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INTENSIVE CULTURE OF WHEAT IN CANADA

1985 - 1988

PROVINCIAL 3 YEAR SUMMARIES

AND

FINAL REPORT

A Research Program Financed by the

New Crop Development Fund
Agriculture Canada

and

BASF Canada Inc.
Ciba-Geigy Canada Ltd.
Cooperative Federee de Quebec
Esso Chemical Canada
Hoechst Canada Inc.
Phosphate and Potash Institute of Canada
Rohm and Haas Canada Inc.
Union Carbide Agricultural Products
Uniroyal Chemical

INTENSIVE CULTURE OF WHEAT IN CANADA

FINAL REPORT

April 1, 1985 to March 31, 1989

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INTENSIVE CULTURE OF WHEAT IN CANADA

PROJECT OBJECTIVES

To determine the agronomic and economic potential of production systems incorporating intensive culture techniques for wheat production in the main wheat producing regions of Canada.

To more fully assess the potential for profitable intensive management in the various regions of the country, a package of agronomic practices will be developed and field tested by cooperating scientists and producers during the period of April 1, 1985 to October 31, 1988.

Specifically, the project will:

1. Evaluate the potential of intensive culture of triple-M (semi-dwarf) and winter wheats.

2. Evaluate the management x cultivar interactions.

3. Determine optimum crop density including row spacing and seeding rates.

4. Evaluate fertility management, specifically nitrogen rates, and method and timing of applications.

5. Evaluate plant growth regulators (PGR) for their effect on yield enhancement in both lodging and non-lodging crop conditions.

6. Evaluate the need for and effectiveness of pest control agents such as fungicides and insecticides.

7. Monitor environmental conditions in order to assess the impact of the various moisture and temperature regimes found both within and between regions on the effectiveness of intensive cereal management.

INTENSIVE MANAGEMENT OF WHEAT
CANADA GRAINS COUNCIL
3 YEAR SUMMARY 1985-87

PROJECT BACKGROUND

The Canada Grains Council was founded in 1969. Its basic function is to provide a forum for discussion for all segments of the grain industry. It acts as a liaison with government and works towards increasing markets for Canadian grains at home and abroad. Coordination of research and dissemination of information form an integral part of its program. ICM became a topic of concern for the Council back in 1982. During late 1984 and early 1985, an intensive wheat management project was initiated, with the objective of determining the agronomic and economic potential of production systems incorporating intensive culture techniques for wheat production in the main wheat producing regions of Canada. The research program was financed by the New Crop Development Fund, Agriculture Canada as well as by:

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Active research programs have been completed in Alberta, Manitoba and Quebec and a liaison was established with other projects in Saskatchewan, Ontario and Nova Scotia. The project involved examination of factors in the following areas:

a) crop establishment
b) cultivar performance
c) nitrogen rates and timings
d) fungicide applications
e) plant growth regulator effects

INTRODUCTION

Intensive Crop Management (ICM) is a term which is most often associated with high input cropping practices employed by European farmers. Yield reports from Europe of 150 bushels/acre to extraordinary yields of 200 bushels/acre of wheat have prompted farmers and scientists in North America to take a long hard look at our current production practices. ICM is not the simple procedure of transferring European production practices to Manitoba or elsewhere. The ICM practices which are used in Europe differ widely between regions within a single country, as they should in Canada. ICM practices which are used on European farms are used because over the long run they tend to maximize net profits. European ICM practices were developed under the same limitations which face Canadian farmers. These limitations include environmental, genetic and economic restrictions. The levels of the limitations are certainly different, nevertheless all areas have the same types of limitations, otherwise Europeans would be producing 300 bushels/acre instead of "only" 150 bushels/acre. The differences in limitations exemplify the need to tailor ICM practices to a particular location or region. ICM is trying to avoid two situations. One is the under-utilization of our resources and the other is excessive use, or wasting of our resources. Either of these extremes can guarantee eventual financial failure, depending on the harshness of the economic environment. The objective of ICM is to maximize long term financial viability within the constraints of environment, present technology and economics.

The next question is "How does ICM differ from current practices?" Undoubtedly there may well be farmers in Canada which are already practicing ICM and achieving the maximum net profit within the constraints of environment, technology and economics. In these cases new opportunity for further income expansion will be dependent on development of new technology. In the situation where a farmer is not producing at a level to generate the maximum long term profits, there is a challenge and in this time of economic restraints, an immediate need for individual farmers, extension personnel and research scientists to discover the combinations and levels of inputs which take full advantage of our environment and economic situations, allowing farmers to produce crops which yield the maximum net profit.

ILLUSTRATING THE NEED FOR IMPROVED WHEAT MANAGEMENT

To illustrate the need for improved management, a survey of wheat production specialists was conducted across Canada. Figure 1 illustrates the potential for improved management practices to influence yields.

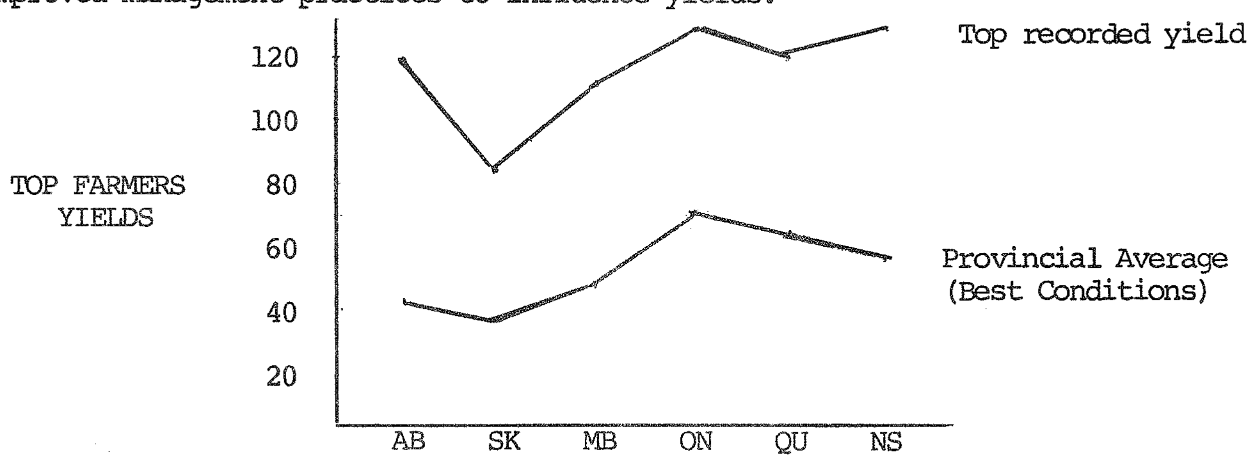

FIGURE 1. PROVINCIAL RESPONDENTS

While the survey is only based on the perceptions of 9 wheat specialists and the yields quoted may only represent small areas within each province, there is a definite trend in the relationship of one line to another. Assuming that the top yield of wheat for the survey equals 100% (112 bu/acre), the provincial average for the highest yielding year in the period from 1978-1985 was only 38% (43 bu/acre) of the highest yields recorded. The yields of the top producers under favourable conditions were considerably above the average for the province. Under favourable conditions top producers had yields of 75 bu/acre; however this still only represents 67% of the highest yields recorded. While the numbers represented from this survey are at best rough, they do show large differences in yields between the various categories, differences which are largely dependent on management factors.

TACKLING ICM

The Intensive Culture of Wheat Project was developed to assist Canadian wheat producers in evaluating the value of incorporating some of the European ICM production practices which have been publicized as being highly responsible for the rapid increase in yields in Europe over the last 10-15 years. The production factors examined included:

a) improved crop establishment
b) use of high rates of N and split N applications
c) use of foliar fungicides
d) plant growth regulators
e) use of high yielding cultivars and cultivar specific management.

RESPONSE OF CANADIAN WHEAT CROPS TO INTENSIVE MANAGEMENT

Table 1 and 2 illustrate the responsiveness of spring and winter wheats to the target management factors measured in the trials conducted from 1985-1987 in Manitoba and Alberta and in trials conducted from 1986-1988 in Quebec.

Generally positive yield responses were found with all the parameters tested at all locations; however there was considerable difference in response between years and differences in consistency of response to certain parameters. The responses shown in Table 1 and 2 were the most positive responses recorded from the trials, thus may not indicate a need for these factors on a continual basis. The response of wheat yields to the target management factors was highly influenced by the conditions of the trial. Factors such as base soil fertility, soil type, weather patterns, wheat cultivar, disease pressure, lodging pressure, seedbed conditions, etc. all helped to determine the responsiveness of wheat to the target management factors.

TABLE 1. SPRING WHEAT RESPONSIVENESS TO MANAGEMENT FACTORS

FACTOR	ALBERTA			MANITOBA			QUEBEC		
	85	86	87	85	86	87	86	87	88
Increased seed rate	–	*	*	*	NT	*	*	*	*
Decreased row spacing	–	NT	NT	*	NT	**	NT	NT	NT
Increased nitrogen rate	–	*	*	*	*	*	–	–	–
Split N application	–	–	–	*	–	*	–	–	NT
Foliar fungicide	–	*	*	**	**	**	**	*	*
Lodging	N	N	Y	Y	N	N	Y	N	N
Lodging control-PGR	NT	NT	*	*	NT	NT	*	NT	NT
Yield effect-PGR	*	–	*	*	–	*	*	–	–
Yield benefit from higher inputs	*	X	*	*	*	*	*	*	*
Top yield achieved t/ha	7.5	6.7	5.2	7.4	6.1	4.7	8.4	4.8	3.5
bu/acre	112	100	77	110	90	70	125	71	52

LEGEND
* – Positive yield response
** – Highly significant positive yield response
– – No effect on yield
X – Negative yield response
NT – Not tested
N – No
Y – Yes

TABLE 2. WINTER WHEAT RESPONSIVENESS TO MANAGEMENT FACTORS

FACTOR	ALBERTA			MANITOBA			QUEBEC		
	85	86	87	85	86	87	86	87	88
Increased seed rate	NT	X	–	–	–	–	NT	*	*
Decreased row spacing	NT	NT	NT	NT	–	–	NT	NT	NT
Increased nitrogen rate	NT	X	–	–	X	*	–	*	*
Split N application	NT	NT	–	*	X	–	–	–	*
Foliar fungicide	*	–	–	*	*	*	**	*	*
Lodging	N	N	Y	Y	N	N	–	NT	NT
Lodging control-PGR	NT	NT	Y	Y	NT	NT	–	NT	NT
Yield effect-PGR	–	–	*	*	*	–	*	–	*
Yield benefit from higher inputs	*	–	–	*	*	X	*	*	*
Top yield achieved t/ha	3.5	2.3	5.7	6.7	4.7	4.7	4.9	5.8	6.5
bu/acre	52	34	85	100	70	70	73	86	97

LEGEND: * – Positive yield response
** – Highly significant positive yield response
– – No effect on yield
X – Negative yield response
NT – Not tested
N – No
Y – Yes

Since it is already known that weather and management affect wheat yield, what additional information has been derived from the Intensive Wheat Management Project?

WHAT HAVE WE LEARNED?

As with most advances in technology or knowledge, not everything is straightforward; the findings of this project are no different. A danger exists in the presentation of these findings in that they may be subject to misinterpretation. It is not difficult to imagine the findings of this research capsulized by the news media, in the following manner:

ICM STANDS FOR IT COSTS MONEY!

The objective of the ICM project has been to reduce the costs of unit of production, thereby increasing net profit. There are, however, examples of situations in our trials where more than the optimum levels of inputs were added, or an unnecessary input was added, causing net profits to be decreased (Table 3).

TABLE 3. WHEAT YIELDS AND RETURNS, MINTO 1985

WHEAT/MANAGEMENT LEVEL		YIELD BU/ACRE	NET PROFIT $/ACRE
HY320	Low input	92	120
	High input	105	87
Katepwa	Low input	65	75
	High input	74	35
Norstar	Low input	61	69
	High input	100	134

In these 1985 trials, the use of plant growth regulators on spring wheat minimized the yield enhancing effect of the high input system as well as increasing cost. Net profits were reduced. The high input systems worked well for winter wheat in 1985.

Unfortunately, not every input available to Canadian farmers will result in a net return under all climatic conditions, or even for all varieties grown under the same climatic conditions. Farmers will have to increase their knowledge of input x cultivar x environmental interactions to be able to obtain the best pay back from using the wide variety of crop inputs available today.

PURCHASING POWER OF WHEAT DROPS TO 40 YEAR LOW

For an alarmingly high number of farmers in Canada, the record low prices have resulted in financial disaster. If grain prices are lower than the cost of production even when the crop is grown using intensive management principles and the lowest cost/bushel possible is being achieved, the net result will still be a lot of red ink at the end of the year (Table 4).

TABLE 4. NET RETURNS FOR MARSHALL, MANITOBA 1985-87

YEAR	MANAGEMENT LEVEL LOW	HIGH
	(NET RETURNS/ACRE)	
1985	102	67
1986	22	37
1987	-14	-11

Price: 1985 $3.18/bu
1986 $2.09/bu
1987 $1.66/bu

Source: Ag-Quest Inc.

100 + BUSHEL/ACRE DRYLAND YIELDS - IN CANADA?

In all the locations conducting intensive management wheat trials, there have been record yields achieved. Surprisingly, the high yielding spring cultivars outyielded the winter wheat cultivars, a reverse of the trend in Europe. The highest yields obtained in the three years of study were from Quebec in 1986 with Max spring wheat with a yield of 125 bu/acre. Favourable growing conditions combined with high inputs produced spring wheat yields of 110 and 112 bu/acre in 1985 in Manitoba and Alberta respectively (Table 5).

TABLE 5. MAXIMUM WHEAT YIELDS RECORDED (DRYLAND) BU/ACRE, 1985-88

LOCATION	SPRING WHEAT	WINTER WHEAT
Edmonton, Alberta	114	85
Minto, Manitoba	110	100
Ste. Hyacinthe, Quebec	125	86

FARMERS ACROSS CANADA INCREASE YIELDS - IMPROVED MANAGEMENT IS KEY

During the last three years it has been shown that higher levels of input than are normally used with conventional practices have resulted in increased yields. Table 6 gives an example of improved yields in the Alberta trials.

TABLE 6. LARGE SCALE TRIAL, SPRUCE GROVE, ALBERTA 1985

CULTIVAR	YIELD (BU/ACRE) LOW INPUT	HIGH INPUT*
Neepawa	68	87
HY320	78	114
Oslo	80	97

*High input includes extra Nitrogen, Phosphorous, Fungicide & Plant Growth Regulator

Similar experience has been found with trials in Manitoba and Quebec (Tables 7 and 8).

TABLE 7. PERFORMANCE OF SPRING WHEAT CULTIVARS UNDER 2 MANAGEMENT LEVELS MANITOBA, 1987 (DRY YEAR)

CULTIVAR	YIELD (BU/ACRE) LOW INPUT	HIGH INPUT*
HY320	46	62
Owens	51	71
Katepwa	42	52

*High Input - Fungicide and 60 kg/ha of extra N

TABLE 8. YIELD RESULTS OF FARM SCALE TRIALS MAX SPRING WHEAT, QUEBEC, 1986

FARM	YIELD (BU/ACRE) CONVENTIONAL	HIGH INPUT*
Hoka	77	81
Gross	86	107
Herbert	47	73

*High input - Fungicide and plant growth regulator

Over the course of the three years, improved yields have resulted with all of the inputs tested. Higher yields have frequently been obtained by the addition of foliar fungicides, increased use of nitrogen, use of plant growth regulators, as well as decreasing row spacings. Increasing seed rates have also contributed to higher yields. However, frequent use of fungicide and narrow row spacings are also prerequisites to achieving a yield response to increased seeding rates. The successful use of these various components is dependent on very discriminate use. Weather patterns and cultivar selection have a large impact on the choice of inputs and the net returns which can be achieved.

Further evidence of the response of wheat cultivars to higher inputs is shown in Table 9. In 19 of 22 station years*, yields were higher with the higher input levels, averaging 28% higher than yields with conventional management.

TABLE 9. RESPONSE OF WHEAT CULTIVARS TO INTENSIVE MANAGEMENT
BEST CASE SCENARIO

LOCATION	YEAR	VARIETY	TYPE	CONVENTIONAL	HIGH INPUT	% INCREASE
ALBERTA	1985	Neepawa	HRS	4591	5589	+21
		HY320	CPS	5272	7500	+42
	1986	Norstar	HRW	2535	3495	+38
		Neepawa	HRS	4741	3728	-21
		Oslo	HRS	5116	4407	-13
	1987	Neepawa	HRS	4340	5503	+27
		Oslo	CPS	3768	5073	+35
MANITOBA	1985	Katepwa	HRS	4352	5005	+15
		HY320	HRS	6169	7074	+15
		Norstar	HRW	4125	6751	+64
	1986	Katepwa	HRS	3243	4172	+26
		HY320	CPS	3149	5186	+58
		Norstar	HRW	2196	4614	+110
	1987	Katepwa	HRS	2836	3504	+24
		HY320	CPS	3075	4169	+36
		Norstar	HRW	3890	3125	-17
QUEBEC	1986	Max	HRS	5767	7209	+25
		Monopol	HRW	3810	4660	+22
	1987	Max	HRS	3476	4016	+15
		Monopol	HRW	3806	5048	+33
	1988	Max	HRS	2897	2422	+20
		Monopol	HRW	3990	3275	+22

CANADIAN CULTIVAR GIVES RARE COMBINATION HIGH YIELD & HIGH PROTEIN

Paying attention to detail and providing for more optimum conditions for growth has not only resulted in increases in yield but also in increased protein content. Table 10 illustrates the average yields and protein response of Katepwa and HY320 wheats to improved management in trials in Mantioba.

TABLE 10. EFFECT OF EXTRA NITROGEN AND A FOLIAR FUNGICIDE ON PROTEIN & YIELD
OF SPRING WHEAT, 1985-87, MINTO, MANITOBA

TYPE OF WHEAT	CONVENTIONAL		CONVENTIONAL WITH EXTRA N & FUNGICIDE	
	% PROTEIN	BU/ACRE	% PROTEIN	BU/ACRE
Katepwa(HRS)	12.8	51	14.4	62
HY320(CPS/Feed)	11.3	61	11.9	81

* Station year is the total number of trials of one type of experiment plus the number of years it is carried out.

FARM PROFITS IMPROVE
INTENSIVE MANAGEMENT PROVES WORTH

The extra yield and protein gains made with intensive management have provided a positive payback. Table 11 illustrates potential impact of using additional inputs to increase net profits from wheat production in Manitoba. Similar gains in profitability have also been found in trials in both Alberta and Quebec.

TABLE 11. MARGINAL COST & RETURNS FOR APPLYING EXTRA N & FUNGICIDE ON KATEPWA & HY320 SPRING WHEAT, MINTO 1985-87

CULTIVAR	PRICE* $/BU	YIELD DIFF.** BU/ACRE	ADDED REVENUE $/ACRE	ADDED COST $/ACRE	NET $/ACRE
KATEPWA	5.50	11	60.50	31	29.50
HY320	4.10	20	82.00	31	51.00

*Yield difference represents a 21% and 33% yield advantage over conventional mgmt. for Katepwa and HY320 respectively.
**Added costs - fungicide at $16/acre and extra N at $15/acre

SUMMARY FINDINGS OF INTENSIVE WHEAT MANAGEMENT PROJECT

In summary, the Canada Grains Council's national intensive wheat management project has made a number of accomplishments. These are listed as follows:

1. The project has shown there is potential to increase grain yields, grain quality and net profits by using higher levels of inputs.

2. The project has and will continue to increase the awareness of farm managements for the need to utilize a more intensive management system to ensure unit production costs are kept to a minimum and profits are maximized. Bulletins are being prepared to inform farmers of the practical information derived form the project.

3. The project has also shown that not all the extra inputs available to farmers are warranted in any one year and that indiscriminate use of inputs can result in decreased profits. The constituents of an intensive management program are site specific and are not a single standard management package for all conditions.

4. The project has drawn attention to the need to develop better benchmarks to indicate when extra inputs will result in improved net profits. The development of a Risk Management Guide is currently being undertaken by the Canada Grains Council to further assist Canadian farmers in developing internationally competitive, environmentally friendly sustainable wheat production technologies.

PART 1

MANITOBA

INTENSIVE MANAGEMENT OF WHEAT
CANADA GRAINS COUNCIL
MANITOBA - 3 YEAR SUMMARY 1985-87

PROJECT BACKGROUND

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INTRODUCTION

Intensive Crop Management (ICM) is a term which is most often associated with high input cropping practices employed by European farmers. Yield reports from Europe of 150 bushels/acre to extraordinary yields of 200 bushels/acre of wheat have prompted farmers and scientists in North America to take a long hard look at our current production practices. ICM is not the simple procedure of transferring European production practices to Manitoba or elsewhere. The ICM practices which are used in Europe differ widely between regions within a single country, as they should in Canada. ICM practices which are used on European farms are used because over the long run they tend to maximize net profits. European ICM practices were developed under the same limitations which face Canadian farmers. These limitations include environmental, genetic and economic restrictions. The levels of the limitations are certainly different, nevertheless all areas have the same types of limitations, otherwise Europeans would be producing 300 bushels/acre instead of "only" 150 bushels/acre. The differences in limitations exemplify the need to tailor ICM practices to a particular location or region. ICM is trying to avoid two situations. One is the under-utilization of our resources and the other is excessive use, or wasting of our resources. Either of these extremes can guarantee eventual financial failure, depending on the harshness of the economic environment. The objective of ICM is to maximize long term financial viability within the constraints of environment, present technology and economics.

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While farmers in all areas of Canada will be able to benefit from an ICM program, areas which have the fewest environmental restraints will face the greatest challenge and potential benefit from ICM.

Throughout the three years of the Manitoba section of the Canada Grains Council project, weather has played an important role (See Appendix for more information). This has had a strong impact on the objectives of the study, as many of the inputs are dependent on weather conditions either for their effect or the necessity of using them. In summary, 1985 was generally cool and had adequate moisture, resulting in record spring wheat yields, in 1986 seeding was delayed by a wet spring and coupled with severe disease pressure, especially from leaf and stem rust resulted in lower yields especially on winter wheat. In 1987 a drought in spring reduced yields of both spring wheat and winter wheat. However in nearly every case, significant advantages were obtained from the addition of extra input and more intensive management.

A summary of results over the three year period will be discussed under the topics of

1. Cultivar x Management
2. Disease Protection
3. Crop Establishment
4. Nitrogen Fertility and
5. Lodging.

CULTIVARS

The selection of the appropriate wheat cultivar for use in an ICM program is extremely important. Cultivars differ in their response to more intensive management, as well as to the environmental conditions during the growing season. Differences in price between the different grades of wheat is also an important criterion for selecting cultivars as there is generally an inverse relationship between yield potential and price. Generally as the price spread between high and low quality wheat decreases the higher yielding lower quality cultivars become more profitable.

MANITOBA 3 YEAR SUMMARY - WINTER WHEAT

All winter wheat cultivars grown in Manitoba must be seeded into standing stubble and seeded before mid September to avoid winterkill and ensure a vigorous stand in spring. Tall cultivars such as Norstar or Sundance have consistently given higher yields than semidwarf cultivars such as Norwin under intensive management while yield differences between tall and short cultivars are small under more conventional management. The variable response to management is exhibited in Table M1 where under lower input levels, there was a difference of only 550 kg/ha between the highest yielding cultivar, Norstar and the lowest yielding, Absolvent, and virtually no difference between Norstar and Norwin under low input management.

TABLE M1. WINTER WHEAT AVERAGE YIELDS IN CULTIVAR X MANAGEMENT TRIALS MINTO 1985-87

CULTIVAR	YIELD (KG/HA)		
	HIGH INPUT	CONVENTIONAL INPUT	HIGH/LOW %
Norstar	4860	3404	142
Norwin	3916	3462	113
Absolvent	3658	2966	123
All cultivars	3969	3076	129

Increased input levels resulted in a 42% yield increase in Norstar to a maximum of 4.8 MT/ha. Norwin responded with only a 13% increase to a yield of 3.9 MT/ha. Absolvent responded with a 23% increase to a yield of 3.7 MT/ha.

Table M2 illustrates the effects of management on yield of Norstar for the individual years of 1985-87. In the initial year the philosophy was to apply as many inputs as possible to maximize yield, the inputs were reduced in 1986 and 1987 as separate analysis of some inputs showed they were of limited economic value. The extra inputs are listed as a footnote to Table M2. The most favourable growing conditions and yields were found in 1985 with a record winter wheat yield of 6.7 MT/ha. The extra inputs provided large yield advantages of 2626 and 2418 kg/ha in 1985 and 1986 respectively, however dry spring weather and summer heat stress caused the extra input in 1987 to reduce yields by 675 kg/ha. Each additional input added to Norstar seemed to be detrimental, completely opposite to results in earlier years.

TABLE M2. EFFECT OF MANAGEMENT ON YIELD OF NORSTAR WINTER WHEAT MINTO 1985-87

MANAGEMENT*	YIELD (KG/HA) 1985	1986	1987	$\bar{X}$
High input	6751	4614	3218	4860
Conventional input	4125	2176	3890	3404
Difference	2626	2418	-675	1456
% of conventional	164	210	83	143

*Extra Inputs over conventional	Costs
1985 - CCC* at 1.15 at G.S.31	37.50
- Tilt at G.S.31, 51 + 81	120.00
- 20/40/40 kg N/ha (G.S.21,31 + 49)	55.00
Total	212.50
1986 - Extra 200 seeds/m2	15.00
- Tilt G.S.49 + 75	80.00
- CCC at 1.15 at G.S.31	37.50
- 20/40/40 kg N/ha (G.S.21,31 + 49)	55.00
Total	187.50
1987 - 40 kg N/ha at G.S.31	22.00
- Tilt at G.S.55	40.00
Total	62.00

*CCC is Cycocel Extra.

Economic analysis of the effects of management on Norstar are given in Table M3. At wheat prices of $150/MT, the added profit attributed to the application of extra inputs averaged $64/ha but ranged from $181/ha to -$163/ha. The results stress the importance of having better guidelines to predict early in the growing season which inputs have a strong likelihood of providing a positive return.

TABLE M3. EFFECT OF MANAGEMENT ON COSTS & RETURNS OF NORSTAR WINTER WHEAT, MINTO 1985-87

	COSTS & RETURNS ($/HA) 1985	1986	1987
Yield difference (kg/ha)	2626	2418	-675
Revenue $/ha	394	363	-101
Costs $/ha	213	188	62
Extra profit $/ha	181	175	-163
Breakeven price $/MT	81	78	NA

ASSUME: Winter wheat at $150/MT
N at .55/kg
Seed at $7.50/100 seeds/m2
Tilt at $40/ha for 12.5 kg ai/ha
CCC at $15/l x 2.5 l/ha = $37.50/ha

DISEASE PROTECTION

Large advances in increasing European cereal yields over the last 15 years have been at least partly attributed to the ability to control foliar diseases. Trials were established to examine the effectiveness and need for foliar fungicides on various types of wheat grown in Manitoba.

WINTER WHEAT

Norstar winter wheat is susceptible to tanspot and septoria, as well as both leaf rust and stem rust. For these reasons, fungicides resulted in yield increases from 323-1305 kg/ha (Table M4). Early applications, that is, before G.S.39 are generally less effective than later applications, resulting in yield increases only 75% of the time when Tilt was applied. There was no increase with 1 application of Dithane applied at G.S.37, due to the limited 7-10 day protection it affords with each application. Table M4 results show that fungicides can increase yield of Norstar on a consistent basis. One application of Tilt usually gave control equivalent to 2 applications of Mancozeb. An average yield increase due to fungicide application is about 500 kg/ha. At wheat prices of $150/MT and Tilt at $40/ha or Mancozeb(2 applications) at $25/ha, the economics of a fungicide application can be favourable. The net return using an average yield response of 500 kg/ha would be between 35-50 $/ha.

TABLE M4. FUNGICIDE EFFICACY ON NORSTAR, 1983-1986

FUNGICIDE	RATE & ZGS	# OF TRMTS	FREQUENCY OF YIELD INCREASE	YIELD INCREASE KG/HA	FREQUENCY OF YIELD DECREASE %	YIELD DECREASE KG/HA
TILT	.125 @ 31	4	75	444	25	410
	39	3	100	323	0	---
	45	15	93	565	7	343
	51	4	100	484	0	---
TILT	.125 @ 31+51	4	100	585	0	---
	51+75	1	100	1305	0	---
MANCOZEB	1.8 @ 37	1	0	---	100	40
	1.8 50	5	100	383	0	---
	1.8@50+7days	16	81	679	19	114

Table M5 illustrates the results when a fungicide is used in less than ideal conditions.

TABLE M5. EFFECT OF FUNGICIDE ON HEAT & DROUGHT STRESSED NORSTAR MINTO 1987

FUNGICIDE TREATMENT	YIELD KG/HA	HEADS/M2	TKW *	KERNELS/ HEAD
Check	4035	532	32.6	24
Mancozeb (2appl)	3900	531	32.2	23
Tilt	3228	503	31.3	20
2 Tilt	2958	447	29.1	20

*Total Kernel Weight.

More typical results are shown in Table M6. In 1985 control of tanspot and septoria as well as some leaf rust resulted in yield increases of up to 875 kg/ha. In 1986, yield increases of up to 1345 kg/ha were noted, primarily as a result of controlling a severe infection of stem rust.

TABLE M6. DISEASE PROTECTION IN NORSTAR WINTER WHEAT MINTO 1985-86

TREATMENT	YIELD (KG/HA)	
	1985	1986
Untreated check	3833	3094
Mancozeb (2 applications)	-----	4170
Tilt	4573	3766
Tilt (2 applications)	4708	4439
L.S.D.	323	242

CROP ESTABLISHMENT

SEEDING RATES - ARE THEY HIGH ENOUGH?
ROW SPACINGS - ARE THEY NARROW ENOUGH?

European farmers especially those in the high yielding areas have over time developed planting recommendations which give them the optimum yield in a high input ICM type of farm practice. The European practice is generally characterized by using high seeding rates and narrow row spacing. Trials were conducted from 1985-87 examining the effect of seed rate and row spacing on disease interaction and yield performance of both winter and spring wheat.

WINTER WHEAT

Changes in seeding rate and row spacing have not had a dramatic effect on the yield of Norstar winter wheat over the 3 years of study. The 18 cm row spacing has shown a slight yield advantage compared to the 9 cm spacing regardless of the fungicide treatment used. Of the two seeding rates tested, the lower rate was favoured when fungicides were applied, whereas higher seeding rates were favoured when foliar diseases were not controlled with fungicides (Table M7).

TABLE M7. ROW SPACING X SEED RATE X FUNGICIDE ON NORSTAR WINTER WHEAT MINTO, 1985-87

		YIELD (KG/HA)			
ROW SP.(CM)	RATE(SEEDS/M2)	CHECK	DITHANE	TILT	2 TILT
9	300	3497	4176	3632	3968
	500	3699	3968	3497	3699
18	300	3699	4170	3900	4170
	500	3766	4035	3766	3968
$\overline{X}$ (9cm)		3564	4035	3564	3833
X (18 cm)		3699	4102	3833	4102

The lack of strong response to seed rate and row spacing is due to Norstar's ability to compensate by tillering to suit environmental conditions.

Norwin, a semi-dwarf, seems to react in a different fashion, perhaps due to a lower ability to compensate by tilling. Results of a seeding rate trial in 1987 show that Norwin yielded up to 400 kg/ha more at a seeding rate of 400 seeds/m2 than at 300 or 500 seeds/m2 and 470 kg/ha more than at 200 seeds/m2 (Table M8). This trial was seeded on 18 cm row spacing. Seed rates of 300-400 seeds/m2 at row spacings of 18 cm have consistently given the highest yields of winter wheat.

TABLE M8. EFFECT OF SEED RATE ON YIELD OF WINTER WHEAT MINTO 1987

SEED RATE (SEEDS/M2)	NORWIN YIELD (KG/HA)	NORSTAR YIELD (KG/HA)
200	3699	--
300	3766	3564
400	4170	--
500	3497	3497

NITROGEN FERTILITY

Split application of N are used on cereal crops in Europe to avoid high leaching losses and ensure nitrogen is available throughout the life of the crop. Nitrogen in European conditions may be applied 4-5 times throughout the season. Splitting the N application can help prevent lodging by controlling the early growth phase, provide optimum N nutrient throughout the season to ensure high yield and later applications can help to ensure high grain protein. Split nitrogen application can also allow farmers to fit the total nitrogen supplied to the crop to the growing conditions within a particular season. A range of split application timings and rates were examined on both winter wheat and spring wheat.

The effect of nitrogen fertility on the agronomic performance of Norstar was examined in a number of trials, including Fertility x PGR and PGR x Fertility trials in the period from 1985 to 1987. Table M9 illustrates the average response of Norstar to increasing rates of nitrogen over the three year period.

TABLE M9. EFFECT OF NITROGEN APPLICATION ON YIELD OF NORSTAR WINTER WHEAT MINTO 1985-87, 3 STATION YEARS

TREATMENT (KG N/HA)	YIELD (KG/HA)
0	3293
60	3551
120	3630
180	3726

Due to relatively high initial soil nitrogen levels, response to N was limited but yield increases were noted up to 180 kg N/ha. Table M10 examines the effectiveness of a split N application compared to a single application of nitrogen.

TABLE M10. EFFECT OF SPLIT NITROGEN APPLICATION ON YIELD OF NORSTAR WINTER WHEAT MINTO, 1985-1988

NITROGEN TREATMENT (KG/HA)	YIELD (KG/HA)		
	1985	1986	1987
120 at G.S.21 *	4940	1919	4615
80/40 at G.S.21 and G.S.31	5340	1524	4706

* Zadoks and Feekes growth stages of wheat. See Appendix.

The largest advantage with split N applications was found in 1985, when very favourable weather conditions existed. Results in 1986 were also quite spectacular; however the 1986 trials showed a negative response to the split N application. Part of the negative response can be attributed to the presence of an early and severe stem rust epidemic. Generally any treatment which delayed maturity (which often also had a higher yield potential), allowed more time for the stem rust to function. Consequently some treatments which initially looked favourable ended up having lower yields than other treatment which initially had lower yield potentials and matured earlier. Stem rust is difficult to control when the disease develops early. Multiple applications of fungicides would be necessary plus extremely good coverage of the stems are required to prevent stem rust from causing serious damage. Treatments which would normally control leaf rust, tanspot or late infestations of stem rust are not sufficient to control early stem rust.

LODGING PROTECTION WITH PLANT GROWTH REGULATORS

Norstar winter wheat is a variety which responds very dramatically to environmental conditions. The height of Norstar can vary between 50 cm in a year with dry spring conditions to as much as 160 cm when growing conditions are favourable. Consequently the lodging potential can also vary considerably between years. Lodging was only a significant problem in 1985. Table M11 illustrates the effect of two PGR's applied on Norstar in the period of 1985-87.

TABLE M11. EFFECT OF PGR ON YIELD OF NORSTAR WINTER WHEAT
MINTO 1985-87

TREATMENT	YIELD (KG/HA)
Cycocel Extra 2.5 l/ha @ G.S.31	4479
Cerone .31/ha @ G.S.37-45	4255
Check	4448

The results strongly suggest there is no benefit from applying a PGR to Norstar when weather conditions and yields varied as they did from 1985-87. Results from 1985 trials show that PGR's can be used to control lodging in winter wheat (Table M12).

TABLE M12. EFFECT OF PGR ON LODGING & YIELD OF NORSTAR WINTER WHEAT
MINTO, 1985

TREATMENTS	RATE & TIMING	LODGING 0-5*	YIELD KG/HA
Cycocel Extra	3.0 l/ha at G.S.31	2.8	5177
Cycocel Extra	2.5 l/ha at G.S.31	2.9	5323
Cycocel Extra	2.5 & .75 l/ha at G.S.25 & 31	2.5	5011
Cerone	.62 l/ha at G.S.39	1.9	5421
Cerone	1.42 l/ha at G.S.39	1.3	4857
Check		2.5	5142
L.S.D. .05			420

* 5 = severe lodging; 0 = no lodging

The high rate of Cerone was the most effective treatment to minimize lodging, however it also gave the lowest yields. The Cycocel treatments were not effective in controlling lodging and had no significant effects on yield. Thus even in conditions where lodging is of concern, the use of PGR's for control of lodging in winter wheat is not well defined.

TABLE M13. AVERAGE YIELD RESPONSE TO MANAGEMENT FACTORS FOR NORSTAR WINTER WHEAT, MINTO 1985-87

MANAGEMENT FACTORS*	AVERAGE RESPONSE (NORSTAR, KG/HA)
Cultivar x Management	1456
Fungicides	500
Crop establishment	100
N fertility	up to 400
PGR	Variable

*A comparison of conventional vs best management practise

The three years of study show intensive culture of wheat can have a positive effect on yields and net profits of winter wheat. The primary factors allowing for the greater productivity are use of foliar fungicides and increased use of nitrogen. Changes to row spacing or seeding rates had only a small effect on the performance of Norstar. PGR's have been shown to be both beneficial and detrimental, with the lack of consistent lodging being a major factor.

Even though positive responses have been found, greater knowledge is needed at the farm level to ensure products such as fungicides and PGR's are used only when needed to avoid extra costs +/or even crop injury in years when crops are not responsive. Intensive culture studies recognize the need to achieve the best management of other yielding factors such as snow trapping, soil moisture management, erosion, crop rotations, weed control, etc. in addition to the "extra inputs" examined in these studies.

MANITOBA 3 YEAR SUMMARY

SPRING WHEAT

In spring wheat, the highest yields were obtained with high yielding semidwarf cultivars like HY320 or Marshall, especially under intensive management. The profitability of these cultivars compared to Katepwa was found to be highly dependent on the price spread between the various cultivars.

Spring wheat cultivars tested for the 3 year period all showed increases in yield from more intensive management, though the magnitude of increase varied with the cultivar. Increases ranged from 1% for Glenlea (1985) to 58% for HY320 (1986). The study focused mainly on 4 cultivars namely Katepwa, HY320, Oslo and Marshall and yield increases due to more intensive management over 3 years were 21%, 34%, 19% and 24% respectively (Table M14).

TABLE M14. SPRING WHEAT AVERAGE YIELD - CULTIVAR X MANAGEMENT TRIALS MINTO 1985-87

CULTIVAR	YIELD (KG/HA)			
	HIGH INPUTS	LOW INPUTS	DIFFERENCE	HI/LOW %
Katepwa	4201	3477	724	129
HY320	5476	4131	1345	134
Oslo	4647	3892	755	119
Marshall	5229	4263	966	124
All cultivars	4680	3744	936	124

More detailed assessments of the effect of management on Katepwa and HY320 are shown in Tables M15 and M16. While both varieties respond positively to management, HY320 is much more responsive than is Katepwa. The yield improvements for the high input management ranged from 653 to 850 kg/ha for Katepwa and from 905 to 1826 kg/ha for HY320. As in the winter wheat trials, a large number of extra inputs were included in the 1985 trials but the list of inputs was shortened by 1987 to include just extra N and fungicide. The extra inputs for both Katepwa and HY320 are listed as a footnote to Table M15.

TABLE M15. EFFECT OF MANAGEMENT ON YIELDS OF KATEPWA SPRING WHEAT MINTO 1985-87

MANAGEMENT*	YIELD (KG/HA) 1985	1986	1987	$\overline{X}$
High input	5005	4093	3506	4201
Conventional	4352	3243	2836	3477
Difference	653	850	670	724
% of conventional	115	126	124	121

*Extra inputs over conventional	Conventional
1985-500 seeds/m2	300 seeds
-Tilt at G.S.31+51(125 kg/ha)	
-CCC at 2.5l/ha at G.S.31	
-80/40/40 kg N/ha	60 kg N/ha
1986-400 seeds/m2	200 seeds
-Tilt at G.S.49 (125 kg/ha)	
-25/50/25 kg N/ha	60 kg N/ha
1987-300 seeds/m2	300 seeds/m2
-Tilt at G.S.49 (125 kg/ha)	
-20/40 kg N/ha	60 kg N/ha

TABLE M16. EFFECT OF MANAGEMENT ON YIELD OF HY320 SPRING WHEAT MINTO 1985-87

MANAGEMENT	YIELD (KG/HA) 1985	1986	1987	$\overline{X}$
High input	7074	5186	4169	5476
Conventional	6169	3149	3075	4131
Difference	905	1826	1094	1275
% of conventional	115	158	136	131

HY320 and Katepwa are very different wheats. HY320 while obviously a semidwarf wheat, has a much larger kernel size, a more limited ability to compensate for low plant populations through tillering (has a lower tillering potential) and a much larger spike size. Table M17 indicates the variability which has been found with HY320 and Katepwa over the course of the study.

TABLE M17. YIELD COMPONENT CHANGES OVER YEARS FOR HY320 AND KATEPWA

CULTIVAR	PLANTS/M2	HEADS/M2	KERNELS/HEAD	TKW	YIELD KG/HA
HY320 1985	254	470	40	36	6591
1986	196	418	32	33	4237
1987	205	346	23	48	3699
% change max/min	130	136	174	145	178
Katepwa 1985	273	655	22	34	4708
1986	186	534	20	35	3564
1987	183	466	18	39	3228
% change max/min	149	141	122	115	146

The average number of heads (spikes)/m2 for HY320 was 411 while the average head number for Katepwa was 552. The large difference in heads/m2 between the varieties was found despite the average plant counts being almost identical at 218 and 214 plants/m2 for HY320 and Katepwa respectively (Max/Min x 100). The range of heads/m2 is expressed as a % change was also slightly larger with Katepwa, 141% compared to HY320 at 136%. Factors which affect tillering potential will have a greater effect on Katepwa than on HY320. HY320 however displayed a much more elastic response in regard to the yield components of kernels/head and kernel size. The average head size of HY320 was 32 kernels/head compared to 18 kernels/head for Katepwa. The range of kernels/head as expressed as a % change (Max/min x 100) was much larger for HY320 than for Katepwa, 174 and 122% respectively. The average kernel size was also large for HY320 than for Katepwa, 39 and 36 g/1000 kernels respectively. The range in kernel size as expressed as a % change (Max/min x 100) was much larger for HY320 than for Katepwa, 145 and 115 respectively. The high elasticity in the magnitude of kernel number and kernel size make HY320 more sensitive than Katepwa to management practices, weather conditions and pest interference which occur later in the growing season. For example, late summer drought or late disease infection could have a higher degree of effect on HY320 than on Katepwa.

The average yield for the two varieties HY320 and Katepwa was 4842 and 3495 kg/ha respectively. The range in yield between the three years as expressed as a % change (Min/max x 100) was 178 and 146% for HY320 and Katepwa, respectively. The large variability in the yield of HY320 compared to Katepwa can be attributed to HY320's greater sensitivity to factors which affect kernels/head and TKW relative to factors affecting tillering. In years such as 1985 when cool wet conditions late in the season provided for near optimum head development, yields were nearly double compared to 1987 when weather conditions reduced the kernels/head by nearly half of the values obtained in 1985. Being aware of the relative contribution and sensitivity of each component of yield should help to optimize management for each variety.

The economic implication of the effects of management for the period of 1985-87 for HY320 and Katepwa are shown in Tables M18 and M19. The average breakeven price for the extra inputs for HY320 was $111/MT whereas (due to lower yield responses) the breakeven price for Katepwa was $175/MT. Despite respectable yield responses the breakeven price required was very high in 1985, especially compared to 1986 and 1987 breakeven price requirements. The major reason for the high 1985 breakeven price is directly attributed to the large numbers of extra inputs used in this year. Complementary studies have suggested that not only were the 1985 inputs very costly but in some cases they contribute little to yield or even worse had a negative effect on yields. With more judicious use of extra inputs, for example using only extra nitrogen applied as a topdressed application at G.S.31 plus the foliar fungicide at G.S.49-55 in 1987 allowed the breakeven price to be as low as $67/MT and $109/MT for HY320 and Katepwa respectively.

TABLE M18. EFFECT OF MANAGEMENT ON COSTS & RETURNS FOR HY320 MINTO 1985-87

	ECONOMIC FACTORS		
	1985	1986	1987
Yield difference kg/ha	905	1826	1094
Revenue $/ha	136	275	164
Costs $/ha	187.50	110	73
Extra profit $/ha	-51.50	165	91
Breakeven price $/MT	207	60	67

ASSUMPTIONS: Wheat at $150/MT
N at .55/kg
Seed at 100 seeds/m2 = $7.5/ha
Tilt at $40/ha for 125 g ai/ha (active ingredient/hectare)
CCC at $15/l x 2.5 l/ha = $37.50

TABLE M19. EFFECT OF MANAGEMENT ON COSTS & RETURNS FOR KATEPWA MINTO 1985-87

	ECONOMIC FACTORS		
	1985	1986	1987
Yield difference kg/ha	653	850	670
Revenue $/ha	130.60	170.0	130.40
Costs $/ha	187.50	110	73
Extra profit $/ha	-56.90	+60	+57.40
Breakeven price $/MT	288	129	109

ASSUMPTIONS: Wheat at $200/MT
N at .55/kg
Seed at 100 seeds/m2 = $7.5/ha
Tilt at $40/ha for 125 g ai/ha
CCC at $15/l x 2.5 l/ha = $37.50

One of the factors which had the potential to have a large impact on the spring wheat Cultivar x Management study was row spacing. All crop management studies unfortunately were conducted using 15 cm row spacing. The complementary row spacing x seeding rate studies have shown that extra yield could have been obtained had 11 cm row spacing been used. The 11 cm row spacing has also been shown to increase the yield contribution from other management factors such as seeding rates and fungicides.

Intensive management was also found to improve protein content of wheat (Table M20). Protein percentage increased 1.2 points and 0.6 points for Katepwa and HY320 respectively when grown using intensive management practices from 1985-87. The increase in protein particularly with Katepwa could further add to the net benefits of intensive management in years when the increase in protein would make a grade and price change to the wheat being sold.

TABLE M20. EFFECT OF MANAGEMENT ON GRAIN PROTEIN OF KATEPWA AND HY320 WHEAT MINTO 1985-87

MANAGEMENT	PROTEIN %					
	KATEPWA			HY320		
	1985	1986	1987	1985	1986	1987
High input	13.5	15.1	14.7	11.3	11.0	13.5
Conventional input	12.4	13.1	13.1	10.4	10.5	13.1
Difference	1.1	2.0	1.6	0.9	0.5	0.4

EFFECT OF INDIVIDUAL MANAGEMENT FACTORS ON HY320 (CPS)

Complementary studies to the cultivar x management trials were conducted to help determine the relative contribution of individual management factors. These included trials with fungicides, crop establishment, nitrogen inputs and plant growth regulators. Most studies involved interaction between the above mentioned factors.

FUNGICIDES

HY320 has responded favourably to application of foliar fungicides (Table M21). The main diseases controlled in the period from 1985-87 have included leaf rust, tanspot and septoria. The average yield increase attributed to disease control by foliar fungicides has been 647 kg/ha or a 15% increase over the untreated control, with a range of yield responses from -28 to 1071 kg/ha. The effectiveness of the fungicide will depend on crop yield potential, disease pressure and weather conditions at time of spraying. The small negative response was measured in a trial where yield potential was low, disease pressure was low and hot dry conditions existed at the time of spraying. The use of a fungicide under these conditions was not advantageous. Although not shown in Table M21, experience has found that 2 applications of Mancozeb at G.S.49 and 7-10 days later (1.8 kg ai/ha) is roughly equivalent to a single application of Tilt (.125 kg ai/ha) in terms of yield recovery of potential yield loss due to disease infection. Since the price of inputs do vary, prospective users should contact their respective dealer for the latest prices. Based on the cost of Tilt at $40/ha, the average return using a fungicide on HY320 is as follows:

Average return = Average yield response x price/MT - costs

Average return = .67 tonnes/ha x $150/MT - $40/ha

Average return = $60.50/ha

TABLE M21. EFFECT OF FUNGICIDE TREATMENT ON YIELD OF HY320 MINTO 1985-87, 6 STATION YEARS

TREATMENT	YIELD KG/HA
Check	4391
Tilt .125 g ai/ha at G.S.55	5038
Difference	647
Range	-28 to 1071

If a comparison is made between conventional practice (15 cm row spacing, 300 seeds/m2 with no fungicide) and the best management practice (11 cm row spacing, 500 seeds/m2 with fungicide) the yield advantage over the 2 years would be 997 kg/ha for the narrow row spacing option. The cost of the extra seed and fungicide would be roughly $15/ha for seed and $40/ha for fungicide. The gross returns with wheat at $150/MT would be .997 tonnes/ha x 150 = $149/ha. The maximum allowance which could be used to pay for the change from seeding at 15 cm row spacing to seeding at 11 cm row spacing would be 149 - (15 + 40) = $95/ha/year. The change would be well worth considering.

NITROGEN FERTILIZER

HY320 has shown a good response to nitrogen fertilizer over the period from 1985-87. Table M24 illustrates the effect of nitrogen rate in single and split applications. HY320 responded positively to increasing rates up to 160 kg/ha. The use of a split N application of 80/40 gave an additional increase in yield of 274 kg/ha compared to the single application treatment of 120 kg N/ha.

If we compare the yield of more conventional treatment of 60 kg N/ha applied as a single application to the 80/40 split application, there is a yield advantage of 910 kg/ha. At a cost of .55/kg of N and wheat price of $150/MT the economic advantage to the split N application would be as follows:

Average return = Added revenue - costs

Average Revenue = .910 tonnes/ha x $150/MT - 60 kg N/ha x .55/kg of N

Average Revenue = $103.50/ha

TABLE M24. EFFECT OF N FERTILIZER ON YIELD OF HY320
MINTO 1985-87, 3 STATION YEARS

RATE KG N/HA	GROWTH STAGE	YIELD KG/HA
0		3537
60	00	4429
120	00	5065
80/40	00/31	5339
160	00	5133
80/40/40	00/31/49	5179

A second set of data shows a similar trend (Table M25). The second set of data is derived from trials which involved a conventional and a high input nitrogen treatment as interaction with other factors such as plant growth regulators. The yield advantage for the high input nitrogen treatment over the 5 station years of data was 680 kg/ha.

CROP ESTABLISHMENT

Changes in seeding rate and row spacing had large effects on the yield of HY320 in trials conducted in 1985 and 1987. The 1985 trial results are shown in Table M22. The 1985 results show a positive response to fungicides, however interactions were noted between the use of fungicides and the use of increased seeding rates or decreased row spacing. Increased seeding rates were found to be disadvantageous when used with wide row spacing and no disease control. On the other hand both increased seed rates and narrow row spacing give positive results when used with a fungicide. Increased seed rates were advantageous in all situations except where wide row spacing and no fungicide was used. The results of the 1987 trial are illustrated in Table M23. Fungicides always provided a positive response irrespective of row spacing or seeding rate. Similarly, narrow row spacing always gave positive responses. High seeding rates however were only advantageous when used with narrow row spacings.

TABLE M22. EFFECT OF SEED RATE, ROW SPACING AND FUNGICIDE ON YIELD OF HY320 MINTO 1985

SEED RATE SEEDS/M2	YIELD KG/HA CHECK ROW SPACING (CM) 11	15	23	TILT ROW SPACING (CM) 11	15	23
300	5924	6028	6088	6566	6337	6306
500	6104	6375	5923	6761	6535	6629
Difference	180	347	165	195	198	323

TABLE M23. EFFECT OF SEED RATE, ROW SPACING AND FUNGICIDE ON YIELD OF HY320 MINTO 1987

SEED RATE SEEDS/M2	CHECK ROW SPACING (CM) 11	15	23	TILT ROW SPACING (CM) 11	15	23
300	4212	3699	3330	4763	4023	4072
500	4566	3073	3308	4958	3538	3665
Difference	354	-626	-22	195	-485	-407

In the 2 years, 300 seeds/m2 at 15 cm depth, no fungicide = 4863 kg/ha
500 seeds/m2 at 11 cm depth, with fungicide = 5860 kg/ha
Difference = 997 kg/ha

TABLE M25. EFFECT OF TWO DIFFERENT N APPLICATIONS ON YIELD OF HY320 WHEAT MINTO 1985-87, 5 STATION YEARS

RATE KG N/HA	GROWTH STAGE	YIELD KG/HA
60	00	4722
80/40/40	00/31/49	5402
Difference		680
Difference in %		14%

PLANT GROWTH REGULATORS (PGR)

Lodging was found to be only a minor problem in production of HY320 during the period of 1985-87. Lodging was noted in 1985 but was restricted to only small portions of whole field on which HY320 was grown. Lodging of HY320 was found only in low poorly drained areas where yields were in excess of 7 tonnes/ha. The results of PGR applications are illustrated in Table M26.

TABLE M26. EFFECT OF SELECTED PGR TREATMENTS ON YIELD OF HY320 NON LODGING CONDITIONS, MINTO 1985-87

TREATMENT	YIELD KG/HA				
	1985	1986 1	1986 2	1987	$\bar{X}$
Check	6118	4917	3984	3873	4723
Cycocel Extra .69 kg/ha at G.S.31	5739	4849	4378	4193	4790
Cerone .15 kg/ha at G.S.39	5883	4736	4854	4252	4931

The effect of the PGR treatment varied from increasing yield by 870 kg/ha in 1986-2 using Cerone to decreasing yield by 379 in 1985 using Cycocel. Since both Cerone and Cycocel affect the natural hormone balance within the crop, the health of the crop, growth stage and weather conditions at time of spraying can all dramatically influence the effect PGR treatments may have on the crop. Cerone will almost always reduce the height of the crop, but it is difficult to predict what effect it will have on the yield. Cycocel has the same characteristics as Cerone on wheat but usually its affects are less dramatic.

EFFECT ON INDIVIDUAL MANAGEMENT FACTORS ON KATEPWA (HRS)

FUNGICIDES

Fungicide trials were conducted on Katepwa for only two years. In two years, 7 station years of data was collected (Table M27). The average yield advantage from the fungicide application was found to 531 kg/ha, however the range of responses varied from -306 to 1351 kg/ha. The negative response was obtained in 1987 in a trial with low yield potential, limited disease pressure and conditions were hot and dry at time of application. The fungicide application caused further stress to the crop and consequently reduced yield.

Using the average yield response of 531 kg/ha with a cost of Tilt at $40/ha and wheat priced at $200/MT the economic advantage to the use of Tilt would be as follows:

Added Return = Added revenue - added costs
= .531 tonnes/ha x $200/MT - $40/ha
= 106.20 - 40 = $66.20

Further work to define conditions where only favourable responses are achieved should further enhance the profitability of this treatment. Also note that one application of Tilt could be substituted with two applications of Mancozeb to achieve the same yield results. Potential users of fungicides should refer to their dealers for the latest information on these and other fungicides registered for control of foliar diseases of wheat.

TABLE M27. EFFECT OF FUNGICIDE TREATMENTS ON YIELD OF KATEPWA MINTO 1986-87, 7 STATION YEARS

TREATMENT	YIELD KG/HA
Check	2878
Tilt*	3410
Difference	531
Range	-306 to 1351

*Tilt used at G.S.49-55 at a rate of 125 g ai/ha

CROP ESTABLISHMENT

The effect of row spacing and seeding rate and interactions with fungicides were only examined in 1987 of this project. Further crop establishment studies with both HY320 and Katepwa have been continued in the Risk Management Guide project. The results of the 1987 crop establishment study are shown in Table M28. Unlike the results of the HY320 study or the majority of fungicide results with Katepwa, the results of this study show the application of Tilt reduced the yields of Katepwa. Again, a combination of low disease pressure and stress conditions existing at the time of application caused a negative response, one which was atypical of the effects of Tilt used in more disease and crop favourable conditions.

Increasing seeding rates was also not advantageous for Katepwa. Katepwa has a much greater ability to tiller than HY320 therefore high seeding rates are not as important for obtaining the optimum yield. The ratio of heads/plant (tillering rates) for HY320 and Katepwa during the three year study period was found to be 1.88 and 2.57 fertile heads/plant respectively.

The only factors which exhibited a positive effect on the yield of Katepwa in this trial was row spacings. Katepwa, similar to HY320 responded favourably to narrow row spacings. By decreasing row spacing from 15 cm to 11 cm at 300 seeds/m2 and no fungicides, yields were increased from 2957 to 3903 or nearly 1000 kg/ha. Narrow row spacing can have a dramatic effect on yields.

TABLE M28. EFFECT OF SEEDING RATE, ROW SPACING AND FUNGICIDES ON KATEPWA MINTO 1987

SEED RATE SEEDS/M2	YIELD KG/HA					
	CHECK			TILT		
	ROW SPACING (CM)			ROW SPACING (CM)		
	11	15	23	11	15	23
300	3903	2957	3047	3486	2646	2666
500	3476	2701	2895	3183	2530	2628
Difference	-437	-256	-152	-303	-116	-38

NITROGEN FERTILIZER

1987 was the only year in which a nitrogen response trial was established for Katepwa. Table M29 illustrates the affects of nitrogen fertilizer on the yield responses of Katepwa and HY320. Katepwa gave positive yield responses to N rate up to 120 kg N/ha whereas HY320 gave positive yield responses up to N rates of 160 kg N/ha. The 1987 growing conditions were not favourable for HY320 relative to Katepwa, consequently HY320 which normally outyields Katepwa by a wide margin had yields which were only equal to Katepwa. HY320 was characterized in 1987 as having lower head counts (346 heads/m2) and smaller heads (20 kernels/head) than normal. The number of kernels/m2 for HY320 in 1987 was 6920 kernels/m2 which was 36% of the kernels/m2 found in 1985 (18,800 kernels/m2). In 1987 Katepwa had 8388 kernels/m2 which was 58% of the kernels/m2 found in 1985 (14,410 kernels/m2).

The HY320 as shown in Table M29 required more nitrogen to achieve the same yield level as Katepwa. Usually Katepwa cannot reach the same yield plateau as HY320 and HY320 normally requires less nitrogen/kg of yield than Katepwa. 1987 illustrates the risk inherent in depending on standard responses in crop predictions.

TABLE M29. EFFECT OF N FERTILIZER ON KATEPWA VS HY320
MINTO 1987

RATE KG N/HA	KATEPWA 1987	HY320 1987
0	2943	2728
40	3536	3487
80	3708	3662
120	4328	3972
160	4327	4351
200	4272	3795

PLANT GROWTH REGULATORS

A review paper is enclosed which considers the many aspects of lodging control in spring wheat both cultural as well as chemical solutions. The role of PGR's as a lodging control agent as well as yield enhancing agents is also discussed.

LODGING - A FACTOR TO BE CONSIDERED

While lodging may not be the first crop limiting factor to come to mind, occasionally much of our management effort and inputs have been lost due to lodging. While the loss in cash cost attributed to lodging can be high, frustration in dealing with the lodged crop provides sufficient motivation to attempt to solve the problem. The greatest complicating factor to solving the lodging problem is that lodging does not occur on every field or in every year.

The solution to controlling lodging must start with the basics. First look at what causes the problem and then what are possible solutions. Lodging in cereal crops is often the result of stems which lack sufficient strength or are too long to withstand the negative effects of wind and/or rainfall. Lodging can result in increased harvest cost, reduced grain quality, uneven plant maturity, higher moisture content and often lower grain yields. The amount of lodging in a cereal crop can be influenced by a number of factors including:

1) Cultivar selection - Cultivars with strong thick stems and/or short stems will resist lodging to a larger degree than cultivars with tall thin stems. It would be desirable to use cultivars that have good resistance to lodging provided other agronomic and quality characteristics are desirable.

2) Plant population and distribution - Excessive plant populations often force plants to elongate rapidly in an effort to compete for light. Provided yield potential can be maintained, seeding at lower plant populations will assist in the prevention of lodging.

3) Firm seedbed can allow better development of the crown roots and assist in anchoring the plant.

4) Weed control - Uncontrolled weeds such as wild oats compete strongly with crop plants. Under certain conditions this may result in elongated plants which are susceptible to lodging. Weeds which are susceptible to lodging can also force lodging in crops which otherwise would stand erect.

5) Fertilizer Management - High rates of nutrients, especially nitrogen will provide lush growth which is often susceptible to lodging. Avoid excessive nitrogen rates, base nitrogen rates on soil tests and moisture availability. Split applications of nitrogen at specific growth stages of the crop can reduce lodging compared to a single heavy application. Nitrogen applications should be balanced with other nutrients. Potassium is especially important in providing increased stem diameter and straw strength.

6) Insect and Disease Control - Insect pests such as Hessian fly (Mayetiola destructor) in winter wheat or the presence of diseases such as eye spot (pseudocercosporella herpotrichioides) and root rots can result in lodging. The use of cultural control factors such as crop rotation and optimum planting dates can help to reduce losses from these diseases and/or insects.

LIMITATION OF CULTURAL CONTROL OF LODGING

Lodging can often occur even when all of the above cultural control measures are taken into account. However we will also note that some of the above mentioned cultural control factors may be unavailable, such as lack of a lodging resistant cultivar, or unusable, such as having semidwarf wheats but not one which fits into the market for which there is a demand and/or premium. Or some cultural practices may be counter productive to obtaining an economic yield, such as restricting nitrogen use or lowering seeding rates. Where lodging remains a problem despite improvements in cultural practices, lodging will prevent farmers from reaching their maximum profit potential. In these cases the use of a plant growth regulator (PGR) may be advantageous. PGR's can contribute to net profits in 6 ways:

1) prevention of yield loss due to lodging. Lodging which occurs during the 10 days following head emergence can cause yield losses of 10 to 35%.
2) aid in harvesting:
   -less time and machinery required to harvest standing crops
   -less grain left on ground or lost through combine
3) reduced drying costs, by allowing crop to remain upright and ripen evenly
4) allowing for higher fertilizer use without fear of losing additional yield benefits to lodging
5) allowing for improved grain quality, by allowing for more even maturity
6) in some cases, PGR's can increase grain yield independent of any effect on lodging.

In Western Canada, lodging is not a regular occurrence but when it occurs, economic losses will be substantial. In areas such as Germany, England and even Eastern Canada where lodging is a frequent problem in crops managed for maximum production, the use of a PGR can be as automatic for them as seeding is for us. PGR's have become an essential component of an MEY*program in these regions. In the other extreme, there are those areas where lodging never occurs. In areas such as the brown soil zones of Saskatchewan where lodging is virtually non-existent, PGR's are not needed. That leaves us with a large area in between where lodging does not occur regularly but when it does, economic losses can result. A large part of the Great Plains of the U.S. and Canada falls into this class. The main problem with PGR applications in this area is not so much "will a PGR work?" but rather "when will a PGR application give an economic return?"

During the past 3 years, information regarding the performance of PGR's on spring wheat in Western Canada has started to trickle in. Barley and winter wheat have received much more attention than spring wheat due to the high incidence of lodging in these crops. Data on spring wheat is at best sparse, approximately 13 station years of data over 3 years were used to assemble this paper. Please use the information provided cautiously, very little of the results have enough data behind them to give firm recommendations. Farmers who wish to use PGR's should consult local agriculture representatives, crop specialists and industry representatives for further information.

An ideal PGR for our area would:

1. control lodging it if occurred and
2. if lodging was not a problem, the PGR would result in a yield increase large enough to provide a profitable return.

*Maximum Economic Yield.

While we have noted that in some cases PGR's have worked in this 'ideal' way, we have also seen examples of no net return or negative returns to PGR's especially when they have been applied to non-lodging conditions. Generally a successful PGR use strategy would involve guidelines which would direct us to situations where lodging is likely to be a problem and then selection of PGR treatments which give good lodging protection or if lodging doesn't occur give a high probability of increasing yield sufficient to pay for the treatment.

GUIDELINES FOR PGR APPLICATION (PREDICTION OF LODGING)

Lodging is dependent on a number of factors which if present in the right conditions will result in a lodged crop. The main factors which need to be considered are:

1) type of wheat and cultivar vs. lodging resistance
2) planting density
3) levels of fertility
4) growing conditions
5) likelihood of rainfall and winds sufficient to cause lodging.

A field assessment prior to a PGR application can help to assess the susceptibility of a crop to lodging (cumulative effects of Factors 1-4). The use of yield prediction models may well assist in helping to predict lodging. Factor 5 will always be a guess based on past experience. Therefore while we can move towards a situation of identifying possible lodging conditions, we will never be 100% certain at least not until we can control or predict the weather accurately. Table M30 illustrates a prototype for a decision making guide for PGR application on Columbus wheat.

TABLE M30. SIMPLIFIED DECISION MAKING CHART FOR COLUMBUS WHEAT AT CRITICAL GROWTH STAGE

CROP HEALTH* (YIELD POTENTIAL)	VIGOUR EXPECTATIONS	LODGING EXPECTATIONS	PGR DECISION
poor	poor	none	no
good	poor	none	no
excellent	poor	none	no
poor	good	none	no
good	good	low-med.	maybe
excellent	good	med.	yes
poor	excellent	none	no
good	excellent	med-high	yes
excellent	excellent	high	yes

*poor < 30 bu/acre
good 30-50 bu/acre
excellent > 50 bu/acre

There are currently 3 PGR's which have been used to control lodging. Cycocel is the oldest commercial PGR used in cereals and has been used in wheat crops in Europe since the mid 1960's. Cycocel is generally used early in crop development before stem elongation (G.S.23-31). Cerone, the second product is applied later than Cycocel at G.S.37-45. Applications of Cerone later than G.S.45 can result in head sterility and will reduce grain yields. All PGR's have use restrictions and users are advised to follow label recommendations closely! A third product Terpel C is an experimental mixture of Cycocel and Cerone. Terpal C is often used at G.S.32-39 but could be used as late as G.S.45.

Trials have also be conducted using sequential applications of one or more PGR. While multiple applications of PGR's are common in Europe, cost can quickly become prohibitive under Canadian economic conditions.

WESTERN CANADIAN PGR DATA 1985-87

Table M31 examines the frequency of lodging found in the PGR trial. Most if not all PGR trials had extra fertility and fungicides in an effort to reach maximum yields.

TABLE M31. FREQUENCY OF LODGING IN WESTERN CANADIAN PGR TRIALS

PRODUCT	HRSW TRIALS* # OF TRIALS	HRSW TRIALS* # OF TRIALS WITH LODGING	CPSW HY320 TRIALS** # OF TRIALS	CPSW HY320 TRIALS** # OF TRIALS WITH LODGING
Cerone	13	2	6	0
Cycocel	11	3	6	0
Terpal C	12	2	5	0

*HRSW - hard red spring wheat - top grade milling wheat
- currently all cultivars tall

**CPSW - Canadian Prairie Spring Wheat - medium quality wheat
- HY320 is a semi-dwarf cultivar

The incidence of lodging in the reported trials was low. Lodging protection was required in the tall hard red spring wheat PGR trials approximately 1 out of 4 times and lodging never occurred in the semidwarf wheat trials. Price differences between HRSW and CPS wheats often make it attractive to grow HRSW despite the higher incidence of lodging. The three PGR's examined in Western Canada differ in their ability to control lodging and influence yields as shown in Table M32.

TABLE M32. EFFECT OF VARIOUS PGR'S ON KATEPWA SPRING WHEAT
UNIVERSITY OF MANITOBA, 1986

PRODUCT	RATE KG/HA	LODGING 0.2 - 9.0*	YIELDS OVER CHECK BU/ACRE
Check		6.8	--
Cerone	.38	1.5	6.7
Cycocel	.46	5.1	6.4
Terpal C	.46	2.6	11.4

*0.2 = crop erect, 9.0 = crop flat

While Table M32 relates to a specific example, the trend shown in this trial is quite common. Terpal C and particularly Cerone are very effective in reducing plant height, strengthening stems and preventing lodging whereas Cycocel as a single application gives only minimal lodging protection.

CERONE TRIALS

Table M33 demonstrates the influence of rate on performance of Cerone to control lodging.

TABLE M33. INFLUENCE OF CERONE ON LODGING AND YIELD IN SELKIRK HRS WHEAT
UNIVERSITY OF MANITOBA, 1986

RATE* KG AI/HA	LODGING 0.2 - 9.0	YIELD BU/ACRE
0	3.0	45
.12	2.0	51
.24	1.8	43
.48	.2	44

*Applied at G.S.45

Increasing rates of Cerone cause increased plant height reduction and increased lodging protection, however increased rates tend to have detrimental effects on yield. Delaying the application of Cerone from G.S.37 to 45 has a similar effect to increasing rates.

The ability of Cerone to modify grain yields is shown in Table M34.

TABLE M34. EFFICACY OF CERONE UNDER NON-LODGING CONDITIONS

TYPE OF WHEAT	RATE KG AI/HA	# OF TRIALS	FREQUENCY OF YIELD INCREASE %	AVERAGE YIELD INCREASE BU/ACRE	FREQUENCY OF YIELD DECREASE %	AVERAGE YIELD DECREASE BU/ACRE
HRSW	.12-.15	8	62	2.6	12	2.9
	.24-.30	8	25	5.3	25	2.2
	.48	2	0		100	1.2
HY320	.15	5	40	9.2	40	4.3

Based on the data collected to date it appears that Cerone should be targeted to situations which require lodging protection. Higher rates (.24-.30) may be used if severe lodging is anticipated. Where lodging is expected to be moderate to light, lower rates (.12-.15) would be desirable. The low rate will give the best chance of a yield increase if lodging does not occur.

It would not be advisable to apply Cerone solely for its yield enhancement effects due to the high risk of causing a yield reduction. Future work may be able to give farmers better direction so that yield increases may be more consistent when Cerone is applied in non-lodging conditions. At present, these conditions are not clearly defined or proven. The current price for Cerone is approximately $10.00/acre for the .12 kg ai/ha rate.

CYCOCEL TRIALS

The ability of Cycocel to control lodging is shown in Table M35.

TABLE M35. EFFECT OF CYCOCEL ON LODGING AND YIELD OF KATEPWA HRS WHEAT UNIVERSITY OF MANITOBA, 1986

RATE* KG IA/HA	LODGING 0.2-9.0	YIELD BU/ACRE
0	6.8	47
.46	5.1	53
1.15	4.7	58

*Applied at G.S.31

Cycocel is applied much earlier than Cerone. Cycocel applications mainly affect only the lowest internodes and has only a minimal effect on the total crop height, whereas Cerone applications reduce the upper internodes and has a greater effect on overall height and lodging. Even at very high rates, Cycocel was not very effective in eliminating lodging in the above example. Cycocel applications however often result in positive yield responses.

The effect of Cycocel applications on grain yields in non-lodging conditions are shown in Table M36.

TABLE M36. EFFECT OF CYCOCEL UNDER NON-LODGING CONDITIONS

TYPE OF WHEAT	RATE KG AI/HA	# OF TRIALS	FREQUENCY OF YIELD INCREASE %	AVERAGE YIELD INCREASE BU/ACRE	FREQUENCY OF YIELD DECREASE %	AVERAGE YIELD DECREASE BU/ACRE
HRSW	.46	4	50	4.2	25	3.2
	.69	8	25	4.3	0	
	1.15	1	100	2.9	0	
HY320	.69	5	40	5.3	40	3.2

The results shown in Table 7 indicate that Cycocel can increase yields, however the frequency of yield increase and magnitude is sufficiently low that the economics of the application would be questionable even at the low rates. The current price of Cycocel at .46 kg ai/ha is about $16/ha. At current price relationships it does not appear that Cycocel would be the product of choice for use as an antilodging agent in spring wheat.

While further studies may isolate the conditions which are conducive to achieving consistent yield increases with Cycocel, the use of Cycocel solely for yield enhancement cannot be recommended at this time.

TERPAL C TRIALS

The effect of Terpal C on lodging and yield of HRSW is shown in Table M37.

TABLE M37. EFFECT OF TERPEL C ON LODGING AND YIELD OF COLUMBUS HRS WHEAT MINTO, 1985

RATE* KG AI/HA	LODGING 0.2 - 9.0	YIELD BU/ACRE
0	7.0	59
.46	4.0	62
.58	2.5	65

*Applied at G.S.30

Increasing the rate of Terpal C to .58 to .69 has generally shown to give more adequate lodging protection than the lower rate of .46.

The effect of timing of Terpal C efficiency is shown in Table M38.

TABLE M38. EFFECT OF TERPAL C ON LODGING AND YIELD OF KATEPWA HRS WHEAT

RATE KG AI/HA	GROWTH STAGE	PORTAGE 1987 LODGING* 0.2-9.0	MINTO 1987 YIELD BU/ACRE
0		4.3	43
.46	32-37	2.9	48
.69	32-37	.6	50
.34	39-45	1.3	--
.46	39-45	1.0	45
.69	39-45	.2	46

*No significant yield differences found between treatments

Terpal C tends to give the best lodging control when applied at higher rates and at the later timing, however it can be effective over a wide range of stagings as shown in Table M37 and M39. The later timings can be beneficial in that it allows more time for the crop to develop before the decision to spray for lodging protection needs to be made. The timing for maximum lodging protection must be balanced with the timing for maximum yield benefit. Yields taken from the trial in Minto (no lodging) show that the highest yields were obtained from the earlier timings. This situation is similar to that found with Cerone.

The effects of Terpal C on wheat yields under non-lodging conditions are shown in Table M39.

TABLE M39. EFFECT OF TERPEL C ON NON-LODGING CONDITIONS

TYPE OF WHEAT	RATES KG AI/HA	# OF TRIALS	FREQUENCY OF YIELD INCREASE %	AVERAGE YIELD INCREASE BU/ACRE	FREQUENCY OF YIELD DECREASE %	AVERAGE YIELD DECREASE BU/ACRE
HRSW	.46	7	57	3.4	14	2.6
	.69	9	44	3.6	22	3.4
HY320	.46	5	20	7.0	0	
	.69	1	100	8.6	0	

Results of a trial conducted in 1987 at Minto also show Terpal C can be used with other cultivars such as Arcola (durum) and Oslo (Canadian Prairie Spring) wheat (Table M40).

TABLE M40. EFFECT OF TERPAL C ON YIELD OF 4 SPRING WHEAT CULTIVARS MINTO 1987

PGR TREATMENT	YIELD (BU/ACRE)			
	KATEPWA	ARCOLA	OSLO	HY320
Check	43	39	39	58
Terpal C at				
.46 @ 32	48	50	43	62
.69 @ 32	50	52	42	67

As with Cerone, Terpal C application should be targeted to situations where lodging is likely to be a problem. If lodging does not occur after the Terpal C application, the application could still have a beneficial effect on grain yields.

The use of Terpal C solely for a yield enhancing agent has potential but cannot be recommended at this time due to the risk of negative results.

SUMMARY

Lodging occurs with different frequencies across the Great Plains. Efforts to control lodging should begin by ensuring good agronomic practices are followed which consider both lodging protection and achievement of high yield goals. Plant growth regulators can be used to an advantage in obtaining the maximum economic yield but only if the PGR application is focused on situations which are associated with a high probability of moderate to severe lodging. PGR treatments such as with Cerone or Terpal C can be applied as late as G.S.45 to provide control of lodging, however slightly earlier applications can give adequate lodging control with improved margins for crop safety. In situations where lodging was anticipated but does not occur, PGR applications still have a beneficial effect on yields. The use of PGR's solely for their yield enhancement effects has potential but cannot be recommended at this time due to insufficient knowledge regarding the correct conditions which would favour an economic response. The risk of a negative result is too high.

PGR's if used wisely and cautiously until experience is gained can be a valuable tool in assisting farmers in "Coping with Lodging" as we move toward maximizing profits in an MEY program.

TABLE M41. AVERAGE YIELD RESPONSE TO MANAGEMENT FACTORS FOR HY320 AND KATEPWA SPRING WHEATS, MINTO 1985-87

MANAGEMENT FACTORS*	AVERAGE RESPONSE HY320 (KG/HA)	KATEPWA (KG/HA)
Cultivar x Management**	1345	724
Fungicides	647	531
Row spacing x Density x Fungicides	997	990
N	910	positive
PGR	highly variable	highly variable

*Comparison of conventional vs best management practice
**Cultivar x Management did not include use of narrow row spacing

The three years of study show intensive culture of wheat can have a positive effect on yields and net returns from spring wheat. The primary factors allowing for the greater productivity are use of narrow row spacing, use of higher seed rates (HY320 only), use of foliar fungicides and use of higher rates of nitrogen; topdressing to achieving the higher rate may be a viable option. While PGR's may have a role in wheat management, low incidence of lodging and large environmental interaction make the use of PGRs more risky than other inputs. Even though positive responses have been found, greater knowledge is needed at the farm level to ensure products such as fungicides are used only when needed to avoid extra costs or even crop injury in years when crops are not responsive.

Intensive culture studies recognize the need to achieve the best management of other yielding factors such as soil moisture management, erosion, crop rotation, weed control, etc. in addition to the "extra input" examined in these studies.

CONCLUSION - MANITOBA 3 YEAR SUMMARY

The three years of study have shown net return to farmers could be increased by adopting some or all of the intensive management factors examined. Positive economic responses have been achieved by adopting:

a) more favourable cultivar x management combinations;
b) reducing row spacing in spring wheat;
c) increased seed rates with HY320
d) use of foliar fungicides to control diseases in spring and winter wheats
e) use of higher N rates and split nitrogen application on responsive cultivars such as HY320.
f) use of PGR's to control lodging and in some cases to enhance yields.

To facilitate the use of intensive management in Manitoba, where weather patterns are particularly variable between years, the development of a risk management guide which would identify the benchmark and thresholds for profitable application of the added inputs would greatly enhance adaptation of this technology.

APPENDIX

WEATHER SUMMARY

Weather is an extremely important factor in determining the performance of the cultivar to be grown. Table M42 illustrates the changes in yields and yield components for four cultivars over the 3 year study. Table M43 reports the weather pattern for each of the three years. In a year such as 1985, adequate precipitation during June and August (tiller initiation and grain fill respectively) coupled with below normal temperatures resulted in high wheat yields. Late seeding and a dry June coupled with high disease pressure reduced yields in 1986. Above normal temperatures and below normal precipitation at initial growth stages severely reduced yields of both spring and winter wheat in 1987. The relative performance of the various cultivars was affected by the type of weather conditions, Cultivars with high yield potential appear to have less yield stability than the lower yielding cultivars such as Katepwa. HY320 had the greatest yield advantage over Katepwa (40%) in the favourable year of 1985 and a much lower yield advantage (14%) under the unfavourable growing conditions of 1987.

Due to the large variation in Manitoba weather and associated yield potentials, development of guides which will assess risk prior to adding an additional input is crucial to applying the correct inputs to achieve the highest net returns for each growing season. Development of reliable benchmarks and thresholds which allow optimum input use in each growing season should be a future goal to achieving the highest available net returns for farmers and the ultimate in providing a low risk MEY program to farmers.

TABLE M42. CROP GROWTH SUMMARY FOR MINTO, 1985-87

YEAR/CULTIVAR	AVERAGE RESPONSE FOR CULTIVAR X MANAGEMENT TRIALS				
	PLANTS/M2	HEADS/M2	TKW	KERNELS/HEAD	YIELD(KG/HA)
1985					
HY320	254	470	36.1	40	6590
MARSHALL	288	634	30.9	32	6590
KATEPWA	273	655	33.6	22	4708
NORSTAR	117	883	32.3	18	5448
1986					
HY320	196	418	32.8	32	4327
MARSHALL	179	614	34.2	23	4708
KATEPWA	186	534	24.6	20	3564
NORSTAR	229	471	25.7	28	4640
1987					
HY320	205	346	48	23	3699
MARSHALL	230	453	40	20	3632
KATEPWA	183	466	39	18	3228
NORSTAR	212	539	32.9	22	3766

TABLE M43. MINTO WEATHER SUMMARY

	APRIL	MAY	JUNE	JULY	AUGUST	SEPT
1985						
T	-	+2	-3	-1	-3	-1.4
PPT%	-	95	164	20	283	93
1986						
T	+3	+3.8	+2.8	+0.9	-0.1	0
PPT%	158	118	60	150	41	97
1987						
T	+6.5	+4.5	+3.4	+0.9	-1.2	+1.7
PPT%	3	87	65	134	170	41

PART 2

QUEBEC

INTENSIVE CULTURE OF WHEAT
QUEBEC 3 YEAR SUMMARY 1986-1988

The Quebec project was part of a 3 province study of Intensive Culture of Wheat. The objective as in the other projects was:

To determine the agronomic and economic potential of production systems incorporating intensive culture techniques for wheat production. The main factors under study included cultivar performance, changes in seeding rates, using higher rates of nitrogen as well as split N applications and use of foliar fungicides and plant growth regulators.

A number of studies were conducted from 1986 to 1988 in the Ste. Hyacinthe-Ste. Rosalie areas of Quebec. Both winter wheat and spring wheats were included. While a number of cultivars were involved in the studies, Monopol was the main winter wheat cultivar examined and Max was the main spring wheat cultivar. Additional data was collected in 1988 on Casavant spring wheat. The growing seasons were quite variable with precipitation and yields being above normal in 1986 and below normal in 1987 and 1988. Winterkill of the 1985-86 winter wheat crop caused major damage resulting in the loss of cultivar x management and seeding rate trials in that year.

Spring wheats yielded higher in 1986 (above average rainfall) than winter wheat but less than winter wheat in 1987 and 1988 when June and July rainfall were more limiting.

WINTER WHEAT TRIALS - 3 YEAR SUMMARY

The three years of winter wheat trials will be reviewed starting with the Cultivar X Management trials to give an overall impression of the potential for intensive management to influence yields and profits. The second part of the review will examine the effects of the various components of intensive management on the performance of Monopol.

CULTIVAR X MANAGEMENT TRIALS

Due to winterkill in 1986, winter wheat Cultivar X Management trials are only available for 1987 and 1988. The extra inputs which distinguish the two management levels are shown below in Table Q1. Table Q1 illustrates the effect of management on the yield of selected winter wheat cultivars in 1987 and 1988. The average yield for all cultivars was 627 kg/ha higher when extra inputs were applied as compared to the yields with conventional inputs. While Monopol responded very favourably to increased inputs (978 kg/ha) the average yield of Monopol was lower than most other cultivars. Monopol however is considered to be a higher quality bread wheat than most of the other wheats tested.

TABLE Q1. EFFECT OF MANAGEMENT ON YIELD OF SELECTED WINTER WHEAT CULTIVARS QUEBEC 1987-88

CULTIVAR	YIELD (KG/HA) HIGH INPUT	CONVENTIONAL INPUT	DIFFERENCE
All cultivars	5253	4627	627
Monopol	4519	3541	978
Odessa	6191	5296	895
Perlo	6045	5162	883
Karat	6312	5011	1301

*High input includes the following input over and above the input used in the conventional management.

-1987-extra 100 seeds/m2
- -110 kg N/ha
- -CCC at G.S.30 at 1.2 kg/ha
- -Bayleton G.S.30(175 g ai/ha) + Tilt G.S.49(125 g ai/ha)

-1988-extra 60 seeds/m2
- -50 kg N/ha at G.S.49
- -CCC at GS 30 at 1.2 kg/ha
- -Bayleton at G.S.30 at 175 g ai/ha) + Tilt G.S.49(125 g ai/ha)

Karat and Odessa were two of the top yielding winter wheat cultivars. Both responded favourably to the high input management compared to conventional management with the increase being 1301 and 895 kg/ha respectively.

A more detailed look at the effect of management in Monopol is given in Table Q2. The yield advantage from the high input management compared to the conventional management was 1242 and 715 kg/ha for 1987 and 1988 respectively. Note that in 1987, different amounts of inputs were used in the high input management treatments (Table Q1). On the first year of the study, the philosophy was to provide maximum opportunity to the crop to achieve higher yields. Subsequent studies indicate that some refinement of inputs was possible which might lead to better net profits. Net profits and breakeven wheat prices are shown in Table Q3. The breakeven wheat price for the extra inputs was $157 and $221/MT in 1987 and 1988 respectively. The lower profit/high breakeven price in 1988 could be attributed to less favourable weather patterns causing lower yield potential and lower response to added inputs.

TABLE Q2. EFFECT OF MANAGEMENT ON MONOPOL WINTER WHEAT QUEBEC 1987-88

MANAGEMENT LEVEL	YIELD (KG/HA) 1987	1988	$\overline{X}$
High input	5048	3990	4519
Conventional input	3806	3275	3541
Difference	1242	715	978
% of Conventional	133	122	128

TABLE Q3. EFFECT OF MANAGEMENT ON COSTS AND RETURNS OF MONOPOL WINTER WHEAT, QUEBEC 1987-88

	COSTS & RETURN $/HA* 1987	1988
Yield difference (kg/ha)	1242	715
Revenue($/ha)	248	143
Costs($/ha)	196	158
Extra profits($/ha)	52	-15
Breakeven price($/ha)	157	221

*Assume -wheat at $200/MT
-seed 100 seeds/m2 = $8.00/ha
-N at .55/kg 110 kg/ha=60.50 50 kg/ha=27.50
-CCC at $16/l x 2.5 l/ha = $40/ha
-Tilt 125 g ai/ha x 2 applications = $80/ha

EFFECT OF INDIVIDUAL MANAGEMENT FACTORS ON MONOPOL

FUNGICIDES

Diseases were shown to be a constant problem for wheat production in Quebec. The two main disease problems were powdery mildew and septoria. Fusariam head blight was also noted in some trials. Table Q4 illustrates the effectiveness of fungicide treatments to control disease and increase the yield of Monopol winter wheat. Due to the constant disease pressure through the growing season, multiple application of fungicides generally resulted in the highest yields. Fungicides applied at both G.S.30 and G.S.55 (usually Bayleton followed by Tilt) resulted in an increase in yield of 700 kg/ha compared to the untreated check in trials from 1986 through 1988. Studies conducted in 1988 have shown that use of Bayleton as a seed treatment can further supplement disease control (See Annual Report).

The cost of a double application of fungicide at G.S.30 + 55 is estimated to be $80/ha. The average revenue for the treatment would be .700 t/ha yield increase x price of wheat ($200/MT) or $140/ha. The average net profit from using a fungicide program in Monopol is (140-80) or $60/ha.

TABLE Q4. EFFECT OF FUNGICIDES ON MONOPOL, QUEBEC 1986-88

TREATMENT	YIELD (KG/HA)			
	1986(6 trials)	1987(1 trial)	1988(2 trials)	$\overline{X}$
Check	3900	2834	2454	3063
G.S.30 + G.S.55	4735	3590	2967	3764
G.S.49	--	3011	--	

SEED RATE

The effects of increasing seeding rates are shown in Table Q5. Increasing seeding rates from 325 to 550 resulted in an average yield increase of 473 kg/ha. The response to the increased seeding rate in 1988 trials was more pronounced when fungicides were used to control diseases. Using a cost of $8.00/100 seeds, the average advantage of seeding at 550 seeds/m2 vs 325 seeds/m2 would be as follows:

Added Revenue	.473 tonnes x $200/MT = $94.60/ha
Extra Cost	550 - 325 seeds/m2 = 225 x $8/100 seeds = $18/ha
Net Profit	94.60 - 18 = $76.60

TABLE Q5. EFFECT OF SEED RATE ON YIELD OF MONOPOL WINTER WHEAT QUEBEC 1987-88

TREATMENT (SEEDS/M2)	YIELD (KG/HA)			
	1987	1988(no fung.)	1988 (fung.)	$\overline{X}$
300	2784	2215	2486	2495
425	2853	2388	3011	2750
550	3413	2463	3029	2968

NITROGEN FERTILITY

Five nitrogen fertility trials were conducted between 1986 and 1988 (Table Q6). While a great number of treatments were examined, Table Q6 only contains summary data for 3 treatments. The 120 rate is the conventional N rate applied at G.S. 00-21. The other rates included topdressing 50 kg N/ha at G.S.31 (170 kg N/ha) and at G.S.49 (210 kg N/ha). The trial results did not show consistency between years. In 1986 the 120 kg N/ha rate was optimum whereas in 1987 and 1988 the optimum treatments were 170 and 210 kg N/ha respectively.

In 1988, an alternative 170 kg N/ha treatment using ammonium nitrate at G.S.21 instead of urea gave a yield of 3773, over 700 kg/ha more than the urea 170 kg N/ha treatment. Unfortunately ammonium nitrate does not appear to be a magical answer as experience in topdressing spring wheat has shown little difference between the 2 nitrogen types in some years to an advantage for urea in another year.

The question of optimal nitrogen fertilizer in Quebec is a perplexing problem due to the high leaching and denitrification potential. However it is suggested that systems involving soil nitrate analysis as well as tissue N content be examined to ensure optimal crop nutrition while helping to avoid over fertilization which could contribute to ground water contamination by nitrates.

TABLE Q6. EFFECT OF APPLIED N RATE ON YIELD OF MONOPOL, QUEBEC 1986-88

TREATMENT	YIELD (KG/HA)		
(kg N/ha)	1986(2 trials)	1987(2 trials)	1988(1 trial)*
120	4596	3774	2441
170	4517	4246	3061
210	4696	3999	3645

*In 1988, an alternative treatment of 170 kg N/ha using ammonium nitrate at G.S.21 gave a yield of 3773 kg/ha.

PLANT GROWTH REGULATORS

The amount of lodging which occurred in trials with Monopol from 1986 to 1988 was minimal. Monopol is a medium height wheat and about 20 cm shorter than Norstar, a western winter wheat. Table Q7 summarizes the yield effects of Cycocel Extra on Monopol. Cycocel Extra applied at 2.5 l/ha at G.S.30-31 had only a marginal effect on yield. One possible exception occurred in the Fertility x Management trial in 1988 (Table Q8). The use of Cycocel on the low fertilizer treatment resulted in a yield increase of 802 kg/ha whereas the Cycocel applied on the higher fertility treatments had no effect on yield. Similar responses have been reported on a sporadic basis in the Manitoba and Alberta trials as well as some early trials by Humphries in England.

Generally the plant growth regulators examined including both Cycocel and Cerone did not provide any consistent positive benefits to enhance the productivity of Monopol winter wheat.

TABLE Q7. EFFECT OF PGR ON YIELD OF MONOPOL WINTER WHEAT
QUEBEC 1986-88, 5 STATION YEARS DATA

TREATMENT	YIELD (KG/HA)
Check	3916
Cycocel Extra 2.5 l/ha at G.S.30-31	4019

TABLE Q8. EFFECT OF CYCOCEL EXTRA ON YIELD OF MONOPOL QUEBEC 1988 (DRY YEAR)

TREATMENT	YIELD (KG/HA) 0 kg N/ha	170 kg N/ha
Check	2381	3773
Cycocel Extra	3183	3750

SUGGESTIONS FOR INTENSIVE WINTER WHEAT MANAGEMENT IN QUEBEC

CULTIVAR SELECTION

Choose cultivars carefully considering yield potential, agronomic characteristics and deficiencies as well as quality and price.

MANAGEMENT

*Use of intensive management appears to be beneficial for a wide range of varieties, however each variety may differ in its requirements.

EXTRA INPUTS FOR MONOPOL

-Use of intensive management has been shown to increase yield, net profit can also be increased.

-When the disease of powdery mildew and septoria are present, a season long fungicide program will be advantageous.

-Monopol responds well to high seed rates, seed at 500 seeds/m2.

-Monopol can respond to N levels greater than 120 kg/ha, however a more detailed system to determine when the higher rates are required is necessary.

-The use of plant growth regulators on Monopol often are not economic and until a better system is devised to predict lodging, the use of a preventative application of a PGR would not be advised.

SPRING WHEAT TRIALS - QUEBEC 3 YEAR SUMMARY

The three years of spring wheat trials will be reviewed beginning with the Cultivar x Management trials, which gives an overall impression of the potential for intensive management to influence yields and profits. A second section will review the effects of various components of intensive management on the performance of Max spring wheat and to a lesser extent on the performance of Casavant.

CULTIVAR X MANAGEMENT TRIALS

The use of higher input levels to increase yields brought variable results in spring wheat. The average yield increase to the extra inputs (see Table Q9 for list of inputs) in trials from 1986 to 1988 was 321 kg/ha. Max was found to be one of the more responsive cultivars to high input management. The average yield of Max increased from 3750 to 4333 kg/ha when input levels were increased. The difference was 583 kg/ha.

TABLE Q9. EFFECT OF MANAGEMENT ON YIELD OF SELECTED CULTIVAR OF WHEAT QUEBEC 1986-1988

CULTIVAR	YIELD (KG/HA)		
	HIGH INPUT*	CONVENTIONAL INPUT	DIFFERENCE
Average for all cult.	4382	4061	321
Max	4333	3750	583
Casavant	4601	4665	-64

*High inputs included the following in addition to the conventional inputs.
- -extra 125 seeds/m2 (425 vs 300)
- -130, 90, 50 kg/ha of N in 1986, 1987 and 1988 respectively
- -2 applications of Tilt, G.S.30 + 49 at .125 kg ai/ha
- -PGR-1986 CCC at G.S.30 + Cerone at G.S.37
  - -1987 CCC at G.S.30 at .46 kg ai/ha
  - -1988 none

TABLE Q10. EFFECT OF MANAGEMENT ON YIELD OF MAX SPRING WHEAT QUEBEC 1986-88

	YIELD (KG/HA)			
	1986	1987	1988	$\overline{X}$
High input	6086	4016	2897	4333
Conventional	5351	3476	2422	3750
Difference	735	540	475	583
% of conventional	114	115	120	

TABLE Q11. EFFECT OF MANAGEMENT ON COSTS AND RETURNS OF MAX SPRING WHEAT, QUEBEC 1986-88

	$/HA		
	1986	1987	1988
Yield difference (kg/ha)	735	540	475
Revenue*	147	108	95
Costs	241	184	108
Extra profit	-94	-76	-32
Breakeven price	327	340	267

*Assume-wheat at $200/tonne
- -N at .55/kg, 130 kg = $71.50, 90 kg = $49.50, 50 kg = $27.50
- -seed at $8.00/100 seeds/ha
- -2 Tilt applications $80/ha
- -CCC at $16/ha at .46 kg ai/ha
- -Cerone at $35/ha

Casavant was found to be a non-responsive cultivar to a general intensive management package. Yields of Casavant were marginally lower (64 kg/ha) when the higher input management was used compared to conventional input levels.

A more detailed look at the effect of management on Max in individual years is given in Table Q10. The yield advantage from the extra inputs varied from 475 to 735 kg/ha which represented a percentage yield increase from 120 to 114% of the conventional treatment. Table Q11 examines the economics of applying extra inputs to Max over the three years. Despite the yield increases, the higher inputs resulted in losses ranging from -94 to -32 $/ha. The breakeven prices for wheat to pay for the extra inputs varied from 267 to 340 $/MT. Obviously more refinement of input levels need to be addressed before any improvement can be made over conventional management of spring wheat.

EFFECT OF INDIVIDUAL MANAGEMENT FACTORS ON MAX

FUNGICIDES

Yield losses from diseases can be substantial in years when disease pressure and yield potentials are high. Table Q12 illustrates the yield advantages which can be obtained through the use of foliar applied fungicides on Max spring wheat. During the three years of the study, the use of a double fungicide application G.S.30 + G.S.55 to control both powdery mildew and septoria resulted in an average yield increase of 449 kg/ha. The response to the fungicides was as high as 701 kg/ha in 1986, a high yield, high disease year to a low of 165 kg/ha in 1987 when yields and disease pressure were much lower. With a cost of approximately $80/ha, the double application fungicide treatment would have returned $60/ha in 1988, -$47/ha in 1987 and $16.6/ha in 1988 with wheat priced at $200/MT.

The single application fungicide treatment at G.S.55 was found to give less yield protection compared to the double application treatments (Table Q12, 1988).

TABLE Q12. EFFECT OF FUNGICIDE TREATMENTS ON YIELD OF MAX SPRING WHEAT QUEBEC 1986-88

TREATMENTS	YIELD (KG/HA)			
	1986	1987	1988	$\bar{X}$
Check	5798	3105	2964	3956
G.S.30 + G.S.55	6499	3270	3447	4405
G.S.49-55	--	--	3120	--

The difference in effectiveness of single vs. double application is further illustrated on Table Q13.

TABLE Q13. EFFECT ON FUNGICIDE TREATMENT AT TWO FERTILITY LEVELS ON YIELD OF MAX, QUEBEC 1986

TREATMENT	YIELD (KG/HA)	
	120 kg N/ha	180 kg N/ha
Check	6768	6941
Fungicide at G.S.31 + G.S.55	7244	7831
Fungicide at G.S.49	7114	6991

At the lower N level, there was very little difference between the two fungicide treatments, however at the higher N level, control and yield levels were considerably better with the double application treatment compared to the single timing treatment.

The use of fungicides have also been shown to enhance the benefits of other factors such as increased seeding rates (Table Q14). Increasing seeding rates increased yields 1325 kg/ha (300 seeds/m2 vs 500 seeds/m2) on treatments where fungicides had been applied, however the increase was only 708 kg/ha in the absence of fungicides. In this trial, the fungicide treatments increased yields up 1257 kg/ha.

TABLE Q14. EFFECT OF FUNGICIDE TREATMENT AND VARIOUS SEED DENSITY ON YIELD OF MAX, QUEBEC 1986

TREATMENT(SEEDS/M2)	YIELD (KG/HA)	
	CHECK	BAYLETON & TILT/BRAVO
300	6441	7081
425	6785	7973
550	7149	8406

SEED RATE

While the results of changes in seeding rate can be very dramatic such as in years of high yields (1986, Table Q14), the overall average effect of seeding rate change is much smaller. The average response of Max spring wheat to seeding rate changes is given in Table Q15. Over all trials, the 425 seeds/m2 seeding rate appears to be optimum, giving a 121 kg/ha yield increase over the 300 seeds/m2 seeding rate.

TABLE Q15. EFFECT OF SEED RATE ON YIELD OF MAX SPRING WHEAT QUEBEC 1986-88

SEEDS/M2	YIELD (KG/HA)				
	1986		1987	1988	$\bar{X}$
	TRIAL 1*	TRIAL 2**			
300	6692	7195	3545	3265	5174
425	6742	7483	3627	3329	5295
550	6710	7738	3600	2864	5228

*Overall fertility levels
**Overall fungicide treatments

Results for a 1988 trial on Casavant suggest the optimum seeding rate for Casavant is 550 seeds/m2 (Table Q16).

TABLE Q16. EFFECT OF SEED RATE ON YIELD OF CASAVANT AND MAX SPRING WHEAT QUEBEC 1988

SEED RATE	YIELD (KG/HA)	
SEEDS/M2	CASAVANT	MAX
350	3464	3265
450	3576	3329
550	3804	2864
650	3859	3091

There is a tendency of the optimum seed rate for Max to be higher (550 seeds/m2) in high yield years such as 1986 and to be lower (425 seeds/m2) in years of lower yield potential 1987 and 1988. Methods which could help predict yield potential ahead of seeding would be valuable. In some parts of Western Canada, early indications from trial results suggest models based on plant available soil water at seeding are highly correlated to final yields. It is doubtful whether this strategy would be of any use with Quebec's higher annual precipitation.

FERTILITY

The role of nitrogen fertility in optimizing yields of wheat is not well defined as illustrated in Table Q17. In the top of the table, the results indicate there was no yield difference between applying rates of nitrogen from 120 kg/ha to 220 kg/ha. This was in spite of yields in 1986 reaching the 6.7 tonne/ha range, which by most calculations would have required a total Nitrogen supply of 224 kg/ha or more. Obviously the nitrogen in the soil had to be very high to support these yield levels. In the lower part of the table, 0 N vs 120, yield responses were found in 2 of 3 years. While the years were very different in terms of yield potential, the range of yields obtained with no nitrogen fetilizer 1477 to 6354 kg/ha indicate a high level of variation in soil N levels.

It is suggested that a system be developed involving both soil tests and tissue tests which can better predict the N requirement of the crop. Besides considerable saving in money spent on N fertilizer or possible low yields due to inadequate N, one should consider that NO3 levels in some of these sites are already very high and the further addition of unneeded N fertilizer could possibly contribute to contamination of ground water.

TABLE Q17. EFFECT ON APPLIED N RATE ON YIELD OF MAX
QUEBEC 1986-88

TREATMENT KG N/HA	YIELD (KG/HA) 1986	1987	1988
120	6692	3198	2806
150	6742	3356	2835
180	6710	3507	2870
220	--	3538	--
	1986	1987	1988
0 KG N/HA	6354	1477	2782
120 KG N/HA	7339	2979	2861

PLANT GROWTH REGULATORS

While lodging can be severe in Max, the use of plant growth regulators to increase yield and control lodging has at times been questionable. In 7 trials conducted over the 3 year period only two treatments were found to have positive effects (Table Q18 + Q19). Table Q18 gives the results of a trial in which Cerone results were positive and in which Cycocel results were negative. However in the same year on a large scale trial, the use of the Cycocel gave a range of responses (Table Q19). In the best case, Cycocel increased yields 682 kg/ha and in the worst case, reduced yields 410 kg/ha.

Neither Cycocel or Cerone have proven to be very farmer friendly products. Both positive and negative results can be obtained with both products and reasons for the differences in performance are not always obvious. It is suggested farmers use these products very cautiously on Max and only in cases where lodging seems assured.

TABLE Q18. EFFECT OF CERONE ON MAX SPRING WHEAT, QUEBEC 1986

TREATMENT	RATE KG AI/HA	YIELD KG/HA	LODGING % OF AREA	LODGING DEGREE
Check	--	4703	96	35
Cerone at G.S.39-43	.36	5050	87	31
Cycocel at G.S.23-30	.36	4388	94	40

TABLE Q19. EFFECT OF CCC ON MAX SPRING WHEAT - FARM SCALE TRIALS QUEBEC 1986

TREATMENT	YIELD (KG/HA) FARM 1	FARM 2	FARM 3
Check	5146	2741	5767
CCC .46 kg/ha at G.S.30	5230	2331	6449

SUGGESTIONS FOR INTENSIVE SPRING WHEAT MANAGEMENT IN QUEBEC

CULTIVAR SELECTION

Choose cultivars carefully considering yield potential, agronomic characteristics and deficiencies as well as quality and price.

MANAGEMENT

Use of intensive management should be approached cautiously as financial rewards have not always been positive.

EXTRA INPUTS FOR MAX

Use of intensive management has been shown to increase yields, but both positive and negative financial responses have been found. Producers need to exercise care in choosing which inputs and under what conditions they are used in order to successfully enhance the financial productivity of Max.

When foliar diseases are present and yield potential is high, the use of season long disease control with fungicide can be advantageous.

Max should be seeded at 425 seeds/m2. In extremely favourable years, higher seeding rates (550 seeds/m2) would be advantageous. However, 425 seeds/m2 is optimal in the majority of years.

Max responds favourably to nitrogen at rates up to 120 kg N/ha. However further work must be done to develop a system to more accurately predict N requirements.

The use of plant growth regulators on Max appear to be very unpredictable. Until a system can be devised which can predict lodging and the response of the PGR in that situation, the use of PGR should be approached cautiously.

PART 3

ALBERTA

Intensive Culture of Wheat in Canada

Canada Grains Council/New Crop Development Program

3 Year 1985-1987 Summary - University of Alberta Program

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1. Climatic and soil conditions, and general yield levels during the study

Adaptability of ICM and MEY approaches to wheat production is limited by constraints of local environment and climate and particularly by moisture conditions. At the commencement of this project longterm weather data typified the Edmonton and Spruce Grove locations as high rainfall sites in which moisture limitations for wheat growth are rare and in which high temperature and/or drought stress conditions for wheat would also be rare. (See Spruce Grove and Edmonton Weather Summary). The major limitations to growing wheat are length of available growing season (average frost free days around 110), lateness of available cultivars, and high harvest risk due to fall rains and cool, wet conditions during ripening. These same conditions also lead to high yield potential, as confirmed by the high average location yields of cultivar testing trials grown at Ellerslie, normally the highest yields of any rainfed trials in W. Canada.

Growing conditions during the three years of this project varied considerably being very favourable for the whole season in 1985, but with some extreme heat stress (5 days > 30^0C) in late May in 1986, and with a hot dry June in 1987. 1987 was also warmer and wetter than usual in late summer encouraging disease development, and extreme high winds (up to 120 km/hr) were recorded on July 31 when a tornado passed within two miles of the Edmonton plots, causing some lodging.

A characteristic of the small plot trials in all years was a fairly high base fertility level in all fields used, whether on fallow or barley stubble. Only the field scale Spruce Grove trials had base fertility levels similar to expectation for farmer fields in the area. The consequence of this high fertility level in small plots trials was a reduction in response to many of the fertility level treatments applied in a number of the tests. Overall yield levels were very high in most trials, however, with 80-100 bushel spring wheat yield levels regularly obtained, and these conditions provided an excellent test of the value of fungicide and plant growth regulators at high yield levels for a range of cultivars. In most cases seedbed conditions in the Edmonton trials were very good to excellent, for the three year period.

Average experiment wide yield levels achieved in different spring wheat trials at Edmonton during the three year period were high, but not atypically so for the Edmonton site on mainly fallow land. Average Neepawa yields in different trials ranged from 3575-5203 kg/ha (53-78 bu/acre), for Oslo from 3771-6183 kg/ha (56-92 bu/acre), and for HY320 from 5220-7146 kg/ha (78-107 bu/acre). For the large scale spring wheat plots at Spruce Grove trial means for Neepawa ranged from 2935 -5090 kg/ha (44-76 bu/acre), from 3143-5990 kg/ha (47-89 bu/acre) for Oslo and in the single year of testing of HY320 (1985), the average HY320 yield was 6386 kg/ha (95 bu/acre). Record farm yields of 7500 kg/ha (112 bu/acre) for HY320 and 5503 kg/ha (82 bu/acre) for Neepawa were obtained for specific management combinations in 1985 and 1987 respectively, although these yields did not give the Maximum Economic Returns per acre. 1985 contributed generally very high yields for the region, 1986 relatively low yields, and 1987 intermediate yields for spring wheat. The range of conditions was very wide over the three years, but the conclusions concerning the value of different ICM inputs apply to what were generally high yielding rainfed conditions.

In the case of the Norstar winter wheat trials, average experiment wide yields were considered low in the large scale Spruce Grove trials in 1984/85, at 3006 kg/ha (45 bu/acre). The two years of Norstar testing in small plots in Edmonton gave very poor experiment wide yields in 1985/867 of 985-2673 kg/ha (15-40 bu/acre), and excellent yields in 1986/87 of 4677-5120 kg/ha (70-76 bu/acre). Yield loss in 1985/86 was more due to untimely heat and drought stress than to winter kill, which was not major in either year.

2. Straw strength, lodging and Plant Growth Regulator use

(A) Spring Wheat

Lodging has rarely been a major problem for the preferred spring wheat cultivars recommended for the Edmonton area over the last twelve years, and did not prove to be a major problem with any of the cultivars grown during the three years of these trials. Even with yields at the 70-100^{+} bushel level, and extremely high fertility levels, straw strength was adequate for the cultivars tested, although the cultivars Glenlea and Bluesky exhibited considerable lodging under the freak storm conditions of 1987 with 120 km/hour winds. Other than for the latter case, no significant lodging occurred for any spring wheat except Glenlea and Wildcat in over 26 experiments (50-106 bu/acre yield range) conducted over the three years, suggesting that PGR use on spring wheat is unnecessary. However, in the same trials PGR use did occasionally cause significant yield reduction, such as the 16% yield reduction recorded from split application of Cycocel and Cerone on 65 bushel yield Wildcat in 1987. The only instance of a significant positive effect of a PGR on yield was a 17% yield increase for Bluesky (on 77 bushels/acre) by the same split application of Cycocel and Cerone. This crop was severely lodged by 120 km/hour winds that occurred late in the season, and the PGR did not improve the lodging rating. In many of the trials use of Cycocel and/or Cerone made maturity significantly later.

(B) Winter Wheat. In the case of winter wheat the straw strength of Norstar is generally not very good and high fertilizer levels and yields can be expected to cause some significant lodging. Climatic conditions (wet falls) only allowed three series of winter wheat plots to be seeded, the first large scale plots at Spruce Grove (1984/85), and the second and third (1985/86, 1986/87) the small scale plot trials at Edmonton. In the first two cases yields achieved did not exceed 45 bu/acre, no significant lodging occurred in any of the trials, and no PGR effects were found on yield. However, in all small plot trials in 1986/87 yields in the order of 70-76 bushels/acre were recorded for Norstar, and lodging up to 5.5 on a 1-9 scale was recorded in several of the trials. (These trials were subjected to 120 km/hour winds at the end of July, associated with a local tornado). In one of these trials Cerone applied at Zadok's Growth Stage 39 was effective in reducing lodging from 5.4 to 2.1, and a split Cycocel/Cerone treatment was able to reduce the lodging further to a score of 1.7. This control of lodging did not, however, result in any increase in yield, and was therefore uneconomic except for possible savings in harvest efficiency. In a Fertility Level x Cycocel treatment trial, Cycocel was also effective in reducing lodging from a 5.5 to a 3.5 score, also without effect on yield. In the same trial, raising the applied nitrogen level from zero to 150 kg/ha increased lodging from 1.7 to 6.2, in a trial with an average 70 bushel/acre yield, but did not raise yield.

It may be concluded from these trials that PGR use on currently registered spring wheats is unwarranted at this time since lodging is not a major problem even at the 70 bushel/acre yield level or higher, and since yield improvements by use of PGR's were rarely found. In many instances, PGR's depressed yields significantly. Some positive effects were found from use of PGR's for lodging control of Norstar winter wheat in some cases, but these instances did not result in higher yields. In two years of winter wheat testing with ICM technique at Edmonton, yields ranged from very low (20 bu/acre) to very high (70^+ bu/acre). Factors other than PGR use appear to be of higher priority in developing a reliable winter wheat production package for the Edmonton area.

3. Diseases and Fungicide Use

(A) Spring Wheat

Diseases did not occur at a scorable level in any of the spring wheat trials (farm scale or small plot) in 1985. In 1986 powdery mildew developed to a level of 3.5 for Oslo and 5.2 for Neepawa on the Horsfall Barrett (0.5 to 11.0) scale on unsprayed controls in small plot trials. A single application of Tilt at GS49-55 was effective in reducing this score to 1.1 for Neepawa and 1.5 for Oslo, and increased the yield of Neepawa by 8% (298 kg/ha) but had no effect on Oslo yield. These yield effects were of insufficient magnitude to make Tilt application economical. Similar results were obtained in 1987 with powdery mildew being the most important disease (with some Septoria), reaching scores of 5.6 and 3.4, respectively, on the 0.5 - 11 Horsfall Barrett scale by late August on the unsprayed control plots of Neepawa and Oslo. Late applications (GS49-55 or later) of Tilt or Dithane in 1987 were effective in significantly reducing the powdery mildew level, but without significant effect on yield or other agronomic trials, rendering these treatments uneconomical.

Powdery mildew has rarely been considered an important disease for rainfed spring wheat production in W. Canada, and its occurrence is rarely reported in rainfed commercial acreage. In this particular three year study the incidence was moderate (up to Horsfall Barrett 5.6) only in the two years when the trials were adjacent to winter wheat trials which were a major source of spring inoculum. Even at this level of infection no significant effect on yield was demonstrable even when the powdery mildew was effectively controlled by Tilt fungicide. The present results lead to the conclusions that (a) Tilt can be an effective, but uneconomical, fungicide for controlling powdery mildew on spring wheat under rainfed conditions in the Edmonton area, (b) Dithane can also be effective, but uneconomical, and (c) recent summer climatic conditions have been favouring powdery mildew development in spring wheats, even though reports of this disease as a major disease in commercial rainfed acreage around Edmonton have been rare.

In a multiple cultivar x management trial a significant level of take-all root was noticed for the unregistered cultivar QT8132, but this was not seen in registered cultivars, underlining the effectiveness of the current high cultivar registration standards in W. Canada for crop diseases.

(B) Large Scale Spring Wheat Trials

In the large scale trials at Spruce Grove, involving Oslo and Neepawa in all three years and HY320 in year one, no significant disease development was found in either of the first two years, except for a late development of

Septoria leaf blotch during cool moist conditions during senescence in 1985 and 1986. In contrast to this, in 1987 significant levels of Septoria were found on Neepawa and Oslo (up to 5% leaf area infection) which were reduced to 1.7% when Tilt was applied, although no significant effect of the fungicide was found on yield. Tilt use was therefore effective, but uneconomical. Other interesting disease effects at Spruce Grove in 1987 were a significant reduction of Septoria level for Neepawa and Oslo as applied nitrogen was increased from zero to 120 lbs/acre, and a very significant reduction in take-all root rot of Oslo as nitrogen applied was raised from zero to 120 lbs/acre.

(c) Winter Wheat

Prior to this three year study, disease data on winter wheat in the Edmonton area were lacking, since relatively few winter wheat yield trials had been conducted previously, and in those that had been completed disease data had not been collected. In the current series of trials powdery mildew proved to be the most commonly occurring disease in all three years, in the farm scale trial in 1984/85 at Spruce Grove and in the small plot trials at Edmonton in the subsequent two years. The only other significant disease was Septoria leaf blotch, but no snow mould was found in any trial during the three years. Even following barley stubble, rootrots were also at a low level (less than 6%) in all trials, but patchy winter kill was observed in both years of the small plot trials conducted.

In 1985/86 severe stunting symptoms resembling copper deficiency were observed in the winter wheats small plot trials at Edmonton, but were not due to copper deficiency, as confirmed by soil and plant tissue tests. These symptoms appear to be secondary effects perhaps related to soil structure variability, and perhaps due to variable root penetration or effectiveness, showing up as the result of severe early and mid season drought stress occurring in these trials. Causal pathogens were not isolatable from the affected plot areas.

Powdery mildew occurred in all winter wheat trials and was identifiable in all cases on very young seedlings in the spring. In the large scale trial of 1984-85 final infections were very high (averaging 7.0 on a 1-9 scale) and one application of Tilt at Zadoks GS34 was ineffective in controlling the final level, but had no effect on yield. In the 1985/86 small plot fungicide trial, maximum powdery mildew levels of 3.5 were recorded on the 0.5-11.0 Horsfall Barrett scale, and several of the Tilt applications were effective in reducing this score to 0.5 or 1.0. However, no significant yield improvement was obtained, rendering these treatments uneconomical. Mancozeb (Dithane) was ineffective in controlling powdery mildew in the 1986/87 fungicide trial, which exhibited disease scores of 4.8 on the flag leaf for the unsprayed control treatment. In this trial, multiple applications of Tilt were effective in significantly reducing powdery mildew, but again without any significant effect on yield or other agronomic characters.

From these three years data of ICM research with Norstar winter wheat, it may be concluded that powdery mildew can be a significant problem in the Edmonton region, and that use of Tilt fungicide under various application regimes can be an effective control method. Such control, however, was not economical since the Tilt treatments in no case resulted in yield improvement.

4. General Nitrogen Fertilizer responses (as measured in Fertility x Plant Growth Regulator Trials)

(A) Spring Wheat

Nitrogen fertilizer response trials were conducted under non-limiting conditions for P and K, in order to test efficacy of plant growth regulators, both under fallow and stubble conditions. A major difficulty for this research on the University farm was the high base fertility level of all fields, which generally resulted in a relative lack of response to applied nitrogen, banded or broadcast, in most small plot trials. Fertilizer responses were individualistic for different cultivars in different years. For Neepawa, typically no yield increase was obtained from adding from 30 to 180 kg/ha of actual nitrogen per acre in the small plot trials. These results generally suggest that the base nitrogen level was already adequate, although soil test data did not always indicate this. Exceptions to this occurred in 1986 when significant yield increases were obtained for Neepawa from a 30 kg/ha nitrogen application and from Oslo for up to 130 kg/ha of applied nitrogen.

In trials where the nitrogen was applied either banded or broadcast, expected yield advantages of banding were not always found, but banding sometimes led to earlier maturity and/or less lodging. With exceptions, higher levels of applied nitrogen often led to delays in maturity, a not unexpected result, expecially in 1987 for Bluesky and Wildcat, even when yield was unaffected. In 1986, for Oslo, earlier applications of nitrogen, whether broadcast or banded, resulted in earlier maturity.

(B) Winter Wheat:

In a total of four Norstar trials involving spring nitrogen application rates from 0-60 kg/ha or 0-150 kg/ha, three trials gave no significant response to yield and one (in the drought stress year) resulted in depressed yield from nitrogen application. As for the spring wheat trials, these results suggest that the base fertility level was already high. Application of nitrogen resulted in significantly delayed maturity in one of the four trials, and significantly increased lodging in one of four trials.

The present studies were not specifically designed to test such a hypothesis, but the data obtained do not suggest that current nitrogen level recommendations for C. Alberta for spring wheat and winter wheat are not appropriate for ICM production. However, in every year the yields of unfertilized control plots deviated substantially from the yields expected on the basis of soil tests, leading to some questioning of the soil test accuracy. Oslo and HY320 may be more responsive to nitrogen application than Neepawa.

5. Stand Establishment, Planting Geometry and Seeding Equipment

In all small plot and large scale trials conducted over the three year period, trials were planted to achieve controlled, targeted, numbers of plants per unit area, and counts of the numbers of plants actually established were made. Almost without exception the double disc seeders used, one a Swift Current model research small plot seeder and the other a six foot commercial International seeder, failed to reach better than 60-90% targeted stand establishment, with 30% loss of seeded plants being a typical result. This result was not due to poor or inviable seed, but was due to field loss of plants. Based on field plant counts the International seeder was particularly inaccurate for calibrating seedrates over the entire 300-500 seeds per square meter range. Both of the double disc seeders, however, gave good depth control and excellent post seeding packing.

In contrast to these two seeders, however, the tractor-mounted Nordsten European (Danish) seeder was usually very accurate in delivering and establishing plants in the field at or near the 100% level, at all seedrates. This seeder was very inadequate at seeding other than very shallow, due to a lack of adequate pressure devices, but part of its success may be due to the shallow seeding occurring under good seedbed conditions. This particular seeder also had a narrower row spacing (5") than the others (9" and 6") which resulted in less interplant competition at constant seedrate.