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rapeseed potential

IN WESTERN CANADA

an evaluation of
a research and
development program

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a research and
development program**

W. Darcovich
Economics Branch
Ottawa, April 1973

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FOREWORD

This report explores the potential of rapeseed as an important cash crop in Canada. It suggests a program of varietal breeding and research and of supporting development activities to improve the quality and increase the markets for rapeseed and its products. It is estimated that increasing international and domestic demands for vegetable oils and meal are capable of substantially expanding rapeseed production in Western Canada.

The report is an economic analysis of the relative costs and benefits of such a program. It is intended to illustrate a methodology which can be used to evaluate a public research and development project. The views expressed are those of the author and do not necessarily represent those of the Economics Branch, Canada Department of Agriculture.

D.H. Plaunt,
Director, Farm and Rural Development Division,
Economics Branch.

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Thanks are also due to Messrs. J. McAnsh, Executive-Director, J.C. Brown, Manager of Research and Development, and K.B. Gray, Secretary of the Rapeseed Association of Canada for providing reports and publications, and responding to numerous questions about the rapeseed industry; and to several colleagues in the Departments of Agriculture and Industry, Trade and Commerce, whose names are mentioned in the body of the report for providing data on rapeseed research costs.

W. Darcovich

SUMMARY AND CONCLUSIONS

The results of this evaluation indicate that a long-term research and development program to improve rapeseed's competitive position among the world's oilseed crops would yield benefits which are more than commensurate with costs. In addition, the program would have some effect on income distribution as it would be largely financed by government funds, while the major share of the benefits would accrue to farmers.

The research activity, emphasizing improvement of the agronomic qualities of rapeseed and the yield and quality of its oil and meal, would be the driving force behind this program. But expenditures for supporting activities such as growth chambers, a storage terminal, oil tanks, market promotion and better management of the carryover would also be necessary if the research was to achieve maximum effectiveness.

With improvement of rapeseed's competitive position, it is estimated that sufficient domestic and export markets would be generated to drive the industry to a sustained production of about 7.5 million acres, about twice its present size, in 15 years. This represents the maximum physical limit for rapeseed acreage in Western Canada, considering that the optimum conditions for its growth are confined to the parkbelt zone and that for sustained production rapeseed requires a rotation of proper sequence and duration.

There is expected to be a considerable expansion of the domestic rapeseed market as a result of substitution for soybean imports from the United States, but this is not expected to affect the growth and production of the Canadian soybean industry. A large expansion is also expected in the export demand for rapeseed, primarily to existing importers (Japan, the Common Market and North African countries) and to Pacific Rim countries which did not import Canadian rapeseed before (China and countries in South and Central America and on the Indian subcontinent). Exports of oil and meal are expected to start after the changeover period to low erucic acid varieties is completed.

The period under consideration is long, extending 20 years into the future, making estimation inherently hazardous. There were data and time limitations which made it impossible to quantify all benefits and costs or which led to the use of some tenuous assumptions in the estimation procedures. Some estimates, such as acreage, acreage benefits, and research costs, are more firmly made and on balance it is considered that benefits tend to be underestimated more than costs, adding credibility to the benefit-cost comparisons. Thus, although the conclusions must be considered as tentative, they should not be without value. The evaluation provides an overview of the growth potential of the industry, and if cautiously used, its results may be compared with expenditures of public funds in alternative programs.

INTRODUCTION

Objective

The objective of this evaluation is to indicate the feasibility of undertaking research and related support activities to improve the quality and to increase markets of rapeseed and its products. The evaluation is carried out within a benefit-cost framework. The primary effort is to capture in a quantitative way the social cost of mounting such a program, the social benefits likely to accrue therefrom, and to relate the two.

The evaluation is long-term in nature. Despite many advances in plant breeding technology, plant research is still a long-term activity and must be evaluated as such. It takes at least eight years from the initial cross selection to the commercial production of a new variety, and it will take up to 12 years before the last stage of the proposed variety improvement program is implemented. Benefits do not start immediately and take even longer to attain their full potential. Fifteen and 20 years are therefore used as evaluation periods in this study.

The evaluation is limited to the industry in Western Canada. There is potential for a small rapeseed industry in Eastern Canada, but it is excluded from consideration because its production conditions, markets and problems are quite different.

Problems in the Rapeseed Industry

As a result of the recent rapid increase in acreage, production and exports and a rapid expansion of domestic crushing capacity, rapeseed has been called Canada's 'Cinderella' crop (1). These rapid developments in the Prairie Provinces' crop economy are the results of a number of factors:

- an expanding demand for vegetable oil and meal in domestic and export markets;
- a decreasing world demand for Canadian wheat;
- the ability of Canadian plant breeders to develop quickly new rapeseed varieties suitable for Canadian conditions;
- the ability of farmers to shift cropland quickly from grains to rapeseed and from existing to improved rapeseed varieties;
- the competitive advantage of rapeseed with other oil crops as a result of its high oil content.

However, Canadian rapeseed faces keen competition on domestic and export markets. Soybeans are produced domestically and soybean oil and meal are imported from the United States. Internationally, Canadian rapeseed must compete with the seeds, oils and meals produced from soybeans, cotton, peanuts, sunflowers, palm and coconut trees; with marine oils and meal; and with animal fats. It must also compete with rapeseed produced in European countries, notably France, Sweden and Poland.

The unprecedented expansion and favorable competitive position which Canada experienced in the last decade cannot be expected to continue without change. Rapeseed oil has been found to be high in erucic acid which is proving to be an undesirable nutritional characteristic. Its meal is being used increasingly in livestock rations in Canada, but further expansion in its use has been slowed by the presence of undesirable sulphur compounds, known as glucosinolates; these cause digestive upsets in animals and poultry unless intake of the meal is carefully controlled. Also, outbreaks of diseases affecting rapeseed crops are expected to increase in severity and frequency as the industry grows in size.

At the same time, important developments in the world vegetable oil system are putting pressure on rapeseed's competitive position¹. Examples are the development in the tropics of a hybrid, fast maturing oil palm and a rapid expansion of oil palm production; the new high oil content sunflowers and the new fatty acid composition varieties of sunflowers, safflower and corn. Rapeseed production is expanding rapidly in Australia and European countries are also developing low erucic acid rapeseed varieties.

Canada must therefore devote additional resources to research and related activities if her rapeseed industry is to continue to grow. The Canada Department of Agriculture, in cooperation with the Department of National Health and Welfare, has already undertaken a 3-year program to change production from high to low erucic acid varieties. The changeover, to be completed by the end of 1974, is expected to improve materially the acceptability of the oil on domestic and international markets.

¹ These comments and several others not specifically indicated in the text are based on discussions with or information provided by R.K. Downey, Chief, Vegetable Oils Section, Research Station, CDA, Saskatoon.

However, the changeover is only the initial step in an overall program of research, promotion and rationalization which must take place if the rapeseed industry is to form a larger and permanent part of the agricultural sector.

COSTS OF RAPESEED RESEARCH AND DEVELOPMENT

Research - to obtain improved rapeseed varieties, and to achieve better control of diseases and better utilization of rapeseed oil and meal - is the prime requisite and the driving force of a rapeseed improvement program. But supporting activities - specialized equipment, market promotion and the rationalization of several aspects of the marketing system - must also be undertaken if the results of the research are to be fully effective.

Research Priorities

At the Saskatoon meeting² on the goals and objectives of rapeseed research, the following priorities were indicated by the group for a long-term research program. Its general purpose would be to improve the agronomic qualities of the rapeseed varieties and the quality of the oil and meal so that rapeseed would increase its competitive position with soybeans and other oil crops. The priorities are:

(1) Because the changeover program to low erucic acid rapeseed (LEAR) is introducing varieties that are lower in yield per acre and in oil and protein content, the first priority would be to restore the agronomic qualities of the new varieties to pre-LEAR levels. Agronomically better varieties of the Argentine and Polish³ types are now under test and it is contended that there is about a 90 percent chance that both will be in commercial production by 1974.

(2) Since the most important limitation to the greater use of rapeseed meal is its glucosinolate content, the next research priority would be to develop low erucic acid varieties that are also low in glucosinolates. It is contended that there is about an 80 percent chance of commercial production of Argentine varieties by 1977

and about a 50 percent chance for Polish varieties by 1978.

(3) The quality and acceptability of rapeseed meal in livestock rations should be further increased by raising the meal's protein content. This would be done by breeding for yellow seeded varieties which are also low in erucic acid and in glucosinolates. It is contended that there is about a 70 percent chance of commercial production of Argentine varieties by 1981 and about a 50 percent chance for Polish varieties by 1980.

(4) Starting immediately and conducted concurrently with the above, more varietal and other research is required on disease control and on the utilization of rapeseed oil and meal.

Research Requirements and Costs

Base Year Amounts

Table 1 indicates the number of man-years devoted to rapeseed research in the base year, 1971-72, in the Canada Department of Agriculture (CDA), other federal departments, and the universities⁴. The table also indicates the type of research being conducted, i.e., whether production (Pr), primarily for variety breeding and agronomic improvement, preventative (Pt), for control of diseases and insect pests, utilization (U) for improvements in the quality of the oil and meal, and engineering (E) for work in processing technology.

Additional research (Table 2) is carried on through the Rapeseed Utilization Assistance Program (RUAP) under the auspices of the Research Committee of the Rapeseed Association of Canada, with the funds being provided by the Department of Industry, Trade and Commerce. The amount allocated in the base year was \$200,000. The research projects are conducted at universities and the researchers usually have access to certain resources without charge, i.e., student assistants, technical, secretarial and administrative staff and equipment, facilities and office space (2). The value of these inputs is unknown but is estimated by the author to be equal in amount to the direct cash outlays (Table 2, column 2).

²Rapeseed Research Work Planning meeting. It was sponsored by the Canada Department of Agriculture and was held on February 24-25, 1972 at the same time as the meeting of the Advisory Group on Rapeseed Varietal Development.

³Polish varieties are earlier maturing but lower yielding than the Argentine types.

⁴These figures were made available to the author by J.W. Morrison, Research Coordinator, Cereal Crops, Research Branch, CDA, Ottawa.

TABLE 1. FULL-TIME PROFESSIONAL MAN-YEARS DEVOTED TO RAPESEED RESEARCH IN BASE YEAR, 1971-72, AND ESTIMATED REQUIREMENTS FOR 1972-73 TO 1991-92

Crop year	Year no.	WESTERN CANADA						OTTAWA			Total profes- sional man-years (6) + (9)
		Research Stations		Universities							
		Saska- toon	Melfort, Beaver- lodge, Lethbridge	Manitoba	Alberta	National Research Council, Saskatoon	Total	Dept. Agri- culture	Dept. National Health and Welfare	Total	
		(Pr, Pt) (1)	(Pr, Pt) (2)	(Pr) (3)	(Pr) (4)	(U) (5)	(6)	(U, Pt, E) (7)	(U) (8)	(9)	(10)
1971-72	B	9.0	1.5	1.5	.75	1.0	13.75	6.0	1.0	7.0	20.75
1972-73	0	10.0	1.75	1.75	1.0	1.0	15.50	6.5	1.0	7.5	23.00
1973-74	1	11.0	2.0	2.0	1.25	1.0	17.25	7.5	1.0	8.5	25.75
1974-75	2	12.0	2.25	2.0	1.50	1.0	18.75	8.5	1.0	9.5	28.25
1975-76	3	14.0	2.50	2.0	1.75	1.0	21.25	9.0	1.0	10.0	31.25
1976-77	4	15.0	2.75	2.0	2.0	1.0	22.75	9.0	1.0	10.0	32.75
1977-78	5	16.0	3.0	2.0	2.0	1.0	24.00	9.0	1.0	10.0	34.00
1978-79	6	16.0	3.0	2.0	2.0	1.0	24.00	8.5	1.0	9.5	33.50
1979-80	7	16.0	3.0	2.0	2.0	1.0	24.00	8.0	1.0	9.0	33.00
1980-81	8	15.0	3.0	2.0	2.0	1.0	23.00	7.5	1.0	8.5	31.50
1981-82	9	14.0	3.0	2.0	2.0	1.0	22.00	7.0	1.0	8.0	30.00
1982-83	10	13.0	3.0	2.0	2.0	1.0	21.00	6.0	1.0	7.0	28.00
1983-84	11	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00
1984-85	12	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00
1985-86	13	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00
1986-87	14	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00
1987-88	15	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00
1988-89	16	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00
1989-90	17	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00
1990-91	18	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00
1991-92	19	12.0	3.0	2.0	2.0	1.0	20.00	6.0	1.0	7.0	27.00

TABLE 2. CASH EXPENDITURES AND COST OF MATCHING RESOURCES FOR RAPESEED RESEARCH UNDER RAPESEED UTILIZATION ASSISTANCE PROGRAM (RUAP) IN BASE YEAR, 1971-72, AND ESTIMATED FOR YEARS 1972-73 TO 1991-92

Crop year	Year no.	Cash outlays for research contracts and grants (1)	Cost of matching resources (2)	Total cost (3)
(\$000)				
1971-72	B	200	200	400
1972-73	0	250	250	500
1973-74	1	275	275	550
1974-75	2	300	300	600
1975-76	3	325	325	650
1976-77	4	350	350	700
1977-78	5	350	350	700
1978-79	6	350	350	700
1979-80	7	350	350	700
1980-81	8	350	350	700
1981-82	9	350	350	700
1982-83	10	325	325	650
1983-84	11	300	300	600
1984-85	12	275	275	550
1985-86	13	275	275	550
1986-87	14	275	275	550
1987-88	15	275	275	550
1988-89	16	275	275	550
1989-90	17	275	275	550
1990-91	18	275	275	550
1991-92	19	275	275	550

Future Requirements⁵

In estimating future resource requirements in Tables 1 and 2 to mount the kind of research program indicated by the Saskatoon meeting, the values in the base year are used as the starting point. Other considerations taken into account in estimating requirements 20 years forward are:

- that the research effort must be devoted to improving both Argentine and Polish types of rapeseed and that research is generally more advanced with the Argentine type than with the Polish, although Argentine rapeseed is grown only on 30 percent of the acreage;

⁵These estimates were discussed and reviewed with R.K. Downey, op cit., and A.E. Hannah, Assistant Deputy Minister, Food Systems, CDA, Ottawa.

- that there must be an early and fairly rapid expansion of research resources for Canada to maintain or widen its lead over other countries in rapeseed research technology and in variety improvement;

- that as the industry grows in size, more and more resources must be devoted to on-going research to overcome constantly arising production, protection, utilization and engineering problems, to ensure that rapeseed is kept competitive with other oilseed crops.

The totals of the man-year requirements in Table 1 are built up from the requirements of individual institutions. These differ and are considered separately.

The Research Station at Saskatoon, centrally located to the production area, and the leader in rapeseed research in the past, is expected to continue its leading role in the proposed research program. This station is in the best position to be sensitive to research developments and to respond to research needs of the future. Its requirements are expected to expand to a peak of 16 man-years, stay at this level through the period of most intensive research, and then decline gradually to 12 man-years, a level which is higher than in the base period.

The Research Stations at Melfort, Beaverlodge and Lethbridge, and the Universities of Alberta and Manitoba are expected to expand their man-year requirements in the early years and to maintain them at a combined level of 8 man-years for the remainder of the period. It is expected that the National Research Council at Saskatoon will maintain the equivalent of one man-year throughout the entire period on basic research in the utilization of rapeseed oil and meal. A similar level of research resources is expected to be maintained by the Department of National Health and Welfare in Ottawa, primarily on basic nutritional studies of rapeseed oil.

CDA's Ottawa activities (Table 1, column 7) are expected to expand quickly to accommodate the urgent need for rapeseed research in the areas of utilization and crop protection. It is expected, however, that the peak requirements will be reached earlier than in Saskatoon, that the plateau will be of shorter duration, and that the decline to base-year levels will start sooner.

Research under the Rapeseed Utilization Assistance Program (Table 2) tends to be coordinating and gap-filling in nature as resources are mustered for research not otherwise being performed. As such the funds are

expected to be problem-responsive and the total cost stream follows a pattern similar to that of the Saskatoon Research Station; a rapid expansion in the early years, a peaking to a plateau while the basic problems of the removal of glucosinolates and raising the protein level of the meal are being solved, and then a tapering off to a constant level, but higher than in the base year.

Costs Per Man-Year

The estimated man-years in columns 6 and 9 of Table 1 are translated into costs in columns 1 and 4 of Table 4 by multiplying each man-year by \$60,300⁶. This estimate of cost was obtained with the assistance of CDA officials and is given in Table 3. It is considered to be a good estimate of the total social cost of rapeseed research per man-year. The figure is maintained at a constant level over the entire 20-year period in spite of the increasing sophistication of research (3), as it is assumed that rising costs therefrom will be offset by the greater productivity of the professionals.

TABLE 3. COST OF RESEARCH AND DEVELOPMENT APPLICABLE TO RAPESEED/FULL-TIME PROFESSIONAL MAN-YEAR, 1971-72

(1)	Operation and maintenance ^(a) , 1970-71	\$52,189
(2)	Capital expenditure on new equipment, 6% of item 1.	3,131
(3)	Space rental, direct and shared facilities; 700 sq ft/professional @ \$3.00/sq ft	2,100
(4)	Sub-total	57,420
(5)	Inflation to 1971-72 @ 5% of item 4.	2,871
(6)	Total estimated cost/man-year, 1971-72	<u>\$60,291</u>

(a) Includes salaries and maintenance of establishment, materials and office supplies, telephone and telegraphs, travel, commissionaire service, repair and upkeep of buildings.

Costs of Uncertainty

The cost figures on research presented in columns 1, 4 and 6 of Table 4 are expected (average) values; they are judged to be the best point estimates taking into account that actual research costs in any one year may vary from

⁶ Figures made available to the author from unpublished sources by R.A. Ludwig, Assistant Director General (Administration), Research Branch, CDA, Ottawa.

their expected values. The uncertainties of success in implementing new varieties by a certain date are not, however, specifically incorporated into the cost stream. These are indicated in Table 5 and arose out of discussions with plant breeders and at the research conference in Saskatoon. Thus Table 5 indicates that there is a 0.5 probability that an improved low erucic acid, low glucosinolate variety of Polish rapeseed will be in commercial production by the 1978-79 crop year, the cost of research in that year, x^6 , being \$1,447,200 in Western Canada (Table 4, column 1). If it is not successful that year, the probability of success the next year is increased to 0.65, but the cost of prolonging research for another year is an additional \$36,000. If success is not achieved in succeeding years, costs continue to rise till 1981-82 when there is certainty of achieving success. The modified decision trees, and the costs associated with the relevant probabilities are given in Appendix A. The results in terms of additional research costs for the Argentine and Polish rapeseed are shown in column 2 of Table 4.

Research Costs and Farm Values

The stream of total research costs in column 7 of Table 4 rises from the base-year level of \$1.65 million to a peak of \$2.75 million 6 years later, then tapers off to a constant \$2.18 million annually for the rest of the period. Assuming a price of \$2.00 per bushel for the rapeseed, the farm value of the crop in 1991-92 of 157.5 million bushels (Table 15) would be about \$315 million. The total research cost of \$2.2 million represents about 0.7 percent of the farm value. Crude calculations indicate that an analogous figure for research in wheat, oats, barley, rye and corn is about 0.4 to 0.5 percent. Bearing in mind the approximate nature of the comparison, the higher proportion devoted to rapeseed research may not be out of line considering the highly competitive nature of the world oilseed system.

On the other hand it should also be kept in mind that research costs at the end of the period in relation to the base year rise by a third, while the industry is estimated to double in size in terms of acreage.

In a period of time as long as 20 years, the institutions undertaking or supporting research can change considerably and a number of proposals to this effect are already under way (4), (5). It is implicitly assumed, however, that the availability of total research funds outlined above will not be affected by institutional changes.

TABLE 4. TOTAL UNDISCOUNTED COSTS OF RAPESEED RESEARCH IN BASE YEAR, 1971-72, AND ESTIMATED FOR 1972-73 TO 1991-92, VALUED AT \$60,300/FULL-TIME PROFESSIONAL MAN-YEAR AND INCLUDING COSTS IN TABLE 2

Crop year	Year no.	Based on Full-Time Professional Man-Years					From Table 2, Col. 3	Total research costs (undiscounted)
		Western Canada ^(a)	Extra cost of uncertainty	Total cost (1) + (2)	Ottawa ^(a)	Total (3) + (4)		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
					(\$000)			
1971-72	B	829.1		829.1	422.1	1251.2	400.0	1651.2
1972-73	0	934.6		934.6	452.2	1386.8	500.0	1886.8
1973-74	1	1040.2		1040.2	512.6	1552.8	550.0	2102.8
1974-75	2	1130.6		1130.6	572.8	1703.4	600.0	2303.4
1975-76	3	1281.4	2.7	1284.1	603.0	1887.1	650.0	2537.1
1976-77	4	1371.8		1371.8	603.0	1974.8	700.0	2674.8
1977-78	5	1447.2		1447.2	603.0	2050.2	700.0	2750.2
1978-79	6	1447.2	3.6	1450.8	572.8	2023.6	700.0	2723.6
1979-80	7	1447.2	20.5	1467.7	542.7	2010.4	700.0	2710.4
1980-81	8	1447.2	16.8	1464.0	512.6	1976.6	700.0	2676.6
1981-82	9	1447.2	37.0	1484.2	482.4	1966.6	700.0	2666.6
1982-83	10	1386.9	14.2	1401.1	422.1	1823.2	650.0	2473.2
1983-84	11	1326.6	7.7	1334.3	422.1	1756.4	600.0	2356.4
1984-85	12	1266.3		1266.3	422.1	1688.4	550.0	2238.4
1985-86	13	1206.0		1206.0	422.1	1628.1	550.0	2178.1
1986-87	14	1206.0		1206.0	422.1	1628.1	550.0	2178.1
1987-88	15	1206.0		1206.0	422.1	1628.1	550.0	2178.1
1988-89	16	1206.0		1206.0	422.1	1628.1	550.0	2178.1
1989-90	17	1206.0		1206.0	422.1	1628.1	550.0	2178.1
1990-91	18	1206.0		1206.0	422.1	1628.1	550.0	2178.1
1991-92	19	1206.0		1206.0	422.1	1628.1	550.0	2178.1

^(a)Based on man-years in columns 6 and 9, respectively, of Table 1.

TABLE 5. DATES OF INTRODUCING NEW RAPESEED VARIETIES INTO COMMERCIAL PRODUCTION, PROBABILITY OF SUCCESS BY THESE DATES AND COSTS ASSOCIATED WITH VARIOUS DATES OF SUCCESS

	Argentine types			Polish types		
	Year	Probability	Cost (a) (\$000)	Year	Probability	Cost (a) (\$000)
Improved low erucic acid varieties as in priority 1 (L.E.)	1974-75	0.9	X_2	1974-75	0.9	X_2
	1975-76	1.0	$X_3 + 12$	1975-76	1.0	$X_3 + 15$
(L.E.) and also low in glucosinolates (L.G.) as in priority 2 (L.E.) x (L.G.)	1977-78	0.8	X_5	1978-79	0.5	X_6
	1978-79	0.9	$X_6 + 18$	1979-80	0.65	$X_7 + 36$
	1979-80	1.0	$X_7 + 25$	1981-82	0.8	$X_8 + 48$
				1981-82	1.0	$X_9 + 54$
(L.E.) x (L.G.) and also yellow seeded (Y) as in priority 3, (L.E.) x (L.G.) x (Y)	1981-82	0.7	X_9	1980-81	0.5	X_5
	1982-83	0.85	$X_{10} + 18$	1981-82	0.65	$X_9 + 20$
	1983-84	1.0	$X_{11} + 24$	1982-83	0.8	$X_{10} + 25$
				1983-84	1.0	$X_{11} + 25$

(a) Designations X_2 to X_{11} represent total costs of research in Western Canada for years No. 2 to 11 respectively as shown in Table 4, Col. 1.

Supporting Costs

In order that the research effort be as effective as possible, it must be supported by additional costs for (i) growth chambers, (ii) rapeseed market promotion, (iii) a higher carryover, (iv) additional terminal facilities at Vancouver, and (v) oil storage tanks at Vancouver and the Eastern Seaboard.

Growth Chambers

Construction of additional growth chambers at Saskatoon is needed early in the program for maximum progress in varietal breeding work. The total cost is estimated to be \$400,000 and it is assumed that \$100,000 will be spent in 1972-73 and \$300,000 in 1973-74 (Table 6, column 2). This is considered to be highly specialized equipment outside the normal 6 percent requirements for new equipment shown in Table 3.

Market Promotion

An effective campaign to promote the products made from the new varieties is essential to fully develop existing markets and to tap new ones. This activity is the function of the Rapeseed Association of Canada and government departments concerned with trade promotion. The estimated cost stream for promotional activities (Table 6, column 3) has as its starting point the

annual financial statement of the Rapeseed Association of Canada (6) and rises to a plateau of \$200,000 annually.

Greater Carryover

The carryover in the last decade has averaged about 20 percent of production. This level is considered to be too low as it is known that export sales were lost because supplies of rapeseed were not available when importers wanted them. It is impossible at this time to make a definitive statement on what a 'normal' carryover should be for rapeseed, although it is generally agreed that it should be higher than at present. It is assumed tentatively that increasing the amount of carryover from 20 to 30 percent of production would go a long way toward a normal carryover concept. Withholding rapeseed from sales to fill the 'carryover pipeline' becomes the cost of better supply management. It can be considered as the fee to insure that the domestic and export sales estimated in Table 14 do in fact take place. This cost stream is developed in Appendix B and is presented in Table 6, column 4.

Vancouver Terminal

In addition to a larger carryover, a rapeseed terminal in Vancouver is essential to insure continuity of supply to the Pacific Rim countries. A million bushel terminal is proposed at an estimated cost of \$3,250,000 in base-

TABLE 6. ESTIMATED TOTAL COSTS OF PROPOSED RAPESEED RESEARCH AND DEVELOPMENT PROGRAM, 1972-73 TO 1991-92

Crop year	Year no.	Total research costs (Table 3)	Growth chambers	Rapeseed promotion	Greater carryover	Vancouver terminal	Oil tanks, Vancouver & Eastern Seaboard	Total
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
					(\$000)			
1972-73	0	1886.8	100.0	100.0	291.1			2377.9
1973-74	1	2102.8	300.0	110.0	317.8	1600.0		4430.6
1974-75	2	2303.4		120.0	351.1	1000.0		3774.5
1975-76	3	2537.1		130.0	391.2		750.0	3808.3
1976-77	4	2674.8		140.0	415.4		600.0	3830.2
1977-78	5	2750.2		150.0	112.4			3012.6
1978-79	6	2723.6		160.0	104.5			2988.1
1979-80	7	2710.4		170.0	104.3			2984.7
1980-81	8	2676.6		180.0	81.7			2938.3
1981-82	9	2666.6		190.0	129.6			2986.2
1982-83	10	2473.2		200.0	99.7			2772.9
1983-84	11	2356.4		200.0	119.8			2676.2
1984-85	12	2238.4		200.0	121.2			2559.6
1985-86	13	2178.1		200.0	144.5			2522.6
1986-87	14	2178.1		200.0	142.5			2520.6
1987-88	15	2178.1		200.0	18.6			2396.7
1988-89	16	2178.1		200.0	18.4			2396.5
1989-90	17	2178.1		200.0	18.2			2396.3
1990-91	18	2178.1		200.0	18.0			2396.1
1991-92	19	2178.1		200.0	17.8			2395.9

year prices. It is also assumed that the probability of building the terminal is 0.8 and of not building 0.2. Taking these probabilities into account the expected cost of the terminal becomes \$2,600,000 (Table 6, column 5). It was assumed that if built, construction would start in 1972-73.

Oil Storage Tanks

If Canada is to become an exporter of rapeseed oil in an important way, oil storage tanks are required at Vancouver and on the Eastern Seaboard to ensure continuity of supply and efficiency of operation through wholesale handling. The costs of such facilities are difficult to estimate. However, people in the trade indicate that about \$750,000 would be required at Vancouver and \$600,000 on the Eastern Seaboard. The highest priority is in Vancouver, and it is estimated that this tank would be built in 1975-76. Some storage capacity already exists in Toronto and Montreal, and it

is expected that the new Eastern Seaboard facility would be built in 1976-77.

THE DEMAND FOR CANADIAN RAPESEED

The general assumption was that if rapeseed is made as competitive as possible with soybeans and other oilseed crops, including rapeseed produced abroad, there will be sufficient world demand to absorb the supplies Canada could economically produce. This idea is also expressed by the Task Force on Agriculture (7).

"In general the future prospects for vegetable oil seed crops, particularly rapeseed, appear to be very bright in Canada. Rapeseed exports account for only seven percent of the total world exports of edible vegetable oil crops, and Canada is the leading exporter of rapeseed. It appears that the export demand for rapeseed is very elastic, and that if Canada is prepared to be price competitive, there is a very substantial market for

Canada's exports of rapeseed. In addition, of course, market promotion developments will continue to be an important aspect of any expansion in world markets for rapeseed."

This section undertakes the estimation of the country-by-country and total demand which improved rapeseed varieties can bring forth.

Nature of Demand

Although rapeseed oil and meal are produced jointly, their demands on domestic and world markets are independently determined⁷. The meal is used primarily as a high-protein concentrate to supplement roughages and grains in livestock and poultry rations. In countries where agriculture is intensive, some meal is also used as fertilizer. The oil is produced for human consumption and is used in the manufacture of margarine and shortenings, in salad dressing and cooking oils, or directly as a food.

With production occurring almost in fixed proportions, the output of oil and meal is insensitive to the relative prices of these products. Output is determined by the commodity with the strongest demand and the other becomes the by-product. In general, the demand for livestock products is strongest in the developed countries and the meal tends to be the principal commodity. In developing countries, the demand for oil as a food is the stronger, making oil the principal commodity and meal the by-product. For rapeseed the situation is unique; its oil content is a high 40 percent so that in Canada, at least, the oil is the principal commodity and the meal the by-product.

Almost all vegetable oil crops produce oil and meal. Although each tends to have its unique characteristics and some food products are manufactured from a mixture of oils, all vegetable oils and meals and some of non-vegetable origin are to some degree substitutes for each other. In estimating the demand for Canadian rapeseed, the availability of substitutes must be considered.

Domestic Demand

Expansion of the domestic demand for rapeseed depends on two sources of growth:

- An increasing population and per capita consumption of vegetable oils and meal, assuming no change in the degree of substitution between rapeseed and soybean products.

- The additional demand if there is substitution of Canadian-grown rapeseed for soybean imports from the United States (import substitution).

This section develops quantitative estimates of these two aspects of demand for the years 1986-87 and 1991-92.

Growth of Population and Consumption

Starting with an estimated population of 21.8 million at the end of 1971-72, estimates for 1986-87 and 1991-92 were derived by assuming a compound rate of growth of 1.5 percent per year (Table 7, column 1). These are believed to be reasonable estimates, taking into account past rates of growth and published estimates available elsewhere (9). It indicates a population increase of 25 percent by 1986-87 and 35 percent by 1991-92 (column 2).

Columns 3 and 4 of Table 7 give indexes of the per capita consumption of vegetable oils and meats. Much of the rise in the oils index is due to their substitution for butter; the index is, however, considered to be on the low side as it includes other animal fats whose per capita consumption has not been growing as rapidly as vegetable oils.

The index for meats shows an increase of 28 percent by 1991-92, greater than the 20 percent increase for the oils index. These consumption trends are in line with the nature of Canadian economy; it is characteristic of an industrialized, high-income economy to favor the consumption of meats over oils and fats. It points up an important aspect of the present domestic rapeseed market, namely that its principal commodity, rapeseed oil, will be facing a weaker domestic demand than its meal, which is the by-product.

The potential demands for rapeseed oil and rapeseed meal, given in columns 5 and 6 of Table 7, are calculated by multiplying the oil and meal indexes by the population index, respectively. In Table 8, these indexes are applied to the crushing of rapeseed in 1971-72 of 10 million bushels, to give estimated crushings in 1986-87 and 1991-92 (columns 2 and 4). The estimates in column 2 assume that rapeseed crushing are geared to the demand for oil, the principal commodity, and in column 4 that they are geared to the demand for meal, the by-product.

⁷An exploratory, simultaneous equations model incorporating these aspects of production and demand in world trade has been developed in a United States' study (8).

TABLE 7. ESTIMATES OF POPULATION, PER CAPITA CONSUMPTION AND POTENTIAL DEMAND FOR OIL AND MEAL, 1986-87 AND 1991-92

Period	INDEXES					
	Population (a) (000,000)	Population growth	Per capita consumption		Potential demand from growth in population and per capita consumption for:	
			Vegetable oils (b)	Meats: beef, pork and poultry	Rapeseed oil	Rapeseed meal
					(2) x (3)	(2) x (4)
	(1)	(2)	(3)	(4)	(5)	(6)
1971-72	21.8	100.0	100.0	100.0	100.0	100.0
1986-87	27.3	125.0	117.0	122.0	146.2	152.5
1991-92	29.4	135.0	120.0	128.0	162.0	172.8

(a) Based on annual compound growth rate of 1.5% for entire period. These estimates are close but below those provided in (9).

(b) Includes vegetable oils and fats (exc. butter).

Sources: Estimates based on data contained in (10) and (11) and calculations made by the author after discussions with Z. Yankowsky of CDA.

TABLE 8. ESTIMATED INCREASE IN CRUSHING CAPACITY ARISING FROM POTENTIAL DEMAND FOR RAPESEED OIL AND MEAL, 1986-87 AND 1991-92

Period	Index of potential demand for rapeseed oil (a)	Estimated crushing of rapeseed based on col. 1 (000,000 bu)	Index of potential demand for rapeseed meal (b)	Estimated crushing of rapeseed based on col. 3 (000,000 bu)	Estimated domestic crushing of rapeseed (000,000 bu)
	(1)	(2)	(3)	(4)	(5)
1971-72	100.0	10.0 (c)	100.0	10.0	10.0
1986-87	146.2	14.6	152.5	15.2	14.9 (d)
1991-92	162.0	16.2	172.8	17.3	17.3 (e)

(a) As in Table 7, col. 5.

(b) As in Table 7, col. 6.

(c) Projected on basis of past trend.

(d) Average of 14.6 and 15.2 in col. 2 & 4.

(e) Same as in col. 4.

As oil and meal are produced in fixed proportions, a rapeseed meal deficit arises when crushing is geared to domestic oil demand. This deficit will be filled by soybean meal. On the other hand, a surplus of exportable oil arises when rapeseed crushing is geared to the domestic demand for meal.

One of the key objectives of the varietal breeding program is to improve quality and economic value of

rapeseed meal. This improvement is to be completed by 1986-87 and the figure of 14.9 million bushels for that year assumes that crushing has responded halfway to the demand potential based on rapeseed meal. The 1991-92 figure of 17.3 million bushels assumes that rapeseed crushing shifts fully to the meal basis. As a consequence of these shifts, some surplus rapeseed oil will be available for export.

Import Substitution

The chief competitor for rapeseed on the domestic market is the soybean. It is grown domestically in southwestern Ontario, but Canada is a large net importer of soybeans and soybean meal from the United States. Soybean oil is also imported, but more is exported so that Canada is a net exporter of this oil. The relative competitive positions of soybeans and rapeseed in terms of their oil and meal is indicated in Table 9.

TABLE 9. COMPARATIVE YIELDS OF OIL AND MEAL FROM RAPESEED AND SOYBEANS

	Content (a)		Yield/50 lb seed (b)	
	Oil	Meal	Oil	Meal
	(%)		(lb)	
Rapeseed	40.0	57.5	20.0	28.8
Soybeans	17.5	80.0	8.9	40.0

(a) Source: Department of Industry, Trade and Commerce, Fats and Oils in Canada, Annual Review, 1969, Ottawa, March 1970, p. 119.

(b) Bushel weight: rapeseed, 50 lb; soybeans, 60 lb.

Rapeseed yields more than twice as much oil as soybeans, though the quality of rapeseed oil is not as good. On the other hand, rapeseed yields only about 75 percent as much meal as soybeans. Soybean meal has the further advantage that its protein content is 45 percent, while in rapeseed it is only 36 percent. Soybean meal also has other characteristics which favor its use over rapeseed meal in livestock rations.

TABLE 10. DOMESTIC UTILIZATION OF OIL AND MEAL FROM RAPESEED AND SOYBEANS, 1965-66 AND 1970-71

Years	Amount		% of 1965-66	
	Oil (000,000 lb)	Meal (000 tons)	Oil	Meal
Rapeseed (a)				
1965-66	72.6	53.5	100.0	100.0
1970-71	164.5	122.1	226.7	228.1
Soybeans (b)				
1965-66	191.2	477.0	100.0	100.0
1970-71	227.0	681.8	118.7	142.9

(a) Source: Statistics Canada, Oilseeds Review, Sept. 1971, Cat. No. 22-006, Quarterly.

(b) Source: Statistics Canada, Cat. No. 22-001.

In spite of these disadvantages, domestic utilization of rapeseed oil and meal in the last decade has expanded phenomenally compared with soybean oil and meal. This period is not, however, a good indicator of the possibilities of market penetration for the rapeseed products as the industry was small and high rates of growth could be expected. A better indication is given in Table 10 which shows these trends for the last 5 years.

Domestic utilization of rapeseed oil and meal increased by over 25 percent annually in the last 5 years; in comparison, the increase was about 4 percent for soybean oil and 8 percent for soybean meal. The high rates of growth in rapeseed use cannot be expected to continue; given, however, the constant improvement of the rapeseed oil and meal, further substantial penetration of the potential soybean market can be expected. This penetration is estimated in Tables 11 and 12.

TABLE 11. IMPORT SUBSTITUTION POTENTIAL FOR RAPESEED PROVIDED BY IMPORTS OF SOYBEANS AND SOYBEAN MEAL INTO CANADA

	1971-72	1986-87	1991-92
(1) Rapeseed equivalent (in millions of bushels of rapeseed) of soybeans imported or expected to be imported into Canada for crushing into soybean oil and meal	27.1	45.6	52.9
(2) Rapeseed equivalent (in millions of bushels of rapeseed) of soy- bean meal imported or expected to be imported into Canada for direct use in live- stock feeding	8.0	12.2	13.8
(3) Total import sub- stitution potential in terms of millions of bushels of rapeseed	35.1	57.8	66.7
(4) Realizable import substitution potential (in millions of bushels of rapeseed), estimated at $\frac{1}{2}$ the quantities in (1)	—	22.8	26.4

Source: Appendix C, Table C-1.

Table 11 indicates the maximum import substitution potential to be 66.7 million bushels of rapeseed in 1991-92. The total includes the rapeseed equivalent of the soybean meal imports (item 2). As the United States soybean crushing industry is larger and more efficient, soybean meal imports are considered to be outside the competitive range of the Canadian rapeseed processing industry. However, this still leaves a large amount of soybeans, (item 1) imported for processing in Canada, for which Canadian industry can compete.

In estimating the penetration that can be made into soybean imports, account is taken of the growth rates exhibited by rapeseed oil and meal in Table 10, the large increase in Canada's rapeseed crushing capacity (10), the possibility of its further expansion, and the improvements in rapeseed meal and oil from the rapeseed breeding program.

Considering all these aspects of import demand substitution, the author's estimate is that the Canadian industry could penetrate one-half (item 1) the soybean import potential. Such penetration would create an additional domestic demand for rapeseed of 22.8 and 26.4 million bushels in 1986-87 and 1991-92 respectively (Table 11, item 4).

TABLE 12. SOURCES OF TOTAL DOMESTIC DEMAND IN TERMS OF RAPESEED CRUSHING

Year	From growth of population and per capita consumption as in Table 8	From substitution against imports of United States soybeans, as in Table 11	Total domestic demand for rapeseed crushing
(000,000 bu)			
1971-72	10.0	—	10.0
1986-87	14.9	22.8	37.7
1991-92	17.3	26.4	43.7

The indicated degree of penetration is considered to be reasonable and realizable on a number of counts. No inroads are made into the Canadian soybean industry; it is assumed that its production will continue to expand by about one percent annually. Similarly, no inroads are made into the imports of soybean meal from the United States. Canada will continue to import soybeans and to be a net exporter of soybean oil, but only at one-half the maximum potential rate. On the other hand, the indicated penetration is a very sizeable demand com-

ponent for rapeseed (Table 12) forming the largest portion of domestic demand.

Export Demand for Rapeseed

This section develops country-by-country estimates of rapeseed exports from Canada for the year 1986-87. The estimates are extended to 1991-92 on the basis that exports to each country are maintained in the same proportion as in 1986-87, after allowing for additional processing.

The countries are grouped into two categories, i.e., those on the Pacific Rim and those beyond it. This separation is important because the probabilities used (Table 13) in obtaining the expected values of exports for the Pacific Rim countries are the same as those for building or not building the Vancouver terminal, i.e., 0.8 and 0.2 respectively. The probabilities for countries outside the Pacific Rim are not related to this cost factor and are judgment evaluations of the author.

Likewise, the export figures for 1985-86 to which the probabilities are applied are judgment estimates made by the author after assessing the evidence available about conditions in these countries in the past, the conditions likely to prevail in the future, and the greater competitiveness of Canadian rapeseed as a consequence of improved varieties.

Japan

Japan has been the largest and most consistent importer of Canadian rapeseed. From a small start in 1955, Japanese imports have grown steadily and reached an estimated 18 million bushels in 1971-72. This was in spite of import quotas and tariffs on rapeseed which were not applicable to soybeans to the same degree.

It is expected that Japan will continue to be the major importer of Canada's rapeseed. Several factors favor this prospect. Japan has a highly developed industrial economy with a gradually rising population, a rapidly rising standard of living, and a rising demand for such foodstuffs as meats, eggs, milk and vegetable oils. Estimates based on FAO sources (11), (12), (13), indicate an increase of 16 percent in population and a 40 percent increase in per capita consumption of vegetable oils between 1970 and 1985. At the same time, its agricultural resources are limited and its rapeseed acreage has been falling rapidly. However, the numbers of dairy cattle, hogs and poultry have been rising sharply, creating a growing demand for livestock feeds.

Quota and duty restrictions are being removed and the Japanese are becoming aware of the potential of rapeseed meal as a livestock and poultry feed, enabling the upgrading of its use. At present, it is applied as fertilizer for citrus fruits and tobacco.

The Japanese crushing industry, geared to domestic production of rapeseed, comprises some 500 small units dispersed throughout the country, and is inefficiently operated in relation to soybean processing plants (14). The rapeseed plants are being rationalized into larger and better located units which, in addition to having a large capacity will be able to produce rapeseed products of better and more uniform quality.

The major part of the Japanese vegetable oil and meal requirements are obtained from imports of soybeans from the U.S. An improved Canadian rapeseed, the provision of better terminal facilities at Vancouver, and the rationalization of the Japanese rapeseed crushing industry should make rapeseed more competitive and result in a much greater substitution of rapeseed for soybeans. The extent of the export demand which this will create for Canadian rapeseed is estimated in Table 13.

Taiwan, the Indian Subcontinent and China

As a group, these Pacific Rim countries are considered to have market potential for Canadian rapeseed exports. In the past, Taiwan has been an intermittent importer. Its future potential as a market arises from the decline in its rapeseed acreage, its population growth, increasing per capita consumption of vegetable oils, the existence of a rapeseed crushing industry, and the possibility of using the meal as a livestock feed rather than as fertilizer (15).

India, the other countries on the subcontinent, and China are producers of rapeseed. However, population growth has outstripped the increase in acreage and production and these countries are expected to be in a deficit supply position in vegetable oils. Their import demands are likely to be highly variable, depending on their harvests of rapeseed and other food crops, and on the supply of competing vegetable oils from neighboring countries. The availability of a terminal in Vancouver, with supplies of rapeseed always available for export, should enable Canada to better accommodate the variable nature of their import demands, whose averages are estimated in Table 13.

Latin America

Except for a shipment of 500,000 bushels to Mexico in

1970, Canada has not exported rapeseed to Latin American countries. Missions to Mexico, to the South American countries of Chile, Peru and Ecuador, and to the countries of Central America (16), indicate that a potential market for rapeseed exists in these countries.

They have growing populations, limited land areas for rapeseed, and a large deficit in the supply of oils which is being met through imports, chiefly soybeans and soybean oil. They have crushing industries but generally these are burdened with overcapacity and short operating seasons due partly to difficulties in disposal of the meal.

These countries show a keen interest in importing Canadian rapeseed which, because of its high oil content and lower meal yield, is more nearly in line with their domestic demands for these products. In Peru there is also the need to substitute some vegetable oils for fish oils which are used almost exclusively in food manufacturing. Such substitution would improve the palatability of these foods.

Considered as part of the Pacific Rim, these countries would be supplied with rapeseed from Vancouver. But to tap their market potential fully, more information must be provided to them on the quality of Canadian rapeseed and rapeseed oil and on the use of rapeseed meal in livestock rations. Ecuador has discriminatory tariffs against rapeseed and their removal should be negotiated.

The expected export potential to these countries is shown in Table 13.

European Common Market

The Common Market has been exceeded only by Japan as an importer of Canadian rapeseed. However, the ECM market has been very variable; its 1970-71 imports of 22 million bushels were far higher than the average annual import of about 8 million bushels. With its enlarged membership, it has a population larger than the United States or the Soviet Union. Growing only rapeseed and some sunflowers, the Common Market represents one of the larger oil and meal deficit areas of the world (17).

Acreage in recent years has expanded due to the higher-than-market prices for rapeseed under the common agricultural policy. There is now some evidence that the physical limit in rapeseed acreage has been reached and it is becoming increasingly difficult to subsidize rapeseed acreage in the face of lower world

prices for vegetable oil crops. Competition from rapeseed surpluses in Poland and Sweden and from surplus sunflower production in the Soviet Union will have a destabilizing effect on the demand for Canadian rapeseed; however, in view of Canada's lead in the development of improved rapeseed varieties, it is expected that the ECM market for Canadian rapeseed will expand (Table 13) and that it will continue second to Japan in purchases from Canada.

North Africa

In the past, North African countries - primarily Morocco and Algeria - have imported about 500,000 bushels of Canadian rapeseed annually and in 1971-72 the volume rose to an estimated 1 million bushels. The domestic acreage of oilseed crops in these countries has been declining each year and in the future they will rely more on imports to meet their requirements. Imports of rapeseed and sunflower surpluses from Europe will tend to destabilize the demand for Canadian imports (18);

however, Canadian exports to North Africa are expected to grow (Table 13).

Export Demand for Rapeseed Oil and Meal

Canada has not been an exporter of rapeseed oil and meal and it is not possible at this time to develop country-by-country estimates of demand for these products. Instead, a gross estimate has been obtained indicating the volume of rapeseed which would have to be processed in Canada to meet the expected exports of oil and meal to foreign countries. The estimate is residual in nature, taking into account domestic and export demand and anticipated production, acreage, yield and dockage. The estimate (Table 14) indicates that 6.5 million bushels of rapeseed will be required to meet export demands for oil and meal in 1986-87 and 7.5 million bushels in 1991-92.

Some of the oil will go to countries on the Pacific Rim such as Taiwan and the Indian subcontinent, the Latin

TABLE 13. EXPECTED CANADIAN RAPESEED EXPORT DEMAND FOR CROP YEARS 1986-87 AND 1991-92

Country or group of countries	Exports 1971-72	Estimated exports 1986-87				Expected exports	
		Amount	Probability	Expected value		1986-87	1991-92
				(2) x (3)	Total		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(000,000 bu)							
<i>Pacific Rim</i>							
Japan	18.0	35.0 45.0	0.2 0.8	7.0 36.0	43.0	43.0	44.5
Latin America (a)	nil	6.0 8.0	0.2 0.8	1.2 6.4	7.6	7.6	7.8
Taiwan, Indian subcontinent (b)	nil	5.0 8.0	0.2 0.8	1.0 6.4	7.4	7.4	7.6
<i>Non-Pacific Rim</i>							
Common Market (c)	8.0	15.0 20.0	0.6 0.4	9.0 8.0	17.0	17.0	17.8
North Africa (d)	1.0	4.0 6.0	0.6 0.4	2.4 2.4	4.8	4.8	4.9
Other countries	3.0	—	—	—	—	6.2	6.4
Total	30.0	—	—	—	—	86.0	89.0

(a) Includes Mexico, Ecuador, Peru, Chile and some Central American countries.

(b) Includes also China and Korea.

(c) Based on expanded membership.

(d) Primarily Morocco and Algeria.

and Central American countries, and other developing countries in the Far East and Africa. On the other hand, some developed countries may also import rapeseed oil; Britain may become an importer as its crushing capacity is steadily being curtailed (19). The United States may also become an importer to have a greater mixture of oils in the manufacture of food products.

The Common Market and other European countries, the United States and Japan would be in a position to import Canadian rapeseed meal. Countries which are large livestock producers and meat exporters such as Argentina, Uruguay, Bolivia, Australia and New Zealand may also become importers of rapeseed meal.

Total Demand in Terms of Acreage

The total demand - domestic and foreign - for rapeseed is summarized in Table 14. A fourfold increase is indicated in domestic demand, most of it resulting from substitution of rapeseed for imported soybeans. Exports of rapeseed are expected to triple. A new element of demand is the export of oil and meal crushed in Canada; this is a residual estimate and likely to be on the low side. A larger estimate for this item would not, however, affect the total demand as it would only lower the exports of rapeseed.

Translated into land area, the total demand will require 7.5 million acres of rapeseed in 1986-87 and 1991-92 (Table 15). Total production is higher in the latter period, but this is because of the 1 bushel increase in yield per acre (to 21 from 20 bushels). Compared with

TABLE 14. TOTAL DEMAND FOR RAPESEED

	1971-72	1986-87	1991-92
	(000,000 bu)		
Domestic demand for oil and meal in terms of rapeseed crushed (Table 12)	10.0	37.7	43.7
Exports of rapeseed (Table 13)	30.0	86.0	89.0
Exports of oil and meal in terms of domestic crushing of rapeseed	—	6.5	7.5
Total domestic and export demand	40.0	132.2	140.2

TABLE 15. ESTIMATED YIELD, ACREAGE, PRODUCTION, SUPPLY AND DISPOSITION OF RAPESEED

	1971-72 ^(a)	1986-87	1991-92
Acres (000,000)	3.5	7.5	7.5
Yield (bu/ac)	18.0	20.0	21.0
Production (000,000 bu)	63.0	150.0	157.5
Starting carryover (000,000 bu)	12.6	41.6	46.8
Total supply (000,000 bu)	75.6	191.6	204.3
Disposition (000,000 bu)			
Exports (Table 14)	30.0	86.0	89.0
Crushing, domestic and for export (Table 14, lines 1 and 3)	10.0	44.2	51.2
Dockage, feed, seed	10.0	16.4	16.8
Ending carryover	25.6	45.0	47.3
	75.6	191.6	204.3

(a) Based on long-term trends rather than actual results expected in 1971-72. Starting carryover is 20% of production, but a temporary surplus carryover at year-end is assumed.

the 3.5 million acres in the base year, 1971-72, this demand more than doubles the acreage and size of the industry. As part of better supply management, the ending carryover in the latter two periods has been increased over the years to 30 from 20 percent of production (Appendix B) and the amount for dockage, feed and seed reduced from about 16 to 11 percent (Table 15).

BENEFITS FROM THE RESEARCH AND DEVELOPMENT PROGRAM

The costs of mounting a research program and supporting activities, the markets which would ensue, and the size of the industry (in terms of acreage and production) which the enlarged markets can support have already been indicated. This section describes and quantifies some of the benefits which may result.

Nature of Benefits

Benefits will arise from an increase in rapeseed acreage as a result of the expansion in domestic demand and larger export markets. This expansion in demand at home and abroad will enable farmers to put more land into a higher valued crop and to reap the economic rent therefrom. Benefits will also flow from new processing

of rapeseed into oil and meal, providing new employment and new capital investment for plant expansion. There will also be strategic benefits from the greater diversification of the agricultural crop base as a consequence of a larger rapeseed industry. Consumers will benefit from having better quality and cheaper vegetable oil for consumption and from the greater variety of food products available. The livestock industry in Western Canada will benefit from the availability of local supplies of rapeseed meal for use in livestock rations.

Of the above, the first two, the benefits to farmers of additional acreage and the benefits from additional processing are evaluated quantitatively.

Benefits per Acre of Rapeseed

Rapeseed production is best suited to the parkbelt zone of Western Canada. Its main competitors for land are wheat and barley. As there appears to be little difference in their costs of production, the gross value per acre is an indicator of relative returns. This is indicated in Table 16, which shows that the average difference in gross value per acre between rapeseed and wheat and barley in the last 9 years was \$4.38.⁸ The gross values are derived from acreage, total production and farm price figures for each crop (Appendix D).

TABLE 16. GROSS VALUE/AC OF RAPESEED COMPARED WITH WHEAT AND BARLEY, PRAIRIE PROVINCES, 1961-62 TO 1969-70

Gross value of rapeseed/ac		\$36.82
Gross value of wheat/ac	\$34.64	
Gross value of barley/ac	\$30.23	
Gross value of wheat and barley (average)		\$32.44
Net return, rapeseed over wheat and barley		\$ 4.38

Source: Appendix D.

In assessing the net return figure of \$4.38 other alternatives were considered, such as a longer time period, including oats and flax in the comparison, or weighing barley more heavily in the average as in many northern areas this crop is rapeseed's main competitor. In each case the net return in favor of rapeseed was increased. On balance it was decided to use the net

return in Table 16. There is some doubt whether the high percentage of dockage in rapeseed is fully expressed in the farm price⁹; to be on the safe side the net return figure was rounded at \$4.00.

It was realized, however, that this figure could not be maintained for the entire expansion in rapeseed acreage. As more land is put into rapeseed, it will be bid away from progressively better wheat and barley acreage and the net return to rapeseed, in the Ricardian tradition, would decline. It was assumed that the decline would be 50 cents an acre for each 500,000 acres of additional land (with the exception of the first increment), until full expansion is reached at 7.5 million acres of rapeseed. The comparable net returns are estimated in Table 17. This assumes that 'marginal' land in rapeseed will be earning \$1 an acre more than the return from the best alternative use.

TABLE 17. CHANGE IN NET RETURN WITH INCREASE IN RAPESEED ACREAGE

Increment	Net return /ac (\$)	Total acreage at end of increment (000,000)
1st — 1.0 million acres	4.00	4.5
2nd — 0.5 " "	3.50	5.0
3rd — 0.5 " "	3.00	5.5
4th — 0.5 " "	2.50	6.0
5th — 0.5 " "	2.00	6.5
6th — 0.5 " "	1.50	7.0
7th — 0.5 " "	1.00	7.5

Benefits per Bushel of Rapeseed Crushed

The benefits to the economy from increased processing can be measured as the value added (the payments to the factors of production, labor and capital) in transforming a bushel of rapeseed into oil and meal. Value added is obtained by summing the value of the oil and meal at factory prices, and subtracting from it the value of the rapeseed and the cost of other materials and supplies, fuel and electricity paid by the factory. This was done for the period 1961 to 1970 and the results are given in Table 18.

The average for the 10-year period is 0.99 of a cent per pound. Rounded up to one cent, the value added is 50

⁸The author is indebted to Huff and Stonehouse (18, pp. 10, 29) for the concept of difference in gross returns/ac as a measure of benefit.

⁹Based on discussions with members of the staff of the Agricultural Section of Statistics Canada.

TABLE 18. VALUE ADDED/POUND OF RAPESEED CRUSHED, 1961 TO 1970

Year	Value added, cents/lb of rapeseed crushed
1961	1.41
1962	0.41
1963	1.31
1964	1.14
1965	0.84
1966	1.13
1967	0.03
1968	0.63
1969	1.26
1970	1.43
Weighted average (10 years) ^(a)	0.99

(a) Weighted by quantity crushed.

Source: Appendix E.

cents per bushel of rapeseed crushed. There are some inherent weaknesses in the year-by-year figures arising from the confidential nature of some of the data, the incomplete cost figures and lack of inventory changes, and averaging is used to obtain a more reliable estimate of the crushing margin in the long run. A similar figure for soybeans gives a value added of 0.5 cents per pound or 30 cents per bushel (Appendix E, Table E-2).

The value added figure for rapeseed is applied as a benefit only in cases where it is clear that there is new processing.¹⁰ Everything else being equal, population growth will require new processing capacity and create a benefit. Also, when Canada begins to export rapeseed oil and meal, their processing will be a benefit. This value added figure is not applied in situations where there is a substitution of rapeseed against another product. These possibilities arise when the per capita consumption of vegetable oil rises while that of animal fats decreases or when rapeseed is substituted against soybean imports. There is value added from the greater processing of rapeseed, but some value added is lost from the smaller processing of the substituted commodities. The benefit is the difference between the two, but it is not possible to quantify it at this time.

Quantifying Benefit Flows

The rapeseed industry is changing over from high to low erucic acid (LEAR) varieties, a process which is expected to take 3 years to complete. While the new varieties will initially be lower in yield and in oil and protein content than the pre-LEAR varieties, it is assumed these disadvantages will be offset by the greater acceptability of the oil in the market place. While there is expected to be some growth in acreage and improvement in the agronomic qualities of the new varieties, the benefits of the research and development program are estimated to begin after the changeover is completed, in the fourth year of the period (1975-76).

¹⁰ Although new processing is considered, this assumption implies that the opportunity cost of labor and capital in the value added estimate is zero. This may be defensible in the case of labor when high unemployment is a critical factor in decision making but it is most difficult to defend the use of a zero opportunity cost for capital. Without the assumption of zero cost for capital, the benefits from additional processing as shown in Table 21 may be considered to be overstated though not to the extent to invalidate the general conclusion of the report. However, the zero cost assumption implies a more favorable (biased) ranking of this project when compared with other viable projects and particularly if compared with projects having a higher labor/capital ratio.

Increased industrial employment for labor can be met from population growth, from falling rates of unemployment and increasing rates of participation in the labor force and from sources of labor where the opportunity costs can be positive, zero or negative. The estimated increase in total employment in rapeseed processing is small, the increase being 120 employees in 15 years and 145 employees in 20 years.

It is difficult to assume a zero opportunity cost for capital as saving and investment would not be expected to occur at a zero

interest rate. Capital for rapeseed processing would need to be bid away from other productive uses; hence the benefit should only be marginal, i.e. the difference in the rate of return between an alternative use and that in rapeseed processing, and not the total return to capital as is the case under the assumption of zero opportunity cost for capital. This marginal rate might be calculated if an estimate of the total capital investment in rapeseed processing were made.

Labor's share of total value added in rapeseed processing has averaged 18 percent, indicating that this industry is a relatively capital intensive activity. This point would be of importance in comparing and making a choice between projects with different labor/capital ratios. Labor intensive and capital intensive projects may rank equally on the assumptions of zero opportunity cost for labor and capital. Dropping the assumption of zero opportunity cost for capital and recalculating the benefits would shift the ranking in favor of the labor intensive and away from the capital intensive project; in this case away from rapeseed processing.

The author is indebted to T.C. Kerr, Economics Branch, CDA, for drawing attention to the implicit assumption of zero opportunity cost in the calculation of value added.

Increase in Acreage

The benefits from increased acreage are illustrated in principle in Chart 1. Because the federal government's program to reduce wheat production (LIFT) was responsible for the unduly high rapeseed acreage in 1971, the chart starts with a long-term trend value of 3.5 million acres in the base year. The acreage rises to 4 million acres by the end of the changeover period;

benefits from increased acreage start at this point and are assumed to comprise the space MN_{SP}. The line MN shows the expansion in acreage as varietal improvements are implemented into commercial production, increasing acreage to the estimated maximum of 7.5 million acres by 1986-87.

Benefits for the entire period are estimated in Table 19 and are made in line with the principle outlined in Chart

CHART 1 – Benefits from Increase in Acreage and Acreage "Saved"

1, the reduced acreage in certain years (column 2) due to uncertainty of research as outlined in Appendix A, and the application of a declining benefit per acre (Table 17).

Increase in Domestic and Export Processing

The benefit of 50 cents per bushel from rapeseed crushing can be applied to the new processing resulting from the growth of population, and to exports of oil and meal. Their benefit flows are shown in Table 20.

As indicated in Table 7, the annual compound rate of population growth is assumed to be 1.5 percent annually, and crushing capacity in 1971-72 is estimated at 10,000,000 bushels (Table 8). When the population growth rate is applied to the base year, the result is the cumulative increase in bushels crushed (Table 20, column 1). By the end of the period the processing

capacity will have increased from 10.0 to 13.47 million bushels due to population growth alone.

Table 14 indicates that exports of oil and meal will require 6.5 and 7.5 million bushels of rapeseed to be crushed in 1986-87 and 1991-92, respectively. In column 4 of Table 20 it is assumed that exports begin after the changeover period, increase slowly at first, and then more rapidly as the oil tank capacity is increased. The total benefits are shown in column 5 of Table 20.

RELATING BENEFITS TO COSTS

This section brings together, summarizes, analyses and assesses the benefits and costs of previous sections in terms of benefits, internal rates of return and present value functions.

TABLE 19. ESTIMATE OF BENEFITS FROM INCREASED RAPESEED ACREAGE FOR YEARS 1972-73 TO 1991-92

Crop year	Year no.	Estimated area	Reduction due to uncertainty in research	Estimated area (1) - (2)	Cumulative increase above 4,000 ac	Average weighted net benefit /ac (a)	Total value of benefit (4) x (5)
		(000,000 ac)				(\$)	(\$000,000)
		(1)	(2)	(3)	(4)	(5)	(6)
1971-72	B	2.500		3.500			
1972-73	0	3.650		3.650			
1973-74	1	3.800		3.800			
1974-75	2	4.000		4.000			
1975-76	3	4.200		4.200	.200	4.00	0.80
1976-77	4	4.400	.015	4.385	.385	4.00	1.54
1977-78	5	4.650		4.650	.650	3.88	2.52
1978-79	6	4.900		4.900	.900	3.78	3.40
1979-80	7	5.150	.020	5.130	1.130	3.66	4.14
1980-81	8	5.400	.090	5.310	1.310	3.57	4.68
1981-82	9	5.700	.070	5.630	1.630	3.42	5.58
1982-83	10	6.000	.125	5.875	1.875	3.30	6.19
1983-84	11	6.300	.100	6.200	2.200	3.14	6.90
1984-85	12	6.600	.065	6.545	2.545	2.97	7.57
1985-86	13	7.000		7.000	3.000	2.75	8.25
1986-87	14	7.500		7.500	3.500	2.50	8.75
1987-88	15	7.500		7.500	3.500	2.50	8.75
1988-89	16	7.500		7.500	3.500	2.50	8.75
1989-90	17	7.500		7.500	3.500	2.50	8.75
1990-91	18	7.500		7.500	3.500	2.50	8.75
1991-92	19	7.500		7.500	3.500	2.50	8.75

(a) Obtained by applying Table 17 data to acreage increase in col. 4.

TABLE 20. ESTIMATE OF BENEFITS FROM INCREASE IN PROCESSING FOR DOMESTIC AND EXPORT DEMAND, 1972-73 TO 1991-92

Crop year	Year no.	DOMESTIC			EXPORT	
		Cumulative increase over base year of 10.0 million bu crushed	Cumulative increase from last year of changeover	Benefits @ 50 cents /bu	Cumulative increase in crushing from last year of changeover	Benefits @ 50 cents /bu
		(1) (000 bu)	(2)	(3) (\$000)	(4) (000 bu)	(5) (\$000)
1972-73	0	150.0				
1973-74	1	302.2				
1974-75	2	456.8				
1975-76	3	613.6	156.8	78.4	100	50
1976-77	4	772.8	316.0	158.0	200	100
1977-78	5	934.4	477.6	238.8	500	250
1978-79	6	1098.4	641.6	320.8	1000	500
1979-80	7	1264.9	808.1	404.1	1500	750
1980-81	8	1433.9	977.1	488.6	2250	1125
1981-82	9	1605.4	1148.6	574.3	3000	1500
1982-83	10	1779.5	1322.7	661.4	3750	1875
1983-84	11	1956.2	1499.4	749.7	4500	2250
1984-85	12	2135.5	1678.7	839.4	5500	2750
1985-86	13	2317.6	1860.8	930.4	6000	3000
1986-87	14	2502.3	2045.5	1022.8	6500	3250
1987-88	15	2689.9	2233.1	1116.6	6700	3350
1988-89	16	2880.2	2423.4	1211.7	6900	3450
1989-90	17	3073.4	2616.6	1308.3	7100	3550
1990-91	18	3269.5	2812.7	1406.4	7300	3650
1991-92	19	3468.6	3011.8	1505.9	7500	3750

Benefit-Cost Ratios

The benefits and costs in Table 21 are detailed to show their composition and relative magnitudes, and totaled to obtain the benefit-cost ratios. The ratios are given for 15- and 20-year periods and, as a test of sensitivity, for three rates of discount - 5, 10 and 15 percent.

Except for capital items, costs tend to peak early and then taper off to a constant level; conversely all benefits are small at first and reach their highest levels in the last five years of the 20-year period. This is reflected in lower benefit-cost ratios for the shorter period (Table 21), there being insufficient time to recoup the largest benefits. In the case of the 15 percent discount rate, the benefit-cost ratio is below unity, the only case among the six ratios in which benefits are insufficient to cover costs.

It is implicitly assumed that the streams of benefits and costs cease at the end of the period under consideration. In fact, if it grows as expected and becomes established as a permanent part of the agricultural economy, the rapeseed industry would 'always be with us' with benefits and costs flowing in perpetuity. It would be possible to obtain 'permanent' benefit-cost ratios if the benefits and costs remained constant at their level of the 20th year. Calculations, not presented here, indicate that such ratios would be higher than for the 20-year time span. However, the likely situation is that even with a constant acreage, the yield per acre, production and benefits will increase; costs may also change and then it becomes impossible¹¹ to obtain benefit-cost ratios without specifying a time period.

¹¹Unless the compound rate of increase in benefits or costs is less than the discount rate.

TABLE 21. SUMMARY OF BENEFITS AND COSTS, BENEFIT-COST RATIOS, AND NET BENEFITS, DISCOUNTED TO 1972-73, FOR 15- AND 20-YEAR PERIODS

	15-yr period Discount (%)			20-yr period Discount (%)		
	5	10	15	5	10	15
	(\$000,000)					
(1) Benefits						
Additional acreage (Table 19, col. 6)	37.02	23.72	15.81	56.15	32.46	19.95
Additional domestic processing (Table 20, col. 3)	3.93	2.50	1.65	6.78	3.79	2.26
Additional export processing (Table 20, col. 5)	10.19	6.20	3.91	17.93	9.73	5.58
Total benefits	51.14	32.42	21.37	80.86	45.98	27.79
(2) Costs						
Research						
(a) Western Canada (Table 4, col. 1)	13.99	10.58	8.36	16.63	11.78	8.93
Ottawa (Table 4, col. 4)	5.60	4.36	3.53	6.52	4.78	3.73
R.U.P.A. ^(a) (Table 4, col. 6)	6.82	5.22	4.16	8.03	5.76	4.42
Total research costs (Table 4, col. 7)	26.41	20.16	16.05	31.18	22.32	17.08
(b) Supporting activities						
Growth chambers (Table 6, col. 2)	.39	.37	.36	.39	.37	.36
Market promotion (Table 6, col. 3)	1.70	1.25	.96	2.14	1.45	1.06
Greater carryover (Table 6, col. 4)	2.32	1.92	1.65	2.36	1.94	1.66
Rapeseed terminal (Table 6, col. 5)	2.43	2.28	2.15	2.43	2.28	2.15
Oil storage tanks (Table 6, col. 6)	1.14	.97	.84	1.14	.97	.84
(c) Total costs (Table 6, col. 7)	34.39	26.95	22.01	39.64	29.33	23.15
(3) Net Benefits (1) – (2)	16.75	5.47	–.64	41.22	16.65	4.64
(4) Benefit-Cost Ratio (1) ÷ (2)	1.48	1.20	0.97	2.04	1.57	1.20

(a) Rapeseed Utilization Assistance Program.

Net Benefits and Internal Rate of Return

Table 22 shows the total benefits, costs and net benefits. As there are no benefits during the changeover period and benefits immediately thereafter are low, net benefits do not result until the sixth year. Thereafter benefits continue to increase while costs decline to a constant level so that the net benefits stream increases without interruption to the end of the period.

The internal rate of return is defined as the discount rate (i) at which the net benefits stream becomes zero:

$$\text{FORMULA: } \sum_{t=0}^{19} \frac{B_t - C_t}{(1 + i)^t} = 0$$

Where: t = time period in years.
i = internal rate of return

An alternative definition is that the internal rate of return is the discount rate at which the benefit-cost is equal to unity. Thus for the 15-year period the benefit-cost ratio is unity at a discount rate of 14.3 percent and at 15 percent it falls below unity (Table 21). For the 20-year period the internal rate of return is 18.5 percent (Table 22). As the net benefits stream changes from negative to positive values no more than once, there can be only a single internal rate of return for each period (20).

Present Value Functions

Given the net benefits stream and the discount rates, it is possible to derive a present value function. Such a function is continuous and positive for all discount rates ranging from zero to its internal rate of return, and

TABLE 22. TOTAL BENEFITS, COSTS AND NET BENEFITS STREAMS, AND INTERNAL RATES OF RETURN, BY LENGTH OF PERIOD

Crop year	Year no.	Total benefits (Sum of col. 6, Table 19, and col. 3 & 5, Table 20)	Total costs (Table 6)	Net benefits
		(1)	(2) (\$000,000)	(3)
1972-73	0	.0	2.38	-2.38
1973-74	1	.0	4.43	-4.43
1974-75	2	.0	3.77	-3.77
1975-76	3	.93	3.81	-2.88
1976-77	4	1.80	3.83	-2.03
1977-78	5	3.01	3.01	0.0
1978-79	6	4.22	2.99	1.23
1979-80	7	5.29	2.98	2.31
1980-81	8	6.29	2.94	3.35
1981-82	9	7.65	2.99	4.66
1982-83	10	8.73	2.77	5.96
1983-84	11	9.90	2.68	7.22
1984-85	12	11.16	2.56	8.60
1985-86	13	12.18	2.53	9.66
1986-87	14	13.02	2.52	10.50
1987-88	15	13.22	2.40	10.82
1988-89	16	13.41	2.40	11.01
1989-90	17	13.61	2.40	11.21
1990-91	18	13.81	2.40	11.41
1991-92	19	14.01	2.40	11.61
Internal rate of return (%) —			15 Years: 14.32;	20 Years: 18.53.

negative for discount rates above the internal rate. In Table 23 and Chart 2 the present value functions are calculated at discount rate intervals of 1 percent for all positive values of net benefits.

The net benefits shown in Table 21 (item 3) are the same (except for differences due to rounding) as those in Table 23 at the 5, 10 and 15 percent discount rates, because they are selected points from generalized present value functions derived from the same net benefits stream.

The advantage of relating benefit-cost ratios, net benefits, internal rates of return and net value functions is that it provides simple choice criteria for determining the viability of a project or program, and shows the

effects of choosing different discount rates. A project or program is considered viable and can be considered for acceptance if any one of the following is true:

- the discounted net benefits are positive;
- the benefit-cost ratio is greater than unity;
- the discount rate is less than the internal rate of return.

If the internal rate of return is unique, as in this case, then satisfying any one of the criteria will also satisfy the other two.

On any one of the above criteria, the research and development program is considered viable except for the 15 percent discount rate in the shorter (15-year) period.

CHART 2. Present Value Functions

TABLE 23. PRESENT VALUES OF NET BENEFITS STREAM AT VARIOUS DISCOUNT RATES, BY TIME PERIODS

Discount rate	Present value of net benefits stream	
	15-year period	20-year period
(%)	(\$000,000)	
0.0	38.00	94.06
1.0	32.58	79.91
2.0	27.83	67.85
3.0	23.65	57.56
4.0	19.98	48.77
5.0	16.75	41.22
6.0	13.90	34.75
7.0	11.39	29.18
8.0	9.17	24.37
9.0	7.21	20.22
10.0	5.48	16.63
11.0	3.94	13.52
12.0	2.59	10.82
13.0	1.38	8.48
14.0	0.31	6.43
15.0	-0.63	4.66
16.0	—	3.10
17.0	—	1.75
18.0	—	0.56
19.0	—	-0.47

LIMITATIONS AND NON-QUANTITATIVE CONSIDERATIONS

The foregoing sections presented an overview of the effects of a research and development program in the rapeseed industry. The evaluation was made on the basic premises that:

- the world and domestic markets for vegetable oil crops would grow considerably in the future;
- the research and development program will increase rapeseed's competitive position sufficiently to drive production in Western Canada to its physical limits.

Maximum Acreage

The physical limit is estimated at 7.5 million acres, double the industry's present size (after allowing for the unusually high acreage in the last 2 years due to the LIFT program). Though low from some points of view, the acreage is considered to be the maximum for

sustained production. Rapeseed requires at least a 3-year rotation and this is doubled to about 6 years if rapeseed is grown only in every other rotation sequence or if allowance is made for periodic reseeding to grasses and forage crops. As the industry grows in size, a rotation of proper sequence and length will become increasingly important, as it will be one of the mainstays in the control of serious outbreaks of diseases and insect pests and in keeping soil productivity at a high level.

A rotation of 6 years duration and a 7.5 million-acre industry could be supported by a total cultivated area of some 45 million acres. This is about the cultivated area of the black soils in the parkbelt to which rapeseed production is naturally best adapted. It cannot be expected that there will be maximum saturation¹² in all parts of this zone, as some will be better suited than others. The maximum acreage estimate envisages some expansion of cropland area in the parkbelt by bringing new land into cultivation and by some spilling-over of rapeseed acreage into the moister parts of the dark brown soils zone in the Prairies.

Further expansion in rapeseed acreage could be expected to result from research into ways - including development of new varieties - to reduce the length of the rotation. Such research is not specifically provided for in the present research program. Once the rapeseed industry has doubled in size, it may be more advantageous to channel research resources elsewhere, such as to sunflowers and mustard. This would serve to diversify Canada's oil seed base and to protect rapeseed markets by producing an alternative source of supply of vegetable oils and meals. At the same time, it would provide alternative crops to wheat on the drier parts of the Prairie Provinces.

Another alternative to the above is varietal research in high protein legumes such as peas and beans as a means of agricultural diversification.

Benefits and Costs Not Quantified

In benefit-cost analyses, costs are generally better quantified than benefits and this appears to be true in this evaluation.

¹² The highest saturation in 1970 was in crop districts 8 and 9 in Saskatchewan and 13 in Manitoba where some 20 percent of the acreage was seeded to rapeseed (22). The saturation rate with a 6-year rotation is about 16-17 percent. Other estimates of possible acreage are given in (18) p. 14.

Eight items of cost (Table 21) are estimated. The estimates could be too high or too low, but with the present state of knowledge, each appears to be equally likely so that the indicated costs are the best estimates. A source of error could be the omission of certain cost items; oil storage tanks at Thunder Bay are not included among the capital cost items. It was considered, however, that the oil tank sites included were of higher priority. If the need for a third oil tank site develops at a later time, it could be built and its cost would presumably be offset or more than offset by the increased oil exports.

Another source of error could be the omission of certain operating costs. Normally a capital cost is also accompanied by a stream of operating costs, but these are not included for the Vancouver terminal or oil storage tanks. These are expected to be recovered through normal handling charges for rapeseed which will be reflected in the farm price, in the benefit margin for rapeseed acreage over wheat and barley, and in the processing margins.

Also not included is rapeseed's share of costs to rationalize the elevator, transportation and storage systems for greater efficiency in moving grain to export positions. This is being considered for the industry as a whole and at this time it is not possible to estimate total costs and to allocate them to individual industries or to estimate the relevant benefits.

On the benefits side, three types are specified (Table 21). A number of other benefits known to exist are omitted from the evaluation as it is impossible, due to time or data limitations or conceptual difficulties, to quantify them at the present time. These are benefits which arise from:

- the substitution of rapeseed oil for animal fats in human consumption;
- the substitution of rapeseed for soybean processing;
- the greater diversification of agriculture, and the reduction in production and price uncertainty from a larger rapeseed industry;
- greater variety, better quality and cheaper foods to consumers;
- advantages to the livestock feeding industry of local supplies of high concentrate protein from rapeseed meal.

The Concept of Acreage 'Saved'

Also not quantified is the rapeseed acreage 'saved' by the research program. It cannot be assumed that rapeseed acreage would stay at the level attained by the end of the changeover period if all rapeseed research were discontinued or cut back to lower levels. The extremely keen competition among world oilseed crops requires a continual research effort and one that is strong enough to keep rapeseed competitive; otherwise the alternative is a reduction in acreage and the size of the industry to a level suggested by the line MTR in Chart 1.

The difficulty in evaluating this benefit is conceptual. What benefits are to be attributed to the rapeseed acreage which has displaced other crops in the past? At what level of research activity will existing acreage be maintained or 'saved' and at what level of research does the acreage begin to decline? It would appear to be a sizeable benefit; the inability to quantify it at this time represents a serious underestimation of the benefit side.

Contingent Benefits

An expanding rapeseed industry will provide the opportunity for innovation and the development of new products, which are not being planned for specifically in the research program and would otherwise not be developed domestically. Variety breeding and new processing techniques may be developed to the extent that they will produce rapeseed meal with sufficiently high quality protein for use in pet foods and in human nutrition. Rapeseed oil and meal may also be used in the manufacture of synthetic substitutes for dairy products and meat. Such a spin-off would have an important effect on the future allocations of land between crop and livestock production. It is contingent, however, on the undertaking of the proposed research and development program.

Distributional Effects

By far the largest benefits from the research and development program which are quantified, arise from increases in acreage (Table 21). These benefits will accrue directly to farmers who, as a group, fall into the lower income levels. As the research and development program is financed primarily by public funds, it should result in a more equitable income distribution in the economy.

Domestic Market and Promotion

The expansion to maximum acreage is based on a sizeable expansion of the domestic market as a result of

rapeseed substitution for soybean imports. This is important in its own right as it increases processing of Canadian raw materials. But it is also important in strengthening and developing foreign demand. One of the more convincing promotional activities abroad appears to be made when it is demonstrated that

rapeseed products are widely and successfully used at home, that the industry is a thriving one, and that Canadian expertise is available to provide advice on the use of rapeseed products under the conditions of the foreign country.

APPENDIX A: AN ASPECT OF RESEARCH UNCERTAINTY

The uncertainty facing researchers in getting new varieties into commercial production is indicated in the text, particularly in Tables 4 and 5 where the effect is to increase the cost of research.

That part of Table 5 pertaining to the uncertainty associated with the introduction of low erucic acid, low glucosinolate, yellow seeded, (L.E.) x (L.G.) x (Y), Polish rapeseed into commercial production, is reproduced and expanded in Table A-1.

TABLE A-1. EXPECTED DATES OF COMMERCIAL PRODUCTION OF NEW VARIETY AND ASSOCIATED UNCERTAINTY AND COSTS

Expected year of commercial production	Probability of success col. 1	Cost of research if successful 1980-81 (a)	Possible cost if research is not successful in 1980-81
(1)	(2)	(3)	(4)
(\$000)			
1980-81	0.50	1447.2	1447.2
1981-82	0.65	1447.2	1447.2 + 20
1982-83	0.80	1386.9	1386.9 + 25
1983-84	1.00	1326.6	1326.6 + 25

(a) Same as in col. 1, Table 4.

To incorporate the above probabilities into the cost stream, each year must be considered as a separate decision problem by research administrators at the end of 1980-81, 1981-82 and 1982-83. The appropriate decision trees (21) and the probabilities and costs at their branch tips are indicated in chart A-1.

The expected costs in each of the 3 years are calculated below:

$$1981-82 = (1447.2) (0.5) + (1447.2 + 20) (0.5) = 1447.2 + (0.5) (20) = 1447.2 + 10 = \$1457.2$$

$$1982-83 = (1386.9) (0.65) + (1386.9 + 25) (0.35) = 1386.9 + (0.35) (25) = 1386.9 + 8.8 = \$1395.7$$

$$1983-84 = (1326.6) (0.8) + (1326.6 + 25) (0.2) = 1326.6 + (0.2) (25) = 1326.6 + 5 = \$1331.6$$

The additional costs are therefore \$10, \$8.8 and \$5 thousand in the 3 years respectively.

Similar decision trees were developed and additional costs calculated for the six different sets of uncertainty (Table 5) in introducing new Argentine and Polish type varieties into commercial production. The results are presented in Table A-2. The total cost is also shown in Table 3, column 2 of the text. The total cost of this aspect of uncertainty is not large in relation to total research and development costs and the importance of this procedure is largely methodological at this time.

The uncertainty associated with the introduction of new varieties into commercial production can be expected to create uncertainty in farmers' rapeseed production plans, resulting in decreased acreage and benefits. Since the process by which this uncertainty is transmitted is not clear, it was impossible to incorporate it into benefits in the same way as for costs. However, to maintain consistency, a fairly mechanical procedure was used to adjust the acreage downward following those years in which there was uncertainty in the research results. This acreage reduction is shown in Table 19, column 2. As on the costs side, the adjustments are not large and do not affect the benefits appreciably.

CHART A-1. Decision Trees

TABLE A-2. TOTAL COSTS OF UNCERTAINTY FROM INTRODUCING NEW RAPESEED VARIETIES INTO COMMERCIAL PRODUCTION

Variety	Argentine type	Polish type	Total cost (a)
		(\$000)	
Low erucic acid (L.E.)			
1975-76	1.2	1.5	2.7
Low erucic acid, low glucosinolate (L.E.) x (L.G.)			
1978-79	3.6	—	3.6
1979-80	2.5	18.0	20.5
1980-81	—	16.8	16.8
1981-82	—	27.0	
Low erucic acid, low glucosinolate, yellow seeded, (L.E.) x (L.G.) x (Y)			
1981-82	—	10.0 (b)	
1982-83	5.4	8.8 (b)	14.2
1983-84	2.7	5.0 (b)	7.7

(a) Same as in Table 4, col. 2.

(b) See calculations above.

APPENDIX B: INCREASING CARRYOVER

Table B-1 provides the necessary calculations to determine the costs of providing the extra carryover which is considered necessary to provide continuity of supply for the enlarged markets. Column 1 gives the yield per acre which begins to increase after the changeover period, slightly at first, and then at the same rate as in the past, about 1 bushel every 5 years. The base year and 1986-87 and 1991-92 yields are the same as in Table 15.

In column 6, it is assumed that the carryover is increased to 22 percent in 1972-73 and by an additional 2

percentage points annually until 30 percent is reached in 1976-77. This results in sharply rising costs (column 11) as carryover is built up quickly to the more adequate 30 percent level. Some of the variation in the cost figures arises because acreage uncertainty has been incorporated into column 2 (See also Appendix A).

The figures in column 11 of Table B-1 represent only the additional costs of building up the carryover from 20 to 30 percent of production. The cost of the first 20 percent is assumed as being paid by farmers and the trade as in past.

TABLE B-1. COSTS OF INCREASING CARRYOVER TO 30 FROM 20 PERCENT OF PRODUCTION, FOR PERIOD 1972-73 TO 1991-92

Crop year	Year no.	Yields (bu/ac)	Acres (000)	(a) Production (000,000 bu)		Usual Carryover		Increased Carryover		Difference (7) - (5)	Acres required (8) ÷ (1)	Benefit (b) (\$/ac)	Total cost (c) (9) x (10)
				(1) x (2)	(3)	Amount, 20% of (3)	Amount, 22% of (3)	Amount, 30% of (3)	Amount, 32% of (3)				
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
1971-72	B	18.0	3500	63.00	12.60	—	12.60	—	—	—	—	—	—
1972-73	0	18.0	3650	65.70	13.14	0.54	14.45	1.85	1.31	72.77	4.00	291.1	
1973-74	1	18.0	3800	68.40	13.68	0.54	16.42	1.97	1.43	79.44	4.00	317.8	
1974-75	2	18.0	4000	72.00	14.40	0.72	18.72	2.30	1.58	87.78	4.00	351.1	
1975-76	3	18.1	4200	76.02	15.20	0.80	21.29	2.57	1.77	97.79	4.00	391.2	
1976-77	4	18.2	4385	79.81	15.96	0.76	23.94	2.65	1.89	103.85	4.00	415.4	
1977-78	5	18.3	4650	85.10	17.02	1.06	25.53	1.59	0.53	28.96	3.88	112.4	
1978-79	6	18.4	4900	90.16	18.03	1.01	27.05	1.52	0.51	27.72	3.78	104.5	
1979-80	7	18.6	5130	95.42	19.08	1.05	28.63	1.58	0.53	28.49	3.66	104.3	
1980-81	8	18.8	5310	99.83	19.97	0.89	29.95	1.32	0.43	22.87	3.57	81.7	
1981-82	9	19.0	5630	106.97	21.39	1.42	32.09	2.14	0.72	37.89	3.42	129.6	
1982-83	10	19.2	5875	112.80	22.56	1.17	33.84	1.75	0.58	30.20	3.30	99.7	
1983-84	11	19.4	6200	120.28	24.06	1.50	36.08	2.24	0.74	38.14	3.14	119.8	
1984-85	12	19.6	6545	128.28	25.66	1.60	38.48	2.40	0.80	40.82	2.97	121.2	
1985-86	13	19.8	7000	138.60	27.72	2.06	41.58	3.10	1.04	52.53	2.75	144.5	
1986-87	14	20.0	7500	150.00	30.00	2.28	45.00	3.42	1.14	57.00	2.50	142.5	
1987-88	15	20.2	7500	151.50	30.30	0.30	45.45	0.45	0.15	7.43	2.50	18.6	
1988-89	16	20.4	7500	153.00	30.60	0.30	45.90	0.45	0.15	7.35	2.50	18.4	
1989-90	17	20.6	7500	154.50	30.90	0.30	46.35	0.45	0.15	7.28	2.50	18.2	
1990-91	18	20.8	7500	156.00	31.20	0.30	46.80	0.43	0.15	7.21	2.50	18.0	
1991-92	19	21.0	7500	157.50	31.50	0.30	47.25	0.45	0.15	7.14	2.50	17.8	

(a) Same as in Table 19, col. 3.

(b) Same as in Table 19, col. 5.

(c) Same as in Table 6, col. 4.

APPENDIX C: IMPORT SUBSTITUTION POTENTIAL

The purpose of Table C-1 is to determine the potential of rapeseed substitution for soybean and soybean meal imports. This is done in columns 9 and 10 which is the basis of the information in Table 11 of the text.

With its high meal content, the strongest source of Canadian demand for soybeans is for crushing into meal for livestock rations. This is not enough to meet all domestic demand and soybean meal is also imported. Data in columns 1 to 5 of Table C-1 for the base year 1971-72, are averages of the data for the previous two crop years 1969-70 and 1970-71. The amounts of domestic disappearance in future years is obtained by applying the index of total demand for meat products column 6 (which is the same as the index in Table 7, column 6 to the base-year values of total domestic disappearance. Total crushings in column 3 of Table C-1 are assumed to grow at the same rate as domestic disappearance, and the crushing of domestically produced soybeans (column 1) is assumed to grow 1 percent annually to the end of 1991-92.

The rate of conversion of soybeans into soybean meal is 78.25 percent. This factor is applied to domestically produced (after allowance for carryover) and imported soybeans crushed to obtain the base year figures of soybean meal produced in columns 1, 2 and 3 of Table

C-1. The figures in columns 9 and 10 are derived from columns 7 and 8 as in the following example:

(1) meal obtained from crushing of imported soybeans in 1971-72 = 389,700 tons.

(2) equivalent of (1) in lb = 389,700 x 2,000

(3) rapeseed equivalent of (2) in lb = (389,700 x 2,000) ÷ .575. (1 lb rapeseed = .575 lb meal)

(4) rapeseed equivalent of (3) in bu = (389,700 + 2,000) ÷ (.575 x 50) = 27,100,000.

The information in Table C-2 is not used directly in the text, but is presented here because of its relation to Table C-1. The data for the base year of Table C-2 is obtained in the same way as for Table C-1. The conversion rate of soybeans into soybean oil is 17.01 percent, based on crushings in the crop years 1969-70 and 1970-71. Column 8 is derived from column 9 in the following example:

(1) oil obtained from crushing imported soybeans, 1971-72 = 158,900,000 lb

(2) rapeseed equivalent of (1) in lb = 158,900,000 ÷ (.40) (1 lb rapeseed = .40 lb oil)

(3) rapeseed equivalent of (2) in bu = (158,900,000) ÷ (.40) (50) = 7,600,000

TABLE C-1. SOURCE OF SUPPLY AND DISPOSITION OF SOYBEAN MEAL AND ESTIMATES OF IMPORT SUBSTITUTION POTENTIAL IN TERMS OF RAPESEED, FOR SELECTED YEARS

Crop year	Source of crushings			Net imports of soybean meal Domestic disap- pearance Increase in demand for meat products			Import substitution potential			
							From soybean imports (5)-(1)- (4)	From soybean meal imports same as (4)	Rapeseed equivalent	
	Soybean imports	Soybean meal imports								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(000 tons)					%	(000 tons)		(000,000 bu)	
1971-72	164.3	389.7	554.0	115.1	669.1	100.0	389.7	115.1	27.1	8.0
1986-87	188.9	656.0	884.9	175.5	1020.4	152.5	656.0	175.5	45.6	12.2
1991-92	197.2	760.1	957.3	198.9	1156.2	172.8	760.1	198.9	52.9	13.8

Source: (a) Based on 1% simple growth per annum.

(b) Based on same rate of growth as domestic disappearance.

(c) Increase: 1971-72 = 100.0; 1986-87 = 168.3; and 1991-92 = 195.0

TABLE C-2. SOURCE OF SUPPLY AND DISPOSITION OF SOYBEAN OIL, AND ESTIMATES OF IMPORT SUBSTITUTION POTENTIAL IN TERMS OF RAPESEED, FOR SELECTED YEARS

Crop year	Source of crushings			Net exports of soybean Oil	Domestic disap- pearance (3) – (4)	Increase (c) in demand for vegetable oils	Substitution potential	
	Domestic production of soybeans (a)	Imports ^(b) of soybeans	Total (1) + (2)				From soybean oil imports (5) – (1)	In terms of rapeseed equivalent
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(000,000 lb)					(%)	(000,000 lb)	(000,000 bu)
1971-72	71.4	169.5	240.9	10.6	230.3	100.0	158.9	7.6
1986-87	82.1	285.3	367.4	30.7	336.7	146.2	254.6	12.7
1991-92	85.7	330.5	416.2	43.2	373.0	162.0	287.3	14.4

Source: (a) Based on 1% simple rate of growth per annum.
(b) Based on same rate of growth as in (c) Table C-1.
(c) Same as column 5, Table 7.

The total rapeseed demand on the basis of crushings for soybean meal (Table C-1) is greater than on the basis of crushings for soybean oil (Table C-2) and includes all of the latter. The results of Table C-1 are therefore used in

the text. With fixed proportions in production between oil and meal, this results in Canada being on a net export basis in soybean oil (Table C-2, column 4).

APPENDIX D: GROSS VALUE PER ACRE

The gross values per acre for the 9-year period before the LIFT¹³ program are shown for rapeseed, wheat and barley in Table D-1. The average per acre is obtained by dividing the total farm value of production of that crop in a particular crop year by the acreage of the crop in the same year. Averages of these figures are used in the calculations of benefits per acre in Table 16 of the text.

¹³ Lower Inventory for Tomorrow; this was a federal government program to reduce wheat average and carryover in 1970-71.

TABLE D-1. GROSS VALUES/ACRE, PRAIRIE PROVINCES, RAPESEED, WHEAT AND BARLEY, 1961-62 TO 1969-70

Crop year	Rapeseed	Wheat (\$/ac)	Barley
1961-62	28.41	18.38	20.90
1962-63	32.25	34.63	29.03
1963-64	44.02	45.37	33.82
1964-65	45.90	31.64	29.97
1965-66	37.88	38.19	36.23
1966-67	41.81	48.74	42.14
1967-68	29.32	31.46	25.72
1968-69	33.73	28.98	28.88
1969-70	38.02	34.34	25.39
Average: 9 years	36.82	34.64	30.23

Source: Statistics Canada; *Quarterly Bulletin of Agricultural Statistics*, Cat. No. 21-003.

APPENDIX E: VALUE ADDED IN PROCESSING

Tables E-1 and E-2 give figures on value added in processing of rapeseed and soybeans for the 10 years 1961 to 1970. The pounds of seed crushed, the cost of the seed at the factory and the value of the meal produced were obtained from the census of manufacturing data (Cat. No. 32-223). The quantity and value of the oil were estimated from data on oil quantities and prices in the other publications quoted as sources. These estimates do not take account of the proportions of crude and refined oil produced and the higher value of the latter, or of inventory change in calculating value added. Costs of materials and supplies and fuel and electricity were pro-rated on the basis of the rapeseed and soybeans processed in relation to total processing.

The figures in Table E-1, column 7, show considerable variation from year to year. The lowest value added was in 1967 and is apparently due to reduction in prices of oil and meal from the dumping of surplus sunflower supplies on world markets by the Soviet Union and Eastern European countries. The figure for 1961 is partly estimated, as the available figures for that year do not separate the crushings of rapeseed and sunflowers.

Value added figures for soybeans (Table E-2) show the same general trends over the 10 years, but have less year-to-year variation than rapeseed.

In addition to value added, the tables are of interest in showing the proportion of total output of rapeseed and soybeans contributed by oil and meal.

TABLE E-1. ESTIMATED VALUE ADDED/POUND OF RAPESEED CRUSHED, BY YEARS 1961 TO 1970

Calendar year	Amount crushed, lb	Estimated value of output			Total cost rapeseed and other inputs (a)	Estimated value added (5) - (4)	Value added/lb crushed (2) ÷ (1)
		Oil produced	Meal shipped	Total			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(000,000)			(\$000)			(cents/lb)
1961	54.6	2,468	748	3,216	2,505	771	1.41
1962	60.5	2,335	916	3,251	3,004	247	0.41
1963	86.7	3,330	1,686	5,016	3,878	1,138	1.31
1964	87.2	3,563	1,710	5,273	4,280	993	1.14
1965	121.2	5,801	2,186	7,987	6,963	1,024	0.84
1966	189.6	8,676	3,522	12,198	10,057	2,141	1.13
1967	218.5	8,745	4,979	13,724	13,659	65	0.03
1968	256.9	8,781	4,433	13,214	11,590	1,624	0.63
1969	343.7	12,469	6,212	18,681	14,335	4,346	1.26
1970	384.4	18,213	7,033	25,246	19,662	5,584	1.43

Source: Statistics Canada: *Vegetable Oil Mills*, Cat. No. 32-223; *Oilseeds Review*, Cat. No. 22-005 and *Oils and Fats*, Cat. No. 32-006,

(a) Excluding cost of labor and capital.

TABLE E-2. ESTIMATED VALUE ADDED/POUND OF SOYBEANS CRUSHED, BY YEARS 1961 TO 1970

Calendar year	Amount crushed, lb	Estimated value of output			Total cost soybeans and other inputs ^(a)	Estimated value added (5) – (4)	Value added/lb crushed (6) ÷ (1)
		Oil produced	Meal shipped	Total			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(000,000)				(\$000)		(cents/lb)
1961	956.5	24,815	26,075	50,890	42,710	8,180	0.86
1962	996.6	20,879	30,916	51,795	47,185	4,610	0.46
1963	1,099.7	22,039	38,293	60,332	57,446	2,886	0.26
1964	1,146.7	24,241	42,003	66,244	59,346	6,898	0.60
1965	1,190.6	28,313	43,227	71,540	65,521	6,019	0.50
1966	1,234.4	29,616	45,812	75,428	71,645	3,783	0.31
1967	1,201.6	24,944	46,810	71,754	69,733	2,021	0.17
1968	1,178.3	19,760	44,862	64,622	62,888	1,734	0.14
1969	1,248.5	22,434	45,438	67,872	64,089	3,783	0.30
1970	1,403.6	34,586	51,743	86,330	73,866	12,464	0.89

Source: Statistics Canada: *Vegetable Oil Mills*, Cat. No. 32-223; *Oilseeds Review*, Cat. No. 22-005 and *Oils and Fats*, Cat. No. 32-006.

(a) Excluding cost of labor and capital.

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METRIC EQUIVALENTS

LENGTH

inch	= 2.54 cm	millimetre	= 0.039 in.
foot	= 0.3048 m	centimetre	= 0.394 in.
yard	= 0.914 m	decimetre	= 3.937 in.
mile	= 1.609 km	metre	= 3.28 ft
		kilometre	= 0.621 mile

AREA

square inch	= 6.452 cm ²	cm ²	= 0.155 sq in.
square foot	= 0.093 m ²	m ²	= 1.196 sq yd
square yard	= 0.836 m ²	km ²	= 0.386 sq mile
square mile	= 2.59 km ²	ha	= 2.471 ac
acre	= 0.405 ha		

VOLUME (DRY)

cubic inch	= 16.387 cm ³	cm ³	= 0.061 cu in.
cubic foot	= 0.028 m ³	m ³	= 31.338 cu ft
cubic yard	= 0.765 m ³	hectolitre	= 2.8 bu
bushel	= 36.368 litres	m ³	= 1.308 cu yd
board foot	= 0.0024 m ³		

VOLUME (LIQUID)

fluid ounce (Imp)	= 28.412 ml	litre	= 35.2 fluid oz
pint	= 0.568 litre	hectolitre	= 26.418 gal
gallon	= 4.546 litres		

WEIGHT

ounce	= 28.349 g	gram	= 0.035 oz avdp
pound	= 453.592 g	kilogram	= 2.205 lb avdp
hundredweight (Imp)	= 45.359 kg	tonne	= 1.102 short ton
ton	= 0.907 tonne		

PROPORTION

1 gal/acre	= 11.232 litres/ha	1 litre/ha	= 14.24 fluid oz/acre
1 lb/acre	= 1.120 kg/ha	1 kg/ha	= 14.5 oz avdp/acre
1 lb/sq in.	= 0.0702 kg/cm ²	1 kg/cm ²	= 14.227 lb/sq in.
1 bu/acre	= 0.898 hl/ha	1 hl/ha	= 1.112 bu/acre

INFORMATION
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IF UNDELIVERED, RETURN TO SENDER EN CAS DE NON-LIVRAISON, RETOURNER À L'EXPÉDITEUR