented in Chile are:

Corporación de Fomento de la Producción or Chilean Development Corporation (CORFO), founded in 1939, is an institution with diverse functions. It is a development bank, an investment agency, an organization for study and research of natural resources and certain aspects of Chile's economic development and a financing agency.

CORFO has been the main source of credit to import machinery. In 1963 a complete analysis of the problems affecting agricultural mechanization in Chile was made by CORFO, which has been the guide for the programs in recent

years. CORFO has an Agricultural Machinery Division with experienced specialists in this area. The main responsibilities are:

a. To determine the types of machinery to be imported;

b. To promote and give economic support for the local agricultural machinery industries;

c. To promote creation of commercial mechanization enterprises, like tractor-hire services;

d. To test equipment to be imported;

e. To make survey studies related to agricultural mechanization.

Other activities related to mechanization in which CORFO is involved are:

a. Since 1942 with the collaboration of the Chilean Army, they have operated programs for the training of tractor drivers and operators. Until 1965, 5,000 soldiers were trained.

b. Since 1963, The Technical Cooperation Service (Servicio de Cooperación Técnica) of CORFO has had programs to train farm workers with mobile units on the farms. The permanent units prepare specialized mechanics for the farms, mechanics for local shops, mechanics for specialized shops, and agricultural machinery instructors.

c. CORFO also has an extension program which assists the farmers.

Servicio de Equipos Agrícolas Mecanizados or Mechanized Agricultural Equipment Service (SEAM) has basically three functions:

a. To do mechanized work at low prices for farmers with small holdings;

b. To do mechanized work for medium and larger farms--at the cost of operation;

c. To do heavy work--like farm roads, dams, clearing land, earth-moving and land-leveling.

The equipment of SEAM consists of 383 tractors, 231 self-propelled combines and a variety of equipment and implements. In recent years, a reorganization of SEAM has been made because of its high costs of operation.

Instituto de Desarrollo Agropecuario or Agricultural Development Institute (INDAP) is an autonomous governmental enterprise established to give technical assistance and credit to small and medium size farmers; to promote the organization of cooperatives and the construction and utilization of storage facilities, slaughterhouses, dairy plants, canning factories, packing houses and other industrial establishment of benefit to farmers or fishermen.

Corporación de la Reforma Agraria or Agrarian Reform Corporation (CORA). This institution has to do with the division by grants of large rural properties, consolidation

of minifundia, formation of small agricultural villages and provision of technical assistance and credit to the farmers to whom the parcels of land are granted.

Ministerio de Agricultura (Ministry of Agriculture). As an executive agency, the Division of Agriculture works in the provinces of Chile (see Figure 1.2) through five administrative offices. It is composed of the following departments: Economics, Research, Stock Raising, Soil Conservation and Extension and Agricultural Defense.

Other organizations that have played important parts or which will have important roles in the future are:

Distributors of agricultural machinery. Their main contribution has been importation of machinery and occasionally some training courses for operators and sales personnel. They must now service machinery and maintain stocks of parts for the equipment they sell; these responsibilities were established very clearly in the Decrete 637, of October 24, 1967.

The distributors and dealers can assume an extremely important role in the future, especially in training personnel, assistance to the farmers in demonstrating the best use of machinery and through supporting research to link the kinds of machinery they import to the agricultural conditions of Chile.

Local manufacturers have now a limited importance but, in the future, they must assume the responsibility to

manufacture most of the machinery to be required in the agriculture, to carry out experiments and testing or to support the research, to give assistance to farmers who buy their machinery.

The role of the universities, research institutions and other institutions related to research will be discussed later.

Favorable and unfavorable conditions for mechanization. In Chile there are many favorable factors for the mechanization of the agriculture such as:

1. Land distribution. There are about 13,000 holdings larger than 200 hectares, where mechanization could easily be intensified.
2. The climate in general is favorable for the mechanization. In the north and central region the irrigated land can be worked through all the year; in the south the rains restrict work, but in most of the cases it is possible to have ten work months.
3. Varieties of crops. This allows a better distribution of the works through the year.
4. Mechanization can improve the quality of farm work, besides the saving of labor.
5. Mechanization improves the social level of the farm workers if they can receive training for jobs with modern machinery.

The main unfavorable condition is the high price of the machinery and parts. However, labor is abundant and cheap. For these reasons, in some periods, farmers who used tractors returned to the use of hand- and animal-power because these were more economical (16, 18).

Table 3.6 shows a comparison of prices for some types of tractors in different countries, in 1964. It can be seen that Chile's prices for tractors are the highest. This situation is similar for the rest of the machinery and for the parts.

Fortunately, legislation in recent years reduced the price of a tractor from $5,770 in 1965 to $3,250 in 1969. The prices of parts were decreased by 35 per cent (5). CORFO estimates that this is only a first stage because a larger decrease can be achieved.

Other very serious obstacles that mechanization still has to overcome are:

1. Lack of trained personnel: agricultural mechanization specialists, technicians, mechanics and operators;
2. Lack of experiment and testing in agricultural mechanization;
3. Lack of extension work in agricultural mechanization;
4. Insufficient use of machinery in cooperatives.

TABLE 3.6.--Prices of Various Types of Tractors in Six Countries, 1964. (In dollars.)

Country	Tractors				
	Nuffield 460	Massey Ferguson	Fordson Super Major	International Harvester B-450	Average
England	$ 2,200	$ 2,461	$ 2,330	$ 2,747	$ 2,339
Colombia	2,859	3,717	3,083	4,311	3,493
South Rhodesia	3,265	3,181	3,139	3,634	3,305
Kenya	3,010	3,184	2,982	3,469	3,180
Ethiopia	---	3,400	3,000	3,120	3,170
Chile	4,700	4,910	4,183	5,527	4,830

Source: CEPAL/FAO Commission (15).

The evolution of mechanization in Chile will depend more on the agricultural development policies of the government than it has in the past. The latest achievements give an optimistic promise for the future.

IV. AGRICULTURAL MECHANIZATION RESEARCH IN CHILE

4.1 Present Stage

Only sporadic efforts have been made in the aspects of research in agricultural mechanization in Chile, specially at the universities and some governmental and private institutions. CORFO (5) indicate that, before 1963 not more than ten research projects of importance had been done.

The first attempts to initiate research in agricultural mechanization were made in 1957 when an Agricultural Mechanization Center was created at the Agronomy Faculty of the University of Concepcion. Until 1964 this was the only institution which carried out organized experiments in agricultural mechanization.

There are four other universities with Agronomy Faculties but they have only sporadically carried out research related to mechanization.

After 1964 CORFO started a research program aimed mainly at finding guidelines for importation and for national production of machinery. With the cooperation of importers various kinds of machinery were tested to find their

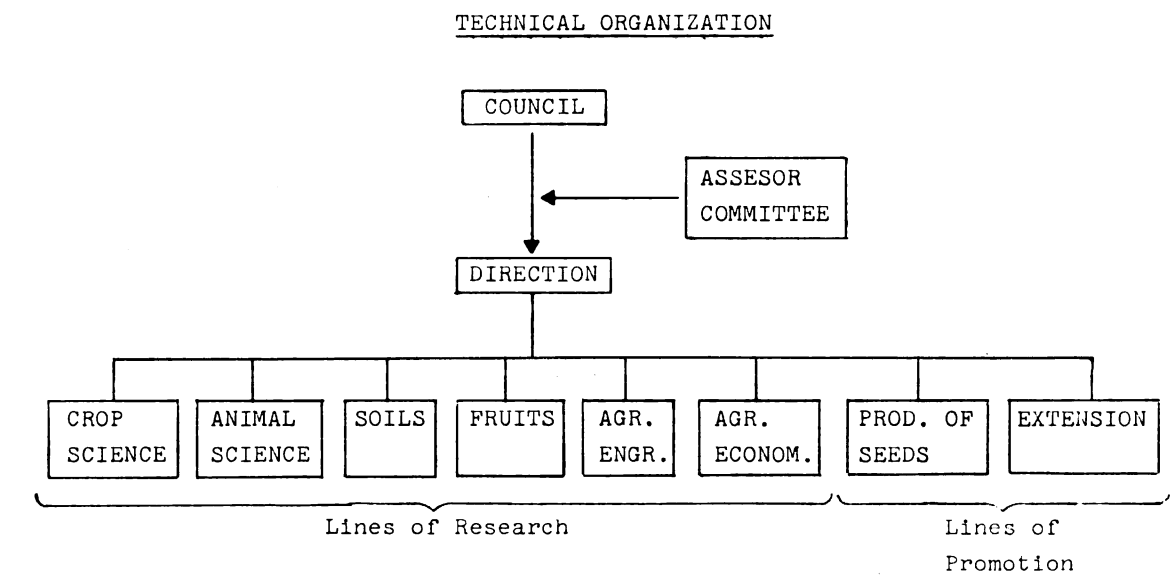
adaptability to Chilean agricultural conditions. CORFO has also been doing experiments on tillage, harvesting methods and mechanization studies of some specific crops. These experiments have been developed in collaboration with the National Sugar Industry (IANSA), The Oil Seeds Industry (COMARSA) and the Agricultural Development Institute (INDAP).

The Agricultural Research Institute started a project on agricultural machinery research in 1965 at its three main experimental stations to determine suitable methods and machinery for tillage, but this project was discontinued because two of the three agricultural-machinery specialists were granted scholarships to study in the U. S. in 1967.

The Agricultural Research Institute with a personnel of 147 professionals and 58 technicians (12) has the responsibility for the whole research in agriculture in Chile. Figure 4.1 shows the technical and administrative organization of the Institute.

The line of agricultural engineering is not organized, nor has a coordinator. There are two specialists in irrigation and three specialists in agricultural machinery.

The research project presented in this report is aimed mainly at organizing the research in agricultural mechanization at the Agricultural Research Institute, and to coordinate Institute work with that of related governmental and private institutions.



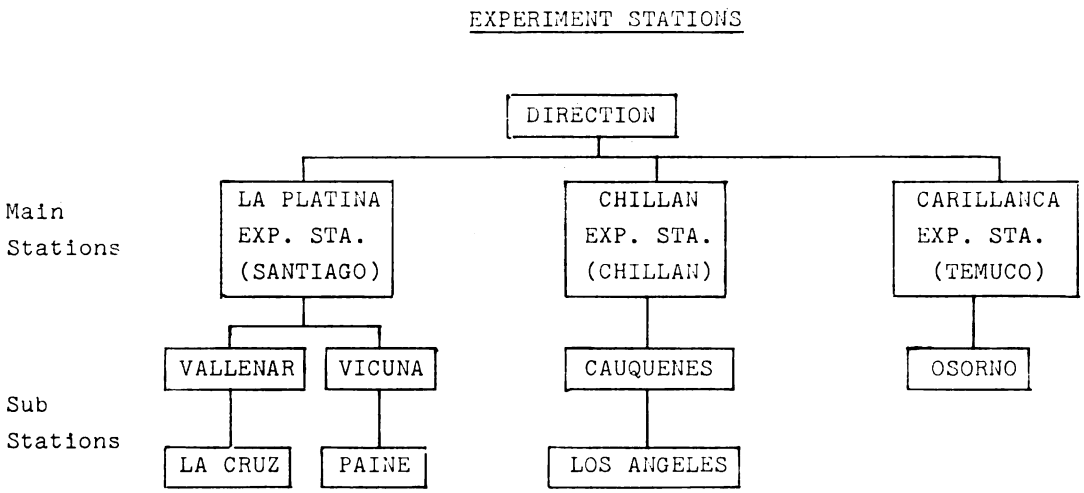


Figure 4.1.--Organization of the Agricultural Research Institute.

4.2 Need of a Research Project

The facts in the preceding chapters show that Chilean agriculture has good prospects of improvement in the next decade. Officials and technical personnel, as well as farmers recognize the importance of mechanization for the success of the developing of agriculture.

The necessity of research in agricultural mechanization is evident, since information in all aspects must be obtained to successfully implement the mechanization process. Many experts have insisted that each country has to develop its own research. There have been many cases of failures in the use of imported machinery in developing countries because different conditions exist than those for which the machinery was originally designed (16).

Obviously researchers will need a solid knowledge of the basic findings already available in developed countries, and they have to keep up to date in related publications. In this way more advanced research can be adapted to local conditions. This adaptation should be the main goal in the research in agricultural mechanization in Chile for the first five or ten years.

The coordination of the research is very important to avoid having different institutions do their own research separately, and solve only their immediate problems. Cooperation between the institutions responsibles or interested, with specialists working together will be of more

benefit to the country as a whole. At the present time there are few specialists in agricultural mechanization and the facilities and equipment are limited and difficult to obtain.

The research results obtained so far should be analyzed by all specialists and the future research must be coordinated in a way that can lead to complete solutions of mechanization problems.

4.3 Essentials for the Success of the Research in Agricultural Mechanization

The following points can be considered as essentials for the success of a project in agricultural mechanization in Chile:

1. The active collaboration between all governmental and private institutions, dealers and distributors of machinery. The support of the industries related will be extremely beneficial.
2. The training in mechanization given by the faculties of agronomy is very limited, more training must be available to the specialists involved in research.
3. Technical assistance to organize or develop specific types of research should be encouraged, specially until a coordinated team of researchers and leaders is organized.

4. Technical exchange between specialists of different institutions, with specialists of all Latin American countries and those of countries carrying out similar projects are also important.
5. The establishment of an agricultural engineering curriculum is an urgent necessity in Chile, because the agronomy curriculum cannot prepare specialists for all aspects of agricultural engineering needs.
6. Extension work in agricultural mechanization aspects has to be increased. Here again the necessity of an agricultural engineering curriculum is felt, because the lack of trained personnel can be a major obstacle to the application of new techniques or machinery recommended by the research.

V. PROPOSAL

5.1 Seminar on Agricultural Mechanization Research

The first step to establish an agricultural mechanization research project is to organize a seminar for all the specialists who are working in research in agricultural mechanization at the present time and representatives of all related or interested instutions.

The seminar should be organized by the Agricultural Research Institute and CORFO, and held in Santiago or Chillan. The program for this seminar should consider the following basic points:

1. Presentation and discussion of the research and studies being done by all institutions;
2. Panel on the future needs of research in agricultural mechanization; and
3. Election of a working committee on study and coordination for agricultural mechanization research.

5.2 Agricultural Mechanization Research Committee

This committee should have the following responsibilities:

1. To prepare a study of the present stage of research in agricultural mechanization.
2. To coordinate all research in agricultural mechanization that can be done in Chile; to establish exchanges with other Latin American research institutions.
3. To organize courses and seminars at national and international levels on aspects related to research in agricultural mechanization.

At least five specialists should constitute this Committee, and should be:

A representative of Agricultural Research Institute,

A representative of CORFO

A representative of the Universities,

A representative of Chilean distributors and industries,

A representative of the Ministry of Agriculture.

At least three of the five members of the committee should work directly in research on agricultural mechanization. Not less than six Committee meetings a year should be held.

It would be best that the Committee operate for at least four years, to have enough time to complete the

organization and coordination of the research. Research will continue through all stages.

Figure 5.1 shows how the research in agricultural mechanization could be established in Chile.

5.3 Goals of Agricultural Mechanization Research

5.3.1 Immediate Goals (should be achieved in first or second year).

a. To determine the state of agricultural mechanization research to date.

b. To evaluate the future needs of research in agricultural mechanization.

c. To run preliminary experiments in areas where no information is available.

d. To secure financing, technical assistance and training of the research personnel.

e. After one or two years, to plan specific experiments for the next three years, as indicated in Figure 5.2.

5.3.2 Intermediate Goals (should be achieved in fourth or fifth year).

After three years of specific experiments including one or two years of preliminary experiments, recommendations in the following areas must be made:

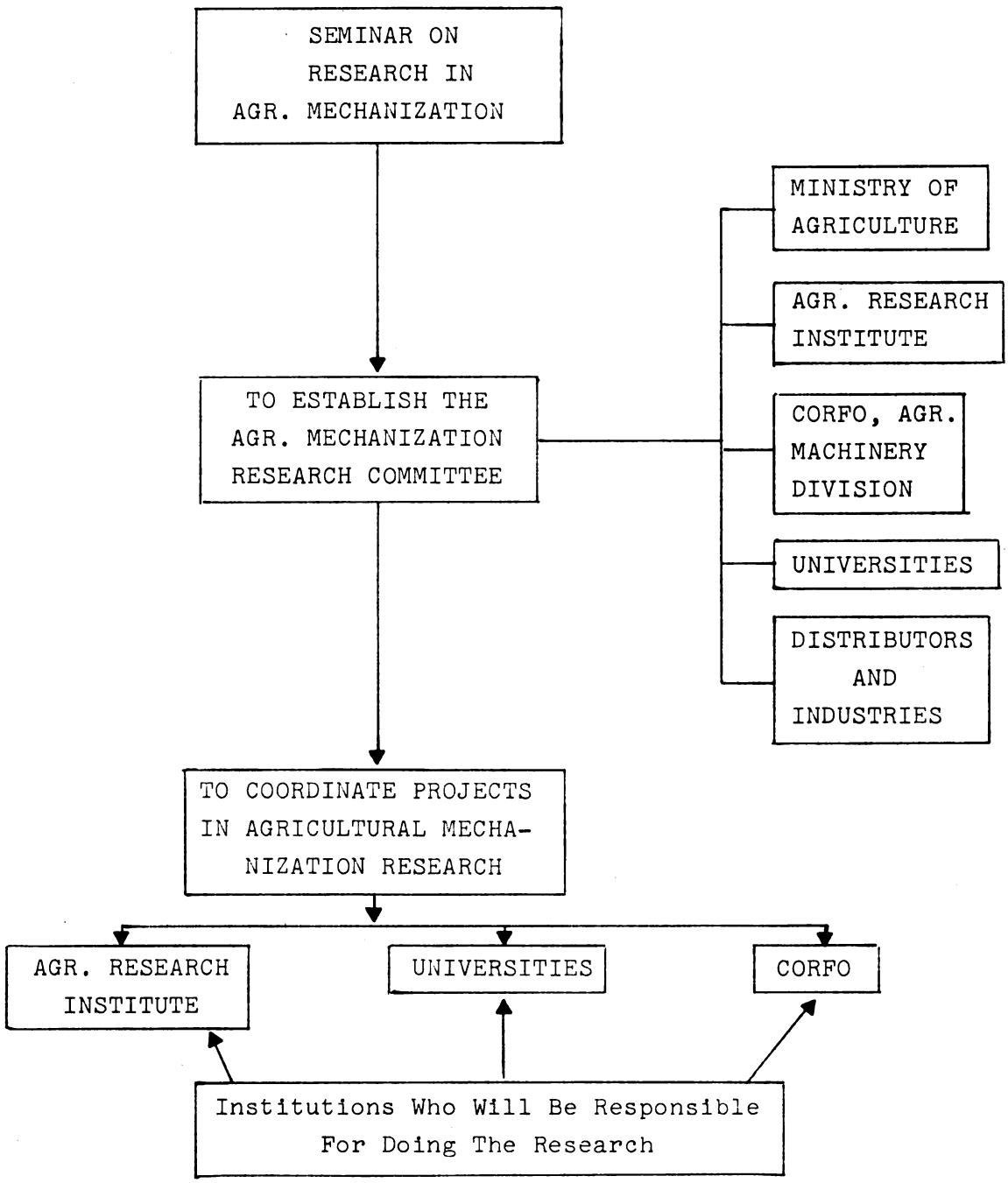


Figure 5.1.--Flow Chart for the Organization of the Research for Mechanization of Agriculture in Chile.

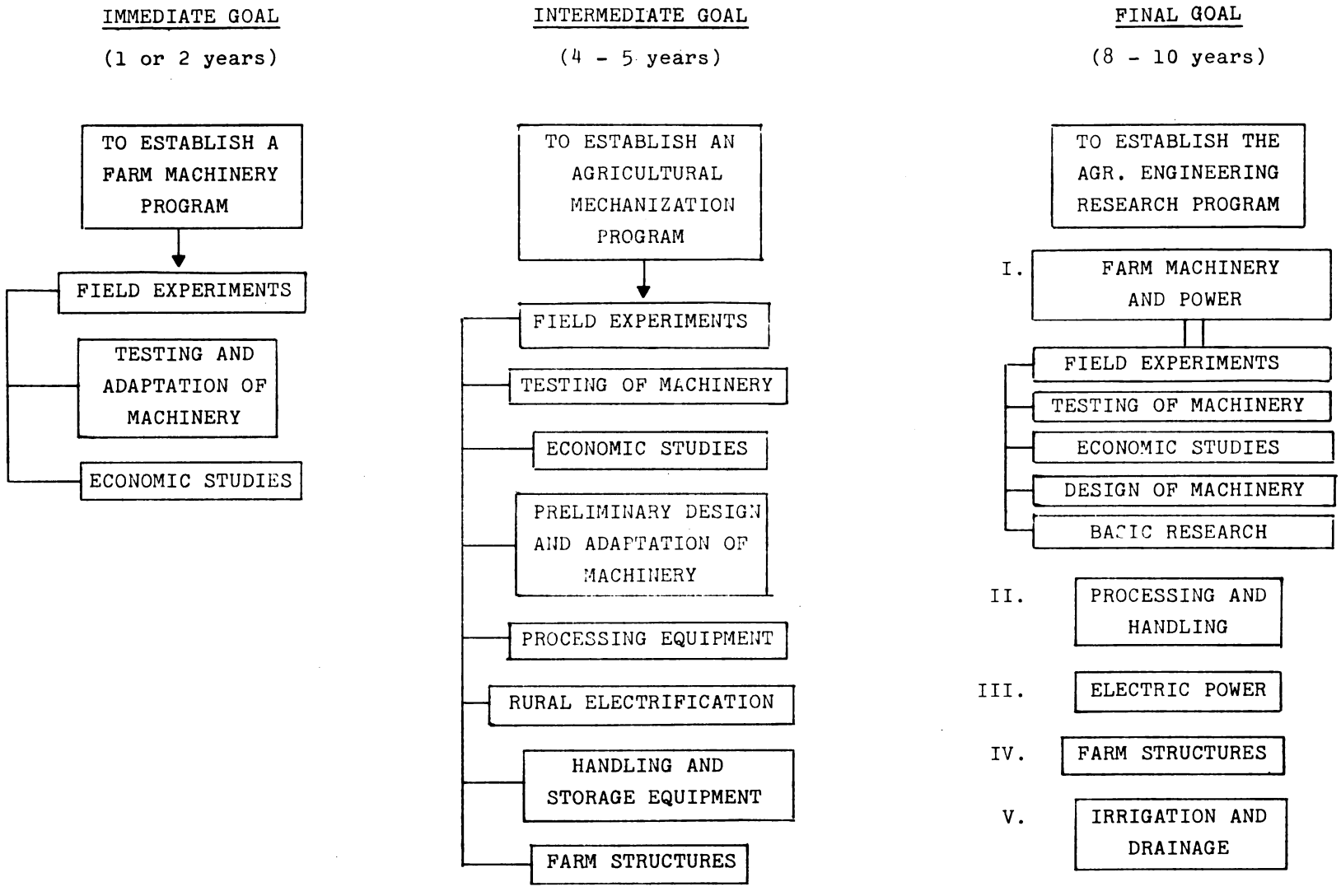


Figure 5.2.--Goals for Agricultural Mechanization Research in Chile.

a. Better methods for using machinery.

b. Which types of machinery should be imported, and which should be manufactured in Chile.

c. Most economical and efficient ways to use the machinery.

d. Specific plans to reorganize and extend the areas of research for the final 5-year period, as indicated in Figure 5.2.

5.3.3 Long-Term Goals

After eight or ten years of having operated the research project, full information should be available and all the most important aspects of agricultural mechanization studied, and recommendations in the following aspects should be available:

a. The most appropriate methods for using machinery.

b. Types of machinery and equipment suitable to Chilean conditions, imported or to be made in Chile.

c. Economic aspects involved in the use of machinery.

d. Most important aspects in design of machinery and implements for Chile.

e. Adequate information on methods and equipment for processing, rural electrification, and handling and storage equipment.

5.3.4 Follow-up Project

a. At the end of eight or ten years that this project will require, plans should be made to reorganize

the research by establishing a new project called Agricultural Engineering Research Project, to consider separately the areas of power and machinery, processing and handling, electric power, farm structures and irrigation and drainage. See Figure 5.2.

b. Advanced studies should be initiated at this point on design of machinery, and in basic research.

5.4 Types of Research to be Done

It has been indicated that after four or five years of study, new research in all aspects of agricultural mechanization should be initiated, and after eight or ten years a more detailed research program named agricultural engineering research should be established.

The research project presented here will consider mainly the aspects of power and machinery, but most of the guidelines presented can be applied to the rest of the areas of agricultural mechanization.

Types of research in agricultural mechanization that have to be considered are:

5.4.1 Field experiments

5.4.2 Testing of machinery

5.4.3 Economic studies

5.4.4 Design and adaptation of machinery

5.4.5 Basic research

This classification is considered suitable for the following reasons:

1. It gives an idea of the different types of experiments and tests that could be done in the area of power and machinery.
2. It could make easier the establishment of priorities for the future research; if some aspects are delayed information will continue to be recorded to start that type of experiment later on a better basis.
3. Future needs of equipment and facilities, and types of training required for the personnel can be better visualized.
4. The work of the different institutions can be better coordinated and complemented knowing the related problems that have to be solved. Each institution can put more emphasis in particular areas, knowing that this is part of a total program.

Many experiments will fall into more than one category specially in the first few years of work. For example, the field experiments will consider both economic aspects and testing of the equipment.

Figure 5.3 shows a general picture of the aspects of agricultural mechanization that should be considered now or in the future in Chile.

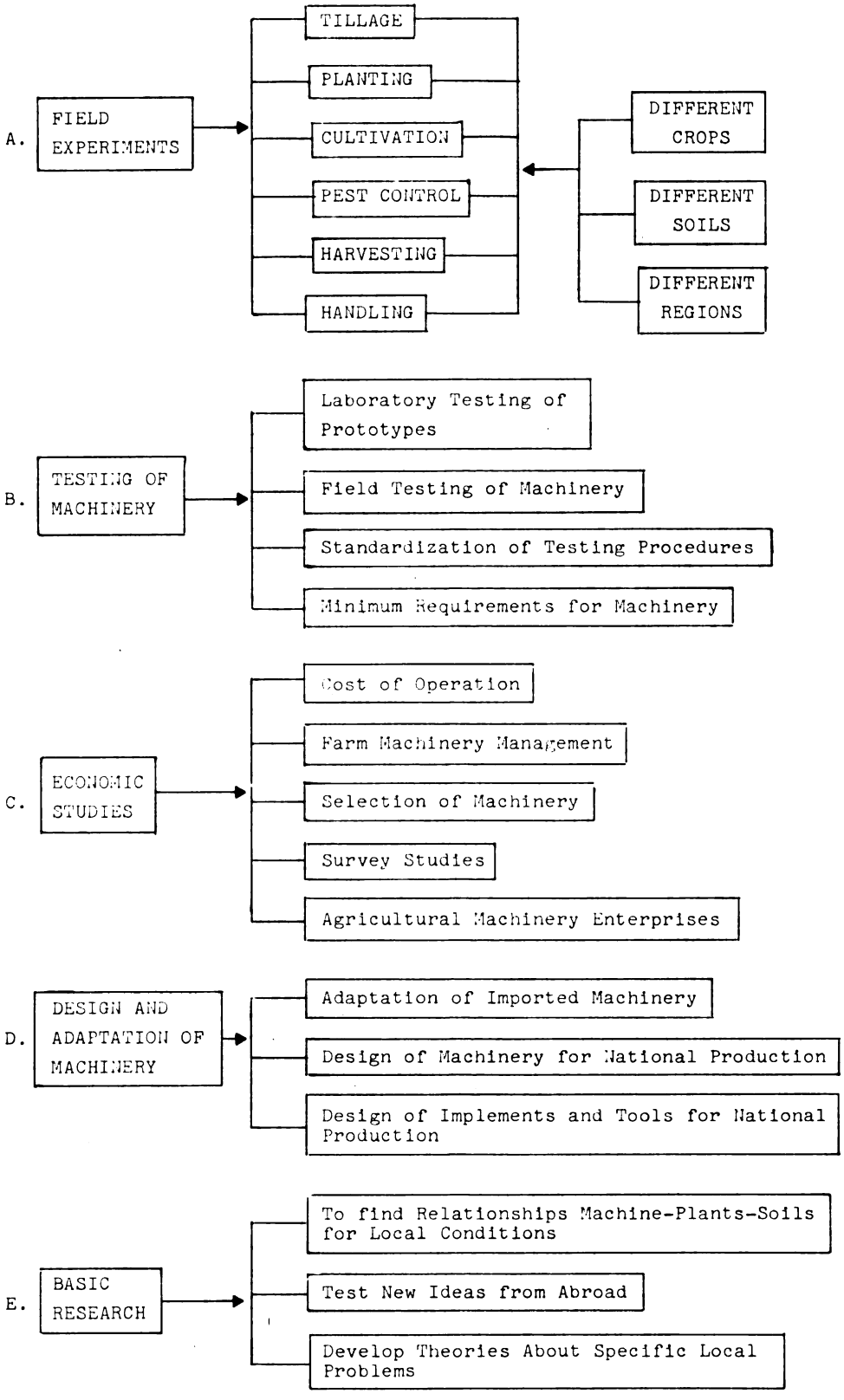


Figure 5.3.--Types of Research in Agricultural Mechanization in Chile.

5.4.1 Field Experiments

The field experiments must have first priority during the first four or five years of the research project, because they are designed to solve the immediate problems of the farmers, and because the lack of information in this area is delaying more extensive and efficient use of machinery.

These experiments should be directed to finding better methods of using machinery more efficiently and economically. The main crops, types of soils, topography, climate and cropping systems used in the different regions of the country have to be analyzed before planning specific programs.

Three types of experiments can be considered:

1. Preliminary experiments. These experiments should be done when no previous information about agricultural problems is available, and the methods and types of machinery used or useable in Chile is large.

For example, if tillage is studied, there is a large variety of machinery, and the possible combinations of machinery and tillage methods are many.

The preliminary experiments can compare all possible treatments without a specific design, and with no replications. The other possibility is to use an experimental design and to make a statistical analysis using a low power to find significant differences.

These experiments can be especially useful in agricultural mechanization research because large plots are used, the cost of the machinery is expensive and the experiment may be too large to handle. A preliminary would identify the most promising factors, and allow reduction of experiments to a workable size.

2. Specific experiments. These experiments would be designed for testing particular crops, work methods and machinery prior to any specific recommendations to farmers.

An experimental design adequate to the purposes of the project must be used. At least four replications have to be used, and a statistical analysis of the results is necessary. These experiments should be repeated over at least three years to counteract any effect of climatic variations through the years.

The standardization of experimental design conducted in all research institutions is essential. Electronic computation can be used for the statistical analysis.

3. Demonstration experiments. These experiments should be done mainly on farms, central to agricultural production areas where farmers can observe the process and compare the results of the different treatments.

It would be best to delay these experiments until results are obtained in the earlier specific experiments. In these cases only two or three of the most promising treatments can be compared with the traditional method.

The different operations, crops and other conditions that should be studied in field experiments are shown in Figure 5.4.

A project outline for methods and machinery for a field experiment in wheat production is presented starting on page 58.

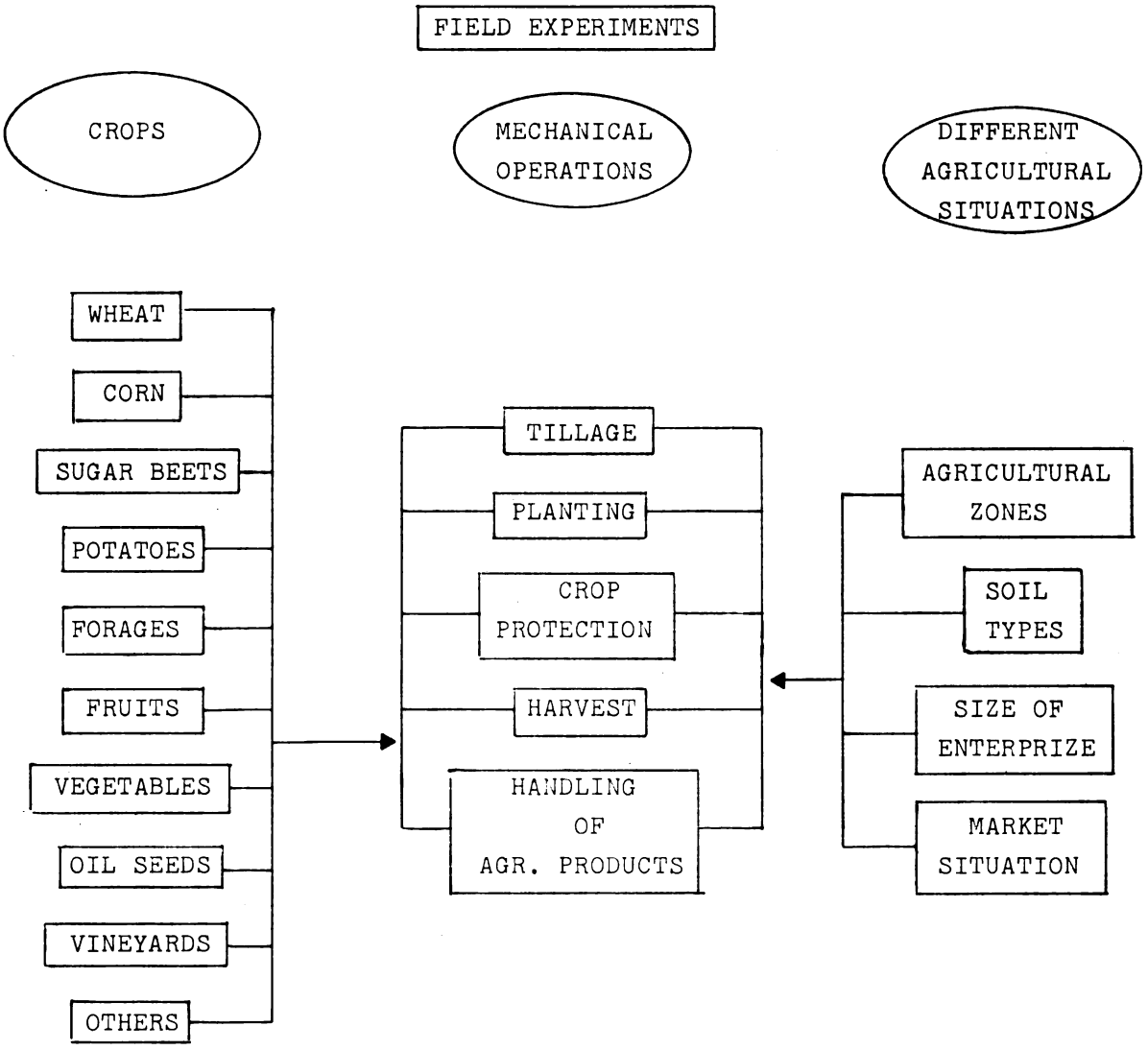


Figure 5.4.--Aspects to be studied by Field Experiments.

PROJECT OUTLINE

PROJECT TITLE: Tillage Methods and Machinery

Subproject : Wheat

Departments : Agricultural Engineering, Soil Science, Crop Science } Agricultural Research Institute

Cooperating agencies : University of Concepción
University of Chile
INDAP
CORA

Date of initiation: December, 1969

Date of revision : June, each year

Probable duration : 5 years. To continue after this 5-year period, after a complete reorganization.

Personnel : 1 farm machinery specialist
1 soil science specialist
1 crop science (wheat) specialist

Leaders : To be selected from the 3 specialists in charge in each one of the 3 main experiment stations.

Cooperators : Agriculture economics specialist; weed control specialist; soil science laboratorist; extensionists.

Location : (Chile)

Main Experiment Stations	Substations
Santiago (Central Zone)	Vallenar (North Central) Paine (Central Zone)
Chillán (South Central)	Cauquenes (Coast Range) Los Angeles
Temuco (South)	Osorno

Importance:

1. Wheat is the most important crop in Chile.
2. Tillage is one of the basic operations for wheat production.
3. There is not enough information about tillage methods, machinery, efficience and cost of the different tillage operations.
4. Most of the farmers use methods of tillage based on their own experience. In many cases this implies excessive tillage with severe damage to the soil, and high waste of power and money.
5. There is very much interest on the part of extensionists, cooperatives, governmental agencies and farmers to know the adequate methods of tillage and machinery for their conditions.

Objectives:

1. To find most adequate methods of tillage for wheat and other cereals in the main regions where it is grown.
2. To be able to select the most adequate tillage machinery for wheat production.
3. To find most economic tillage methods.
4. To obtain guidelines for governmental and private agencies about what kind of equipment to import or to manufacture in Chile.

5. To standardize the experimental procedure.

Resume of Previous Investigations:

In general there has been no organized research. Some experiments especially at the universities as thesis for students of agronomy have been done. The rest has been demonstrative types of experiments carried out by some governmental or private agencies.

The University of Concepcion at the experiment station of the Faculty of Agronomy has made some experiments in tillage for wheat which could answer the problem in their area. These experiments deal with tillage methods and cost of operation.

The Agricultural Research Institute started experiments in tillage for wheat and there are results of two years. Tillage methods, types of machinery, cost of operation and time to initiate the tillage were compared.

Method of Procedure:

1. Experimental Design.

a. Randomized Complete Blocks: This will be the most common design to compare various tillage methods. The plot size will depend upon the size of the tillage implements. In general the plots will be 10 meters (30 ft) in width by a minimum of 20 m. (60 ft). Sufficient headland for the free movement of equipment is necessary. Four replications should be the minimum.

b. Split Plot Design: This design could be used when studying more than one factor, as for example: (1) tillage methods and date to initiate the operations; (2) tillage and type of weed control; (3) tillage methods, week control and fertilization.

c. Incomplete Blocks or Incomplete Blocks with fractional replications could be used when comparing two or more factors at various levels and the number of treatment combinations is too big. This type of design could be used after having collected information in which to base the decision about what treatment combinations and what interactions could be neglected.

2. Tillage Machinery. It is necessary to consider that many farmers own some type of tillage machinery, many of which probably should not be used. If a large number of farmers own certain pieces of equipment they should be included in the experiments in order to know the less harmful way to use it until the farmer could afford the purchase of better equipment. One example is the rotary tiller that some farmers use excessively and probably should not be used in many of the cases.

At least some of the following tillage equipment should be included:

1. Moldboard plows. To compare different types of bottoms.
2. Disc plows. The most commonly used in Chile.

3. Rotary tiller.
4. Chisel plows.
5. Offset disc harrow. Very much used in Chile.
6. Field cultivators.
7. Double action disc harrow.
8. Spring tooth harrow.
9. Spike tooth harrow.
10. Rollers, packers, mulchers.

3. Treatments. In each region the farmers are using a large variety of tillage methods and tillage implements. In those areas where no previous experimentation has been done it would be convenient to start the first year with a preliminary experiment comparing all possible tillage methods or combination of methods. This could include up to 20 treatments without any replication. This will permit to watch the work of each implement, to define what measurements are more convenient, to prepare the personnel, and to observe the effect of soil moisture, date to initiate the plowing, velocity of the equipment, etc.

The definite design will be established after knowing the results of the first year.

In areas where previous experimentation has been done, the definite design could be done without running a preliminary experiment.

The treatments that could be compared in Chile are:

1. Conventional method in the particular area.
2. Disc plow + secondary tillage.
3. Disc plow and plant.
4. Moldboard plow + secondary tillage + plant.
5. Moldboard plow and plant.
6. Plow plant (moldboard plow with drill, one operation).
7. Offset harrow + moldboard plow + secondary tillage + plant.
8. Offset harrow + moldboard plow + plant.
9. Offset harrow + plant.
10. Offset harrow and plant (one operation).
11. Rotary tiller + plowing + secondary tillage + plant.
12. Rotary tiller + plowing + plant.
13. Rotary tiller + plant.
14. Rotary tiller and plant (one operation).
15. Chisel plow + secondary tillage + plant.
16. Chisel plow + plant.
17. Chisel plow and plant in one operation.
18. Field cultivator + secondary tillage + plant.
19. Field cultivator + plant.
20. Field cultivator and plant in one operation.

Not all of these 20 methods have to be compared in all regions, but only these that seem more adequate.

For the definite design a maximum of eight treatments should be compared. Perferable 4 to 6 treatments with four or more replications.

For experiments including two or more factors, not more than four tillage methods have to be included.

It is likely that the definite design could include the following treatments or some of them:

1. Conventional (generally will have excessive tillage).
2. Moldboard plow + secondary tillage + plant,
3. Moldboard plow + plant.
4. Disc plow + plant.
5. Rotary tiller or offset harrow + plant.
6. Chisel plow or field cultivator + plant.

4. Measurements.

Soil measurements
- Mechanical analysis
- Fertility level
- Bulk density
- Permeability
- Agregate size
- Soil moisture
- Photographs

Implement measurements
- Depth and width of work
- Forward speed
- Draft
- PTO requirements
- Turning time
- Cost of operation

5. Report of the Results. The most common type of statistical analysis will be analysis of variance to the yields of the crop to find if there are significative differences between the treatments.

Simple regression analysis between any factors that could affect the yield could be done. Also multiple regression analysis between the yield and the most important of the many factors that affect the yields could be done. The computer facilities that the Agricultural Research Institute has available should be used.

Studies of correlation between the different factors affecting the yields could also be done.

5.4.2 Testing of Machinery

This experiment will also have priority because of the importance of having standard methods to test the machinery to be imported and that from national precedence. CORFO has already a program for testing imported and national machinery.

It would be necessary to establish at least two centers for testing machinery: one at Santiago run by CORFO and the other could be at the University of Concepción where agricultural engineering may be established. These centers should be adequately equipped and staffed; the technical assistants from countries where this kind of program has been done for many years have to be obtained for the best organization of these centers.

The collaboration of importers and industries related, and the exchange with foreign testing centers should be encouraged.

The main aspects to be studied at these centers will be the mechanical characteristics of the machinery, such as: simplicity of the design, size, mechanical efficiency, materials used, field efficiency, facility in the use and maintenance, power requirements under different agricultural situations, etc.

The personnel at each center should at least include:

An agricultural engineer,

An agricultural mechanization specialist,

A technician,

mechanics, and

operators.

SAMPLE PROJECT OUTLINE

Project title: Testing of machinery. Planters.

Institution : CORFO. Machinery Testing Center.

Cooperating agencies: Universities, distributors of machinery

Date to start: 1970

Duration : 3 years

Leaders : 1 agricultural engineer

1 agricultural mechanization specialist

Collaborators: agricultural economists

agronomists

farmers

Objectives:

1. To standardize testing procedures for planting machinery;
2. To compare functional, mechanical and structural characteristics of planters;
3. To know draft requirements and power consumption under local conditions;
4. To encourage importers and national industry to sell suitable machinery for Chilean agricultural conditions.

Previous information:

CORFO is the only institution carrying out testing of machinery. The results of such tests should be available to all farmers and persons interested.

The literature from abroad is abundant and has to be carefully reviewed, especially that from the United States and Europe.

Procedure:

The testing procedure for planters should be established first. This has to be obtained from the literature and adapted to local facilities and personnel available.

Laboratory tests should be preferred. One simple method which has been extensively used is to mount the hopper and metering device on a stand, and passing a recollection board beneath. The distribution of the seeds over the board

can be analyzed statistically to have an idea of the performance in the field. Field studies to observe the final stand would be necessary initially, and regression analysis of laboratory and field data can be made to find laboratory procedures which give the highest correlation with field performance.

The aspects of structural characterisitcs, quality of materials, simplicity of the design, care and maintenance required should also be recorded under field or laboratory conditions.

The experimental equipment can be installed with available resources, but efforts should be made to obtain all necessary equipment later on.

Report of the results:

The results of the tests must be published and made available to specialists in machinery, extension personnel and farmers. The format used for the report could be like that in the Red Book published by Implement and Tractor (U.S.A.), or like the reports of the National Institute of Agricultural Engineering (NIAE), England.

5.4.3 Economic Studies

This study should also have priority because the economic aspects are extremely decisive for the present and future development of agricultural mechanization in Chile. Also the social implications of mechanization (replace labor) have to be considered.

Some of the aspects that have to be studied are:

1. Cost of operation of farm machinery;
2. Capacity and efficiency of machinery;
3. Optimum mechanization level for given size-farm;
4. Possibilities and procedures for establishing cooperatives for buying and/or using agricultural machinery;
5. Governmental and/or commercial agencies for hired machinery;
6. Rural labor situation and its implications for the mechanization process;
7. Cost studies of mechanizing a given crop for different regions of the country;
8. Comparative cost studies of using hand power, animal power, and tractors for a given operation;
9. Survey studies of the situation of national production of machinery, market situation for various kinds of machinery, etc.

The use of electronic computation, which is available in Chile, would be very convenient for processing all the information obtained from this type of study.

5.4.4 Design and Adaptation of Machinery

These studies will be essential for the success of the national production of machinery.

During the first years of the project more emphasis on adaptation is preferable so that machinery already owned by farmers can be used at its full capacity.

Strong cooperation between agricultural engineers from universities and industries, and specialists in mechanization will be required to initiate this type of experiment. After the creation of an agricultural engineering curriculum these professionals will be incorporated to the research project, and the design of machinery for Chilean conditions can be strongly improved.

In this report it is suggested that adaptation studies can be initiated first. Design of machinery can wait until trained personnel would be available, which could mean four to eight years after the initiation ofthe project.

In the future the agricultural engineers should design manual implements, animal drawn machinery and tractor machinery for Chilean agricultural conditions.

5.4.5 Basic Research

This type of research can be considered after the eight-year period, at the end of the proposed research project, and when the agricultural engineering project could be organized.

During the first two stages no time should be spent in this type of research; during the last stage (from the fifth to eighth year) the recording of information related to basic aspects should be considered so that this information could be the basis for initiating definite research later on.

It is also recommended that the researchers can keep up to date on the research that has been done in other countries. The exchange of information with other research institutions should be enforced and the participation of researchers in national and international meetings should be encouraged. These exchanges and keeping up to date will be valuable to initiate basic research, probably at the agricultural engineering departments, as theses for students to get their professional degrees as agricultural engineers.

Because this type of research could be initiated only after six or eight years from now, the preparation of a project outline would not be worthwhile at this time.

5.5 Equipment and Facilities

Prototypes of agricultural machinery will be necessary for any type of research, with the only exception of survey studies. The most important equipment and facilities will be:

1. Field experiments:

   Manual implements

   Animal drawn implements

   All kinds of tractor machinery

   Tractors, fuels and lubricants

   Self-propelled machinery

   Arable land, fertilizers, seeds, pesticides, etc.

   Laboratory instrumental

Measurement instrumental

Plot equipment

Photographic equipment

Transportation facilities

Shop facilities

Electronic computing facilities

Expensive facilities such as shop facilities, field and laboratory equipment, computing facilities should be shared whenever possible.

2. Testing of machinery. All kinds of prototypes of the machinery sold in the country should be tested. Important facilities should include:

All kinds of testing instrumentsl

Reports from other testing centers

Electronic computing facilities

3. Design and adaptation of machinery will require laboratory and experimental shop facilities. Research instrumentsl and equipment should be obtained.

Complete lists of instruments, equipment and materials have to be prepared according to the research projects to be developed.

4. The basic research will require more sophisticated measurement instruments and laboratory facilities. Most of these will probably have to be imported.

Simulated models of machinery, the reproduction of field situations in the laboratory, simulated agricultural

products could be used in this type of research, and the correlation between prototypes and models can be established. The use of computers would be essential in most of these experiments.

5. The economic studies will require mainly transportation, survey personnel and computing facilities. Most of the studies should be planned in such a way that the data can be processed by means of computers.

5.6 Personnel Required

Many people are required for the accomplishment of the complete research project. It will be necessary, however, to start with the personnel already available, and incorporate new specialists whenever possible.

The kinds of personnel required for the first few years are:

1. Agronomists with specialization in agricultural mechanization. Post-graduate studies in agricultural mechanization or agricultural engineering are essential.
2. Agricultural engineers for the testing of machinery. At least one in each testing center is needed.
3. Agricultural economists to carry on economic and survey studies.
4. Technical advisers from countries with established research programs, mainly the United States and European countries.

Mechanical engineers with proper orientation can be substituted for agricultural engineers until such time agricultural engineers are available in sufficient numbers. Agricultural engineers should take the main responsibilities in the research, with the cooperation from other disciplines.

The most important task for research personnel in agricultural mechanization is the undertaking of further specialization, because the personnel that will be working for the first six to eight year will not have received complete training in all aspects of agricultural mechanization. These advanced studies must be taken in foreign countries until such time as an agricultural engineering curriculum is provided in Chile.

5.7 Prospects for the Project

There are excellent possibilities for the success of the project for research in agricultural mechanization proposed. With the personnel, equipment and facilities available at the present time it is possible to complete in one or two years the first stage which consists mainly of evaluating all the research done, analyzing the results, and carrying out preliminary experiments in the areas lacking information. The main need for a successful start and final achievement of all the goals of the project is full coordination and collaboration between the institutions.

It is believed that the necessary conditions for full cooperation exist, especially because of the current

recognition among government officials, technicians and farmers of the importance of mechanization in Chile.

Another encouraging fact is that many institutions already have initiated research dealing with agricultural mechanization.

If other essential aspects for agricultural mechanization are improved, as expected, like education (creation of curricula of agricultural engineering), extension work, industrialization, national production of machinery, and training for dealers, mechanics, drivers and operators, etc., then the possibilities of achieving the total goals of the proposed project are excellent. In fact, when the cited conditions exist, exchanges of information between research programs will be a necessary adjunct.

The financing during the first years will not be a problem because the first stage will involve mainly the personnel, facilities and equipment already available. After two years, when definite programs are established, an increment of the monetary support will be needed. This has to be secured before initiating specific experiments and tests.

In the future the main sources of financing the research in agricultural mechanization should be:

1. The institutions responsible for the research, mainly Agricultural Research Institute, CORFO and the Universities.

2. Collaborating agencies (governmental and private) such as COMARSA, IANSA, INDAP, CORA.
3. Economic support from distributors of imported machinery, and from the developing national industry.
4. Support from international agencies, especially for technical assistance, the establishment of laboratories and purchasing of experimental equipment, and for the training of personnel. The Rockefeller Foundation, Ford Foundation, FAO, AID are the most important for this purpose.

It is very important that the future programs be prepared in accordance with available funds. The project proposal presented in this report helps to visualize short- and long-term financing requirements.

VI. CONCLUSIONS

1. Among Latin American countries, Chile has a high level of agricultural mechanization, but this level is low when compared with European countries or the United States.
2. The research for mechanization of agriculture has been limited and scattered. Only in the last few years has interest been demonstrated in the area of field experiments and testing of machinery.
3. The necessity of organizing the research for the next ten years is essential, because much information is needed in all aspects of agricultural mechanization to fully implement the National Agricultural Development Plan (1965-1980).
4. A proposal for research in agricultural mechanization is presented here. The most important goals of this proposal are:
   a. In the initial stage, efforts must be concentrated in the analysis of the existing situation, securing the financing and preparing specific experiments.
   b. During the intermediate stage specific tests and experiments in the most urgent aspects should be started.

c. During the third stage a more expanded program, involving all the aspects of agricultural mechanization should be developed.

d. At the end of the first stage, which means after eight or ten years of research, a project named Agricultural Engineering Research Project should be established.

5. If essential factors necessary for the improvements of mechanization such as education, industrialization, extension and training and general economic improvement are achieved, and if coordination between the institutions working in research with the support of the industries, importers of machinery and national producers of machinery is obtained, the chances of achieving the goals indicated in this proposed project are excellent.

BIBLIOGRAPHICAL REFERENCES

BIBLIOGRAPHICAL REFERENCES

1. Chang, C. W.
1966 Agricultural Research. An example of practical approach. In Selected Readings to Accompany Getting Agriculture Moving. Edited by R. E. Borton. The Agricultural Development Council: New York. pp. 210-221.

2. _____.
1966 Research planning and coordination. In Selected Readings to Accompany Getting Agriculture Moving. Edited by R. E. Borton. The Agricultural Development Council: New York. pp. 705-715.

3. Chile.
1966 Tenencia de la Tierra y Desarrollo Socio-Economico del Sector Agricola. CIDA (Comite Interamericano de Desarrollo Agricola), 2da. edicion, Santiago. p. 405.

4. CORFO, Corporacion de Fomento de la Produccion.
1965 Geografia Economica de Chile. Texto Refundido. Santiago, Chile. p. 885.

5. _____.
Participacion de la Corporacion de Fomento de la Produccion en el Proceso de Mecanizacion Agricola. Cuenta para el Comite Ejecutive. (Mimeographed report.) p. 17. n.d.

6. _____.
1964 Ministerio de Agricultura & Universidad de Chile. Insumos Fisicos en la Agricultura, Ano 1961-1962. Santiago, Chile. p. 572.

7. ECONOMIC Highlights of the Fifth State of Nation Address
1969 by President Frei on May 21, 1969. Chile, Economic Notes No. 45. Issued by CORFO, Chilean Development Corporation, June 13. p. 14.

8. Elgueta, Manuel.
1965. El Instituto de Investigaciones Agropecuarias. Agricultura Tecnica 25:(1), Santiago, Chile, Enero-Marzo. pp. 1-8.

9. Giles, G. W.
1966 The First Step in Advancing Mechanization. In Selected Readings to Accompany Getting Agriculture Moving. Edited by R. E. Borton. The Agricultural Development Council: New York. pp. 722-731.

10. Gill, John L.
1969 STT 423, Statistic 3 and ANS 854, Design of Animal Experiments. Notes from Classes. Michigan State University, East Lansing.

11. Hansen, E. L., H. F. McColly, A. A. Stone and J. B. Davidson
1949 Introducing Agricultural Engineering in China. Chicago, Illinois. pp. 61-108, 159-197.

12. Instituto de Investigaciones Agropecuarias. Tercera
1967 Memoria Annual, 1966-1967. Editorial Universitaria, Santiago, Chile. Diciembre. p. 170.

13. Inventory of Information Basic to the Planning of
1964 Agricultural Development in Latin America, Chile. Pan American Union, Washington, D. C. December. p. 98.

14. McMeekan, C. P.
1966 What Kind of Agricultural Research? In Selected Readings to Accompany Getting Agriculture Moving. Edited by R. E. Borton. The Agricultural Development Council: New York. p. 196-204.

15. Naciones Unidas, Consejo Economico y Social. El Uso
1968 de Maquinaria Agricola en Chile. Estudio Preparado por la Division Agricola Conjunta CEPAL/FAO y colabcracion del BID. E/CN. 12/799, Santiago, Chile. 14 Febrero. p. 83.

16. Olivares, Jose.
1962 Estudio de la Mecanizacion Agricola en la Provincia de O'Higgins. Año Agricola 1958-1959. Universidad de Chile & Ministerio de Agricultura. Boletin Tecnico N 15 Febrero. p. 49.

17. Paddock, William and P. Paddock
1966 How to Alter the Hand of God: Research. In Selected Readings to Accompany Getting Agriculture Moving. Edited by R. E. Borton. The Agricultural Development Council: New York. pp. 716-721.

18. Stenstrom, Lars
1959 Informe al Gobierno de Chile Sobre Mecanizacion de la Agricultura y Estudio Acerca de la Situacion Actual en el Pais. FAO, N 1065 Roma. p. 81.

19. Storie, R. E. and C. Mathews
1945 Preliminary Study of Chilean Soils. Proceedings of Soil Science Society of America. Vol. 10. p. 351-355.

20. Thiesenhusen, William
1966 Chile's Experiments in Agrarian Reform. The University of Winconsin Press, Madison. pp. 3-54.

MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03062 5515