A Model of Dryland Cereal and Oilseed Production[1]

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1. *Introduction*

Farmers are being deluged with new technologies of many kinds. Some are new versions of familiar items and are relatively simple to evaluate and adopt, (eg. new varieties of cereals and oilseeds), while others are less familiar and, if adopted, may require substantial alteration of production systems or management practices. Computer technology applied to management decision-making is in the latter category for most farmers.

Computers have many actual and potential applications in primary agriculture. For example, machines are now on the market that use small computers for monitoring and controlling various aspects of machine performance. Computers are used to varying degrees in financial control, record-keeping, cost accounting and farm planning.

This paper describes a computer model of dryland prairie grain farms. It can be used; 1) as a farm planning tool by farmers or extension personnel, 2) for economics research concerned with assessment of alternative technologies, and 3) for economic evaluation of the farm level effects of policy and program changes. The description outlines the technologies included in the model, the input needed to operate the model, and the output produced. Several applications pertinent to topics on the agenda of this workshop are reviewed.

2. *The prairie crops model*

2.1 *Model overview*

Developmental work on the prairie crops model began as a graduate student project (Zentner, 1975) at the University of Saskatchewan. Developmental work and applications are continuing as part of the economics research program at the Agriculture Canada Research Station, Lethbridge, Alberta. One of the principal objectives is to fit together into a systematic package the various pieces of technology and economics that are available from plant breeders, engineers, agronomists, soil scientists, market analysts and others. This provides a tool useful in economic evaluation of technologies under study at Research Stations (Zentner et al., 1978).

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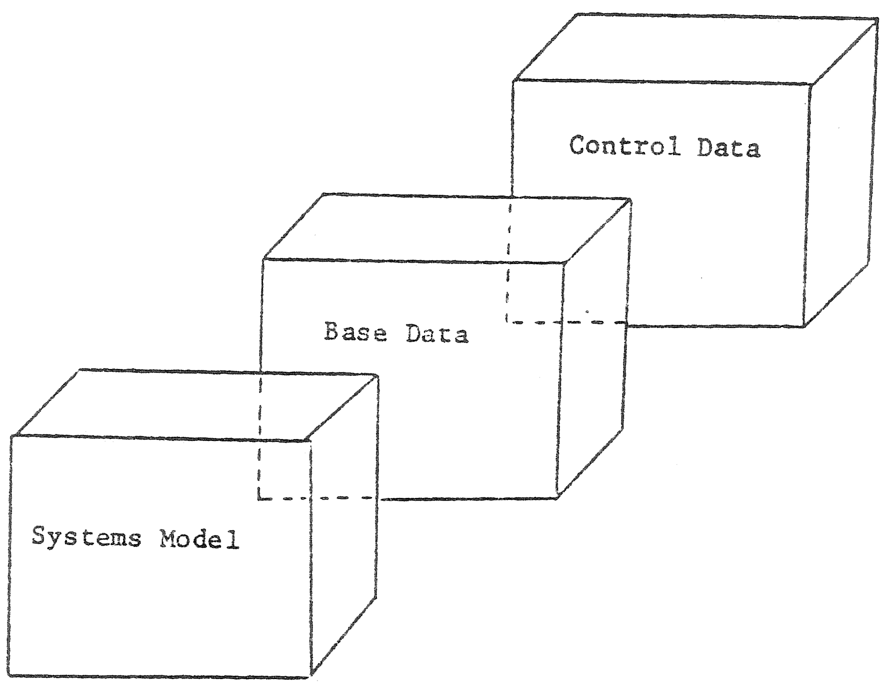
The prairie crops model is a computer model of a grain farm. The farm is viewed as a system composed of biological and economic subsystems that react and interact.[3] *The farm is assumed to be controlled or directed through time to achieve a predominantly economic objective, eg. profit maximization. The model contains mathematical representations of important biological and economic variables involved in the evaluation of new dryland farming technology. It provides a mechanism for testing new production opportunities.*

To get some understanding of the content and operating procedure for the prairie crops model consider it in three parts - a systems model, a base data block and a farm data block (Figure 1).

Figure 1 Schematic Diagram of the Crops Simulator



[3]A 'system' is a complex of factors or elements that are interrelated and integrated in such a way that a change in one component can affect some or all of the other components.

The systems model is a computer program of the basic biological and economic processes that are common to most prairie grain farms. The production alternatives in the model encompass the major opportunities available for dryland farming in the prairie region.[4] *Producing spring wheat on fallow with a particular combination of machines and other inputs is an example of a production alternative.*

The base data block contains input-output coefficients, input and product prices and other technical data for average farms in a region. The sources of these data include Research Station experiments, provincial soil test labs, provincial extension services, Statistics Canada, machine companies and farm input suppliers. Many of these coefficients are treated as examples or suggested values and are used in the subsequent calculations unless replaced by farm-specific data from the farm data block. (This demonstrates one of the roles played by the computer, i.e. data storage.)

The farm data block contains data specific to an individual farm. A device called an 'input form' is used to describe the farm situation to the computer. When the farm-specific data from the input form are merged with the base data, the model becomes unique to a particular farm. The model has sufficient flexibility to enable good representation of farms that differ widely in terms of size, location, soil type, management practices (eg. rotations), machine inventories and other features.

A completed input form contains the following:

1. *Inventories*
   - i. *Machines by size, type and age*
   - ii. *Land area by tenure*
   - iii. *Storage facilities by size, type and age*
   - iv. *Grain and oilseed quantities in storage*
   - v. *Permanent and seasonal labor supplies*

2. *Production alternatives and management practices - crops grown, rotations used, machine combinations for specific tasks, incidence and extent of herbicide applications, machine replacement policy and input purchase policies.*

3. *Prices and technical coefficients - expected product and input prices, application rates for inputs, and performance rates for specific tasks.*

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[4] *A production alternative is defined as a specific method of producing an end product (eg. wheat) or some clearly defined intermediate product.*

4. *Financial situation - debt position and cash balance.*

5. *Personal financial considerations - living expenses, tax exemptions, and off-farm investment and income.*

6. *Other items - soil type, expected delivery quotas, rate of farm growth and model operating instructions.*

How does the model transform the data from the base data file and the input form into information for management decisions? This is a three-stage process. In the first stage two major activities are performed; 1) the base data and farm data are merged to create a model of a particular farm, and 2) the production plans[5] to be explored or evaluated in subsequent stages are selected. In the second stage, a production plan is transformed into a set of time-dependent jobs or tasks - pre-seed tillage, seeding, herbicide incorporation, spraying, swathing, combining, summerfallow tillage, etc. The size, time period and machines needed for each job are determined in this stage (Figure 2).

Figure 2 Example - Partial Job Matrix

	Jobs							
Period	PR	C & H	H	PD	SP	SW	SPC	AV
9	467							
10		1120	747	467				467
11		747	560	373				373
12		233	93	93	747			93
13		233						
14		233						
15		233						
16		467						
17		233						
18		233				373		
19		233				560	467	
20		233					373	
21		700					93	
22		700						

[5]*A production plan specifies the rotation, crop combination, machine operations, tillage sequences, machine and input purchase policies, and related items to be considered for the simulated farm.*

In the third stage, the model proceeds through a budgeting process. Resource requirements for each job are calculated and checked against resource supplies. (The calendar year is divided into 26 two-week periods to accommodate the time-dependent nature of crop production activities.) Where resource deficiencies exist, additional resources are obtained through purchase or rental. Expenses, receipts, resource use, product output, etc. are recorded.

Stages two and three are repeated for each year in the planning period (one to ten years). The user may elect to evaluate or budget a number of production plans to determine what is called a 'best' plan, i.e. the production plan with the highest value of the objective function (eg. net worth, net farm income). Each production plan is evaluated under identical conditions - resource base, prices, managerial expertise, and weather parameters. Furthermore, the user can test the range of outcomes from a production plan if prices, weather parameters, or both, are altered from their average values.

The output from the model is a set of tables that contain:

1. *Year-end inventory of land, machines, buildings and stored grain with an estimate of the value of each item (Figures 3 and 4).*

2. *Resource and product flows for each year that show the quantities of specific inputs used and products produced by two-week periods (Figure 5).*

3. *Receipt and expense flows for each year that show cash flows for various categories of inputs and products (Figure 6).*

4. *Summary statements for the entire planning period that describe the cropping program, the financial picture, various performance measures and other aspects of the simulated farm (Figures 7, 8 and 9).*

Figure 3 Example - Beginning Inventory

TABLE I BEGINNING INVENTORY,1980.

	YEAR NEW	CAPACITY (AMOUNT)	REMAINING VALUE
CULT 32 FT	1979.		7121.
HARROW 40 FT	1974.		1129.
DISCER 16 FT	1972.		2364.
DRILL-PR 21	1978.		8408.
SPRAYER 50	1975.		805.
SP SWTH 18	1974.		5697.
SP SWTH 18	1970.		3495.
COMB PTO 45	1979.		16191.
COMB SP 50	1969.		13477.
TRUCK 1/2 T	1977.		4593.
TRUCK 1/2 T	1975.		3838.
TRUCK 2TON	1953.		1374.
TRUCK 2TON	1974.		8968.
AUGER 30	1960.		55.
AUGER 39	1970.		260.
AUGER 39	1964.		125.
AUGER 60	1976.		810.
TRA 90 HP	1974.		13346.
TRA 110 HP	1975.		18492.
TRA 165 HP	1975.		25975.
GR STOR 1000	1983.	8000.	1560.
GR STOR 1500	1985.	1500.	388.
GR STOR 1500	1985.	1500.	368.
GR STOR 2000	1990.	2000.	965.
GR STOR 2000	1990.	2000.	965.
GR STOR 2000	1990.	2000.	965.
GR STOR 2000	1990.	2000.	965.
GR STOR 3000	1990.	3000.	1358.
GR STOR 3000	1990.	3000.	1358.
GR STOR 3000	1990.	3000.	1358.
MACH ST 1600	1985.		2436.
OWNED LAND		1400.	560000.

Figure 4 Example - Ending Inventory

TABLE II ENDING INVENTORY,1980.

	YEAR NEW	CAPACITY (AMOUNT)	REMAINING VALUE
CULT 32 FT	1979.		6302.
HARROW 40 FT	1974.		999.
DISCER 16 FT	1972.		2092.
DRILL-PR 21	1978.		7441.
SPRAYER 50	1975.		712.
SP SWTH 18	1974.		5042.
SP SWTH 18	1970.		3093.
COMB PTO 45	1979.		14329.
COMB SP 50	1969.		11927.
TRUCK 1/2 T	1977.		4226.
TRUCK 1/2 T	1975.		3577.
TRUCK 2TON	1953.		1264.
TRUCK 3TON	1974.		8251.
AUGER 30	1960.		49.
AUGER 39	1970.		230.
AUGER 39	1964.		110.
AUGER 60	1976.		717.
TRA 90 HP	1974.		12279.
TRA 110 HP	1975.		17013.
TRA 165 HP	1975.		23897.
GR STOR 1000	1983.	8000.	1040.
GR STOR 1500	1985.	3000.	520.
GR STOR 2000	1990.	8000.	3474.
GR STOR 3000	1990.	9000.	3665.
MACH ST 1600	1985.		1950.
OWNED LAND		1400.	560000.
TRAILER 9TON	1977.		520.
RAPESEED		2571.	15628.
SPRING WHEAT		10953.	43811.
BARLEY		5168.	12919.
5 YR DEBT	1980.	509.	509.
CASH ON HAND		-14367.	-14367.

NOTE-FOR BUILDINGS YEAR NEW-MEANS REPLACEMENT YEAR

Figure 5 Example - Resource Flow

TABLE III RESOURCE FLOW PER BI-WEEKLY PERIOD, 1980.

PERIOD	LABOUR		WINTER WHEAT		RAPESEED		FLA
	PERM	HIRED	INVENT	SOLD	INVENT	SOLD	INVENT
	----HRS-----						
1. JAN 1							
2. JAN 15							
3. JAN 29							
4. FEB 12							
5. FEB 26							
6. MAR 12							
7. MAR 26	17.						
8. APR 9	17.						
9. APR 23	23.						
10. MAY 7	174.	52.					
11. MAY 21	158.						
12. JUNE 4	79.						
13. JUNE 18	23.						
14. JULY 2	43.						
15. JULY 16	43.						
16. JULY 30	32.						
17. AUG 13	16.						
18. AUG 27	64.						
19. SEPT 10	156.	227.			1714.		
20. SEPT 24	151.	146.			2571.	857.	
21. OCT 8	98.				3428.		
22. OCT 22	48.				3428.		
23. NOV 5					3428.		
24. NOV 19					3428.		
25. DEC 3	35.				2571.	857.	
26. DEC 17					2571.		
TOTAL	1179.	425.				1714.	

NOTE--HOME GROWN SEED USED-DEDUCTED FROM INVENT

Figure 6 Example - Cash Flow

TABLE IV RECEIPT AND EXPENSE FLOW,1980.

	PERIOD	CROP RECEIPTS $	CROP EXPENSES $	MISC.RES EXPENSES $	CASH BALANCE $
1.	JAN 1				
2.	JAN 15				
3.	JAN 29				
4.	FEB 12				
5.	FEB 26				
6.	MAR 12				
7.	MAR 26		2170.		-2170.
8.	APR 9		1743.		-3913.
9.	APR 23		26523.		-30436.
10.	MAY 7		5165.	-207.	-35808.
11.	MAY 21		475.		-36283.
12.	JUNE 4		2454.		-38737.
13.	JUNE 18		2354.	-94.	-41185.
14.	JULY 2		681.	-31.	-41897.
15.	JULY 16		378.	-844.	-43119.
16.	JULY 30		169.	-156.	-43444.
17.	AUG 13		84.	-31.	-43559.
18.	AUG 27		212.	-63.	-43833.
19.	SEPT 10		2586.	-1094.	-47513.
20.	SEPT 24	24150.	2679.	-617.	-26659.
21.	OCT 8		403.	-906.	-27968.
22.	OCT 22		253.	-156.	-28377.
23.	NOV 5		2170.	-31.	-30579.
24.	NOV 19			-63.	-30641.
25.	DEC 3	24119.	143.	-313.	-6978.
26.	DEC 17			-604.	-14367.
	TOTAL	48270.	50642.	-5210.	

NOTE-MISC.REC.AND EXP.INCLUDES MACHINE SALES,WAGES,
DOWN PAYMENTS,LOAN PAYMENTS,INCOME TAX,CONSUMPTION

Figure 7 Example - Output Summary

K FARMS

OUTPUT SUMMARY

PRAIRIE AGRICULTURAL FARM SIMULATORS- CROP ENTERPRISE

FARM PLAN SUMMARY

	1980.	1981.	1982.
ACRES OF CROPLAND	1400.	1400.	1400.
ACRES OF WINT WHEAT			
ACRES OF RAPE	187.	187.	187.
ACRES OF FLAX			
ACRES OF WHEAT	560.	560.	560.
ACRES OF BARLEY	187.	187.	187.
ACRES OF OATS			
ACR WINT WHEAT SOWN			
CROP LABOR-FARM.	1179.	1254.	1254.
CROP LABOR-HIRED	425.	488.	488.

FINANCIAL SUMMARY-YEAR END

TOTAL ASSETS	752810.	793002.	832017.
TOTAL DEBT	509.	1893.	1570.
TOTAL EQUITY	752301.	791109.	830446.
DEBT PAYMENT		139.	541.
CHANGE IN NETWORTH	43023.	38807.	39338.
PCT. RET. ON EQUITY	6.07	5.16	4.97
NET FARM INCOME	49808.	58102.	50847.

GRAIN-PRODUCTION, SALES AND CARRYOVER

WIN WHT PRODUCED BU			
WIN WHT SOLD -QUOTA			
WIN WHT SOLD-OFF BD			
WIN WHT CARRYOVER			
RAPE PRODUCED BUS	4285.	4285.	4285.
RAPE SOLD QUOTA	1714.	4285.	4285.
RAPE CARRYOVER	2571.	2571.	2571.
FLAX PRODUCED BUS			
FLAX SOLD -QUOTA			
FLAX CARRYOVER			
WHEAT PRODUCED BUS	18255.	18255.	18255.
WHEAT SOLD - QUOTA	7302.	17555.	17555.
WHEAT SOLD-OFFBOARD			
WHEAT CARRYOVER	10953.	10953.	10953.
BARLEY PRODUCED BUS	8613.	8613.	8613.
BARLEY SOLD -QUOTA	3445.	8333.	8333.
BARLEY SOLD-OFF BRD			
BARLEY CARRYOVER	5168.	5168.	5168.
OATS PRODUCED BUS			
OATS SOLD -QUOTA			
OATS SOLD-OFF BOARD			
OATS CARRYOVER			

Figure 8 Example - Receipts and Expense Summary

RECEIPTS AND EXPENSE SUMMARY

	1980.	1981.	1982.
OPERATING RECEIPTS			
CROP RECEIPTS	48270.	116762.	99226.
FINAL GRAIN PAYMENT			9522.
CROP INSURANCE PAYT			
WGSA PAYMENT			
OTHER RECEIPTS		345.	6556.
TOTAL RECEIPTS	48270.	117107.	115304.
OPERATING EXPENSES			
CROP EXPENSES	50642.	43719.	44300.
WAGES AND SALARIES	1699.	1951.	1951.
TOTAL EXPENSES	52341.	45670.	46251.
INPUT EXPENSES			
SEED	6589.	4989.	4989.
FERTILIZER	11099.	11099.	11099.
CHEMICALS	7054.	7054.	7054.
FUEL AND OIL	4586.	4139.	4139.
MACHINE REPAIR	7998.	6623.	7204.
BUILDING REPAIR	587.	587.	587.
CROP INSURANCE PREM	4213.	4213.	4213.
WGSA CONTRIBUTIONS	500.	500.	500.
CHANGE IN INVESTMENT			
GRAIN VALUE CHANGE	72358.		
BLDG.VALUE CHANGE	-1956.	-1956.	-1956.
MACH.VALUE CHANGE	-12503.	-21781.	-9476.
NET INVEST. CHANGE	57899.	-23736.	-11432.
DEBT SITUATION			
NEW LOANS	509.	1465.	
DEBT PAYMENTS		139.	541.
CHANGE IN DEBT	509.	1384.	-323.
INTEREST PAYMENT	3510.	715.	218.
PERSONAL EXPENSES			
FAMILY LIVING			
INCOME TAX	20480.	17959.	18276.
CROP PROGRAM			
ROTATION--2/3 CROP-1/3 FALLOW			
GRAIN PRICE INDEX	1.00	1.00	1.00
NO. OF SMF OPS.	6.	6.	6.
MACH. PURCHASE AGE	3.	3.	3.
MACH SELLING POLICY	0.87	0.87	0.87

Figure 9 Example - Crop Production Detail

CROP PRODUCTION DETAIL

	1980.	1981.	1982.
ACR WINT WHT FALLOW			
AVERAGE YIELD			
N-FERTILIZER			
P-FERTILIZER			
ACR WINT WHT STUBLE			
AVERAGE YIELD			
N-FERTILIZER			
P-FERTILIZER			
ACR RAPE ON FALLOW	187.	187.	187.
AVERAGE YIELD	23.0	23.0	23.0
N-FERTILIZER			
P-FERTILIZER			
ACR RAPE ON STUBBLE			
AVERAGE YIELD			
N-FERTILIZER			
P-FERTILIZER			
ACR FLAX ON FALLOW			
AVERAGE YIELD			
N-FERTILIZER			
P-FERTILIZER			
ACR FLAX ON STUBBLE			
AVERAGE YIELD			
N-FERTILIZER			
P-FERTILIZER			
ACR WHEAT-FALLOW	280.	280.	280.
AVERAGE YIELD	36.1	36.1	36.1
N-FERTILIZER			
P-FERTILIZER			
ACR WHEAT-STUBELE	280.	280.	280.
AVERAGE YIELD	29.1	29.1	29.1
N-FERTILIZER			
P-FERTILIZER			
ACR BARLEY-FALLOW			
AVERAGE YIELD			
N-FERTILIZER			
P-FERTILIZER			
ACR BARLEY-STUBBLE	187.	187.	187.
AVERAGE YIELD	46.1	46.1	46.1
N-FERTILIZER			
P-FERTILIZER			
ACR OATS-FALLOW			
AVERAGE YIELD			
N-FERTILIZER			
P-FERTILIZER			
ACR OATS-STUBBLE			
AVERAGE YIELD			
N-FERTILIZER			
P-FERTILIZER			

THE MODEL WAS RUN AS A BUDGET ONLY-NO CONSIDERATION OF GROWTH

2.2 Dryland crop production technologies

A large number of dryland crop production technologies are included in the model (Figure 10). Technologies deemed relevant to the particular farm situation under consideration are selected by the user via the input form.

The model contains seven crop rotation alternatives - four traditional (1/2, 2/3, 3/4 and continuous crop) and three moisture-reserve IF rotations. The latter three are available only in the Brown soil zone version of the model. In these rotations, the decision to seed stubble land, depends on soil moisture status in the spring. If soil moisture is deemed adequate, some or all of the stubble is seeded, if not the fallow area is increased.

The cropland area is separated into three distinct classes - fallow, fallow crop and stubble crop. The model maintains the identity of each class in order to simulate the production characteristics of the land over time.

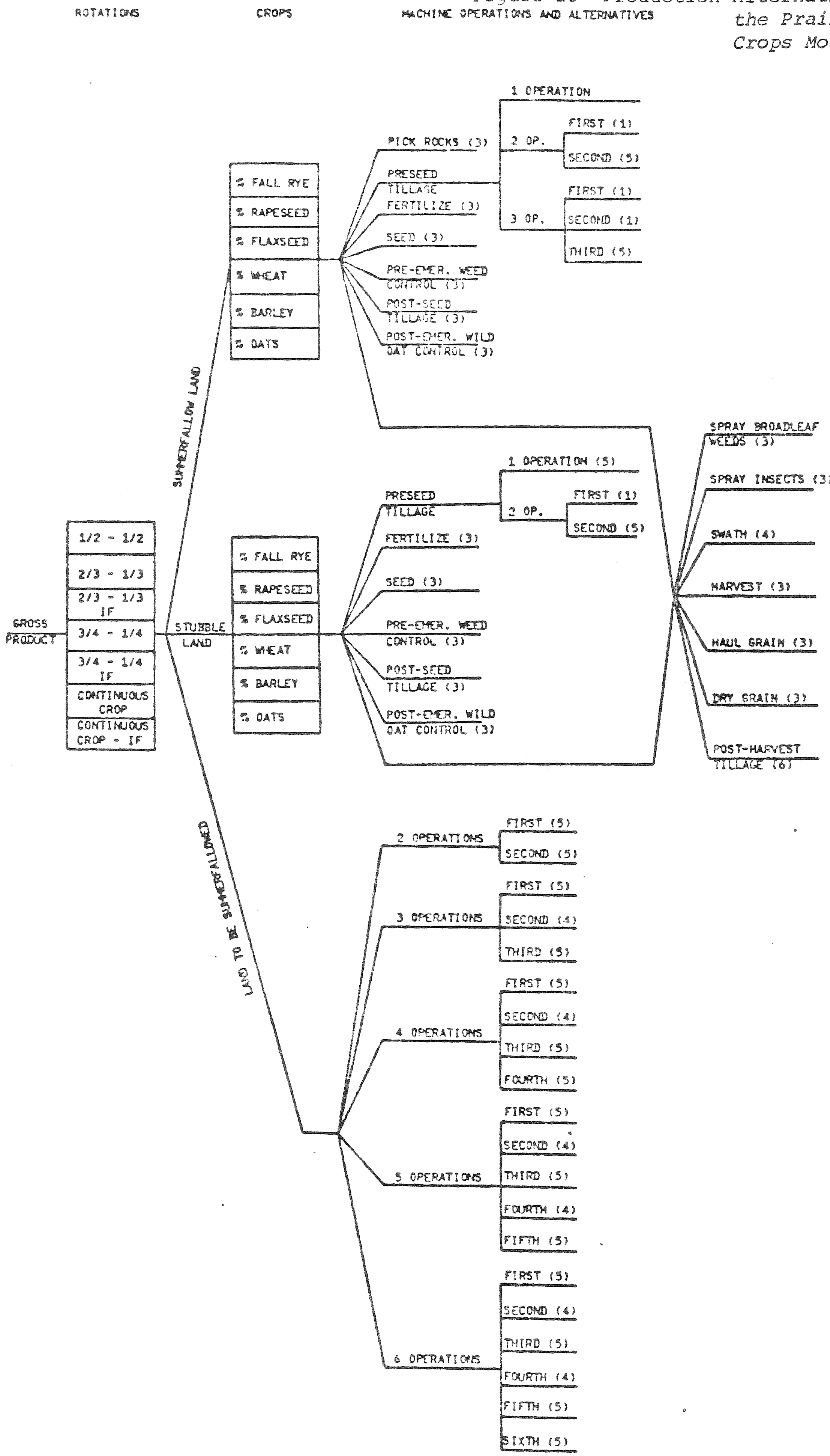
The model can accommodate any combination of six different crops - spring wheat, barley, oats, rapeseed, flax and fall rye (winter wheat). The model user can specify the crop combination completely or explore many combinations within constraints he establishes.

Yield relationships have been developed for all crops on fallow and stubble. Crop yields are related to soil texture, spring soil moisture, residual and applied N and P and amount and distribution of growing season rainfall. Yields are also affected by seeding date, seeding method, weed control practices and harvesting method.

Production plans are divided into a number of distinct operations that occur over the crop production cycle - pre-seeding tillage, seeding, fertilization, post-seeding tillage, swathing, combining and post-harvest tillage. Several methods are available in the model for performing each of these operations. For example, seeding can be done with a double disc press drill, hoe drill or discer. Combining can be done with an SP or PTO combine or custom hired. The first operation on fallow can be any of five alternatives - cultivator and harrow, discer and harrow, cultivator, discer or sprayer.

An important feature of the crops model is its flexibility. Other crops can be substituted for those now in the model. New production technologies and management practices can be added to the present set as they become available. Modification of physical and financial coefficients prompted by research findings, changing economic conditions and other events is a fairly simple operation. All of these revisions are, of course, contingent on availability of adequate data.

Figure 10 Production Alternatives in the Prairie Crops Model



2.3 Model applications - examples

Three recent research applications of the prairie crops model related to topics on your agenda are reviewed.

2.3.1 Altering fertilizer application rates on the basis of spring soil moisture status - Zentner and Read (1977) used the crops model to calculate optimal nitrogen and phosphorus application rates for wheat in the Brown soil zone for a range of fertilizer and wheat prices and soil moisture situations. The results showed that adjustments in fertilizer rates that accounted for available soil moisture in the spring were generally advantageous, especially under conditions of high soil moisture. This suggests that agencies responsible for making fertilizer recommendations should examine the feasibility of including this factor in their recommendations.

2.3.2 Zero tillage in wheat-fallow rotations - Zentner and Lindwall (1978) assessed the economic feasibility of using herbicides to replace mechanical tillage operations in two and three year wheat-fallow rotations in southern Alberta. The biological and physical data indicated improved crop yields and erosion resistance with zero tillage. Potential savings in labor, operating costs and overhead costs were demonstrated. Break-even prices for herbicides were calculated to show where net revenues were equated from conventional and zero tillage methods. The authors concluded that due to the high cost of effective herbicides"further investigation of agronomic and economic aspects of zero tillage under various crops, rotations, soil types, herbicide programs, with and without the application of commercial fertilizers, is required before recommendations for widespread adoption of zero tillage should be made. Available results suggest that zero tillage has the greatest potential in a recropping system where herbicide requirements are low and yield advantages are substantial."

2.3.3 Dryland cropping programs in the prairie provinces - Zentner et al. (1979).

The optimal cropping program on individual farms depends on several criteria including expected net income, seasonality of resource requirements, and variability in income (risk). Individual farmers attach differing weights to these and other criteria when making decisions on cropping programs. Zentner et al. (1979) showed substantial differences among rotations, crop combinations, and soil zones in expected net incomes, seasonal resource use, and income variability. The results showed that cropping programs now in general use by prairie farmers can be rationalized on economic grounds.

The widespread use of the crop-fallow rotation in the Brown soil zone is consistent with the results of this study. Expected net incomes were generally highest, resource use (especially labor) was uniformly distributed over the growing season, and income variability was lowest with this rotation. Crop combinations with cereals usually produced more stable incomes than those with oilseeds. Crop combinations that included winter wheat generally had the highest expected net incomes.

In the Dark Brown soil zone, trade offs among the three criteria can explain widely differing rotations and crop combinations among farms. Differences in expected net incomes among rotations and crop combinations were generally smaller than in the Brown soil zone. Income variability was lowest and labor requirements were fairly evenly distributed with the crop-fallow rotation. On farms where these criteria are heavily weighted, rotations with high proportions of fallow are likely to be selected.

In the Black soil zone, trade offs similar to those in the Dark Brown soil zone were apparent in the results. Expected net incomes and income variability were highest with continuous cropping. With this rotation, spring and fall labor accounted for a large proportion of the total labor requirement. Income variability was considerably lower, seasonal labor demands were more uniform, and expected net income was lower with the other rotations. Rotations that include some fallow could be optimal in the Black soil zone when expected grain prices are low and for farmers who are highly averse to risk or high seasonal labor requirements.

3. Future applications of the prairie crops model

3.1 Research applications

The model was developed as part of the bio-economics research program in the western region of the Research Branch of Agriculture Canada. It is used there in economic evaluation of dryland cropping technologies such as those reviewed above. Topics that will receive attention in subsequent applications include further study of minimum tillage, dryland salinity control and reclamation, and crop production systems in the Parkbelt area. These relate to priority areas in the Research Branch regional program.

3.2 *Extension applications*

Computer models for farm planning purposes can be viewed as new technologies in the same vein as new varieties or machines. One means of evaluating the applicability of new technology is to observe its use elsewhere. The Top Farmer Program at Purdue University in Indiana has been operating since 1968. Thousands of farmers in the cornbelt have used models to budget the outcomes from decisions on crop mix, tillage systems, machine size, etc.

Farmers are usually introduced to the model in a three-day workshop. They learn how to describe their present situation to the computer, i.e., each farmer develops a model of his farm. Farmers then explore the effects of alterations to their present plan. In other words, they test before they invest their time and other resources. Fees are $100 for on-campus sessions that include paid guest experts and $30 for district sessions with less frills. Subsequent computer runs can be made for $10 each on a mail-in basis.

Technical sessions on various aspects of production and marketing are conducted throughout the workshop by various specialists. Thus, the workshops are used as a vehicle to deliver extension information to farmers.

4. *Concluding comments*

1. *Bio-economics research at Research Stations in western Canada has developed models that incorporate many of the important biological, physical and economic factors pertinent to management of prairie farms. The usefulness of the models in research has been amply demonstrated. These applications will continue. Results of applications pertinent to the interests of this group could be presented at subsequent sessions of this workshop.*

2. *Models like the prairie crops model have potential for farm planning purposes through direct use by farmers. However, further input is needed from farm service agencies (private or public) to develop an appropriate delivery system to make these models accessible for individual farmer use. The models themselves and the mechanism used to deliver them, eg. workshops, can facilitate technology transfer to farmers.*

3. *Computer technology is available to facilitate farmer access to planning models. The relative cost of this technology is decreasing which suggests greater utilization of it in the future. Cooperative work involving research scientists, economists, extension personnel and potential clients is needed to adapt computer technology for efficient use in farm management.*

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