WINTER WHEAT "CONSERVE AND WIN" DEMONSTRATION AND DEVELOPMENT PROGRAM

D. B. Fowler and L.R. Moats[2]

1 Crop Development Centre
University of Saskatchewan
Saskatoon, Saskatchewan
S7N 5A8

and

2 Ducks Unlimited Canada
1606 - 4th Avenue
Regina, Sask.
S4P 3W7

SUMMARY

The winter wheat "Conserve and Win" demonstration and development program is a continuing project that was initiated in 1991 with the objective of developing management packages and demonstrating production systems that allow Saskatchewan farmers to realize the full production and conservation potential of winter wheat in an integrated cropping system. The first three years of this program focused on the east-central region of Saskatchewan. Sixty-five winter wheat fields were monitored throughout the crop year and the limitations and opportunities of a wide range of production systems were identified. Farmers who followed recommended production practices had a high level of success and were able to clearly establish that there is a good production potential for winter wheat in the target region.

INTRODUCTION

Winter Wheat is not a new crop to western Canada. However, until a few years ago, winter wheat was grown almost entirely on conventional summerfallow or tilled stubble fields and the risk of winterkill confined production to southern Alberta. More recently, no-till seeding into standing stubble from a previous crop (stubbling-in) has proven to be a successful method of overwintering wheat. Snow trapped by the standing stubble essentially eliminates the risk of winterkill, with the result that winter wheat can be successfully over-wintered throughout the prairie region.

The stubbling-in production system for winter wheat has undergone over 20 years of commercial evaluation in Saskatchewan. Field trials during that period have demonstrated an average 36 percent yield advantage for properly managed Norstar winter wheat over hard red spring wheat when both are grown as a stubble crop. The release of new, higher yielding semi-dwarf winter wheat varieties has increased this potential by an additional 40 percent under favourable moisture conditions. This translates into an enormous increase in production potential for Saskatchewan if present winter wheat management and marketing limitations can be solved.

In addition to providing increased yield potential, production of stubbled-in winter wheat embraces the philosophies of profitable conservation farming by providing the opportunity for a) improved control of soil erosion, b) more efficient crop moisture utilization, c) longer crop rotations without summer-fallow, d) reduced tillage, e) reduced pesticide use, and f) less disturbance to wildlife.

Reduced tillage, low pesticide requirements, and the maintenance of a crop residue cover on the soil surface make stubbled-in winter wheat one of the most environmentally friendly cropping options available in western Canada.

BACKGROUND

Farmer success with winter wheat was good in the early 1980's. Prior to 1983, average winter wheat yield from properly managed stubbled-in re-crop fields was approximately 40 bu/acre (2700 kg/ha) in Saskatchewan. Several mild winters had been experienced in the early 1980's and winterkill had not been a problem. In 1983-84 a large acreage of winter wheat on summerfallow was overwintered in southwestern Saskatchewan. Success meant increased production (Figure 1). However, the use of highly questionable management practices put part of this increased planting in jeopardy. Production problems were forecast since it was expected that "improperly managed fields would fail if a severe winter was encountered". Subsequently, in 1984-85, Saskatchewan experienced the worst year for winterkill in 30 to 50 years. Further complicating production problems were the worst stem rust epidemic in almost 30 years in 1986, followed by four years of severe drought, and a crash in world wheat prices.

Winter wheat production in Saskatchewan had moved from less than 2,000 acres (800 ha) harvested in 1972 to 860,000 acres (350,000 ha) harvested in 1985 (64 percent of western Canadian winter wheat production). The cumulative effect of problems starting in 1984 reduced Saskatchewan's winter wheat production to 82,500 acres (33,500 ha) in 1989 and 33,200 acres (13,500 ha) in 1993-94 (Figure 1). However, production problems were experienced throughout the prairie region and Saskatchewan still accounted for one-third of the western Canadian winter wheat acreage in 1993-94.

Successful winter wheat production in Saskatchewan requires the adoption of a low-disturbance direct seeding system (stubbling-in) and an appreciation of critical differences in the management of spring and fall sown crops. While the differences may appear small at first glance, the production system for stubbled-in winter wheat has required major changes in management philosophy for most farmers. As a result, many farmers have had difficulty inserting winter wheat into their rotations. Surveys conducted as part of the federal-provincial Economic Regional Development Agreement programs and by the Western Canadian Wheat Growers Association revealed that most farmers did not employ recommended management practices for the production of winter wheat during the peak production period of the 1980's. Poor management increased the risk of failure. Failures resulted in lost income and wasted resources. This, in turn, has had the effect of neutralizing efforts to establish winter wheat as a viable cropping option in Saskatchewan.

Figure 1. Winter wheat production in Alberta, Saskatchewan, and Manitoba.

{ **--- Figure at end of paper ---** }

Failures, mistakes, and unsubstantiated testimonials became the main focus of the information provided on winter wheat in Saskatchewan by the end of the 1980's. It was obvious that successful production methods would have to be clearly demonstrated if winter wheat was to become a viable cropping option for more than just a few Saskatchewan farmers in the 1990's. Consequently, the winter wheat "Conserve and Win" program was initiated in 1991 with the objective of developing management packages and demonstrating production systems that would allow Saskatchewan farmers to realize the full production and conservation potential of winter wheat in an integrated cropping system.

MATERIALS AND METHODS

The "Conserve and Win" program was designed to a) provide inexperienced growers with the opportunity to acquaint themselves with proven winter wheat production systems, and b) interact directly with experienced winter wheat producers to strengthen their management practices and provide model systems for new producers. The program was based on the producer club concept where participants were to be given maximum opportunity to exchange information. The longer term goal of the program was to work towards expanding the club concept into a viable winter wheat growers' association in Saskatchewan.

Survey Size and Area

A total of sixty-five winter wheat fields were surveyed during the three years of this study (199 1-92 = 22, 1992-93 = 22, 1993-94 = 21). An additional two Crop Development Centre research sites were also monitored each year (total of six additional sites) to provide baseline production reference points for the region.

Ninety-three percent of the fields in the survey fell within the area that extends from Canora to Churchbridge in the east, Esterhazy in the south, Imperial and Watrous in the west, and Watson and Kelvington in the north. This region, which contains the Quill Lake-Touchwood/Beaver Hills, was chosen because it is a prime nesting area for many waterfowl species of concern to conservation groups and it is a low winterkill risk area for stubbled-in winter wheat.

Program Design

Information on the "Conserve and Win" program was provided to the agricultural community through radio, press, television, and direct mailings in the early summer prior to the start of each project year. Interested farmers joined the program by registering with their local Ducks Unlimited area office.

Financial assistance or a zero-till drill was provided to first-time growers to ensure that they had access to suitable direct-seeding equipment. This assistance was made available with the condition that recommended agronomic practices for winter wheat production would be followed throughout the production year. Experienced winter wheat growers were also encouraged to join the program and each year the top winter wheat managers were recognized with awards. A "Winter Wheat Challenge", which was open to all producers in the target area, was introduced during year two of the program to encourage greater participation by experienced growers. The Saskatchewan Wheat Pool provided awards of significant value for the top winter wheat managers in the winter wheat challenge.

First time winter wheat growers were provided with advice on optimum seeding practices in the field at the time of seeding. All fields that farmers had entered in the "Conserve and Win" program were assessed in the fall, spring, first week in July, and the first week in August of each production year by a field technician who was an experienced winter wheat grower.

Farmer cooperators were sent a copy of the assessment of their field after each survey. Each farmer cooperator also received a general summary of all the survey data collected during each survey period. The farmer cooperators provided additional information on their fields and a one pound grain sample from each field for grade and quality assessment. The grain samples were sent to the Canadian Grain Commission Grain Research Laboratory in Winnipeg where bushel weights, kernel size, protein concentration, and official grades were determined.

Data for all variables considered were subjected to an analysis of variance to identify differences that were statistically significant (P c 0.05). Correlation and regression analyses were used to determine the closeness and complexity of relationships.

RESULTS AND DISCUSSION

1. Weather and Related Issues

The winter wheat came through the winter of 1991-92 in excellent condition. The snow melt provided adequate soil moisture to get the crop off to a good start in the spring of 1992. Cool temperatures minimized the effect of poor early spring rainfall in the western part of the survey region; however, lower than average June rainfall produced crops that were under severe drought stress in the Wynyard-Punnichy area by the end of June. Timely rains and cool temperatures in July improved the crop condition over much of the area and winter wheat yields as high as 50 bu/acre were reported on both the eastern and western edges of the survey region. Harvest conditions in the fall of 1992 were the worst experienced in many years. Cool, damp weather set-in just as the winter wheat harvest started. An additional week to 10 days of fair weather would have seen most of the winter wheat in the bin with a high grade.

Interest in winter wheat production was high in the fall of 1992. Unfortunately, abnormally late and wet fall weather delayed harvest of all crops and the optimum seeding date passed before most farmers were in a position to seed their winter wheat. Fortunately, the winter was easy on winter wheat and late seeding did not affect winter survival. The winter wheat got off to a good start in the spring of 1993. Soil moisture was poor to good at the end of May and excellent in most areas at the end of June. Good rainfall in July and early August maintained or improved the early season yield potential; however, crop maturity was delayed considerably. A late maturing crop and cool damp weather delayed harvest in the fall of 1993.

There was continued strong interest in winter wheat production in the fall of 1993. Unfortunately, abnormally late and wet fall weather once again delayed harvest of all crops and the optimum seeding date passed before most farmers were able to seed their winter wheat. There were a few very minor winter-kill problems on exposed hills and headlands adjacent to roads during the winter of 1993-94. Spring temperatures were cool and early season soil moisture was adequate. Consequently, the winter wheat got off to an excellent start in the spring of 1994. Soil moisture was generally good up to the time of heading; however, there were a few fields in need of rain early in June. Soil moisture was excellent in all fields in early July. Favorable conditions for growth and grain production continued throughout the summer and fall of 1994. Harvest weather in the fall of 1994 was the most favorable of the three years in which this survey was conducted. Near normal harvest conditions also meant that farmers were in a position to seed winter wheat at the optimum time. Many farmers took advantage of this opportunity and there was a nearly 5-fold increase in the number of farmer cooperators who signed up to participate in this program in the fall of 1994.

2. Crop Insurance Soil Class Ratings

Fields with a wide range of crop production potential were included in this survey.

	Soil Class								
	A	F	G	H	J	K	L	M	P
Crop Year	------------------------- Percent of Fields ---------------------------								
1991-92	0	19	33	14	10	14	0	10	0
1992-93	0	19	19	14	10	14	0	5	19
1993-94	5	9	24	24	9	24	5	0	0
Mean	2	16	25	17	10	17	2	5	6

3. Previous Crop

Most of the winter wheat in this program was direct seeded into chemical fallow fields and fields from which canola, barley, wheat, or sweet clover had recently been harvested.

Winter wheat direct seeded into fall rye stubble proved to be a poor crop rotation option because the winter wheat did not compete very well with volunteer fall rye.

Winter wheat seeded into couch grass sod, which had been treated with Roundup, established successfully and got off to a good start in the spring. However, a severe nitrogen deficiency limited the winter wheat production potential early in the growing season with the result that this attempt to direct seed winter wheat into grass was not as successful as it might have been with better nitrogen fertilizer management.

	Previous Crop							
	Chem. Fallow	Canola	Barley	Wheat	Sweet Clover	Canary Seed	Couch Grass	Fall Rye
Percent of Fields	17	25	25	16	11	3	1.5	1.5

4. Stubble Height and Density

Snow trapping potential of standing stubble is determined by the height and density of the stubble of the previous crop.

A stubble height of four inches (10 cm) is considered the minimum necessary for snowtrapping in stubbled-in winter wheat production systems. However, snow will blow out of thin stands of stubble even if the stubble is taller than the minimum recommended height of four inches. Therefore, stubble density must also be considered when we determine how well the standing-stubble-snow trap holds the snow during the winter.

A simple index of stubble snow trapping potential (STP), which is calculated using the formula

$$STP = \text{stubble height (cm)} \times \text{stems per } m^2 \div 100,$$

was developed to provide an objective estimate of the snow trapping capability of the stubble fields in this program. Winter wheat had a high risk of winterkill when it was seeded into fields, or large areas within fields, that had a STP of less than 20.

	Stubble Height (inches)	Stubble Height (cm)	Stubble Density (stems per m^2)	Snow Trap Index (STP)
Previous Crop				
Chem. Fallow	6.4	16	105	17
Canola	9.8	25	111	28
Barley	7.2	18	508	91
Wheat	8.9	23	310	71
Sweet Clover	10.0	25	187	47
Canary Seed	4.5	11	185	20
Couch Grass	6.5	17	263	45
Fall Rye	5.0	13	258	34

5. Residue (Trash) Management

Straw was uniformly spread on all of the fields in this survey.

Poor chaff management was the most common residue problem observed during the surveys of the fields in this project.

Difficulties with residue clearance of seeding equipment was the most common residue management problem reported by the farmer cooperators.

6. Seeding Equipment and Operation

In this project, 77 percent of the fields were seeded with knife or narrow hoe openers, 16 percent of the fields were seeded with no-till disc drills, 5 percent of the fields were seeded with air seeders equipped with 8 to 12 inch (20 to 30 cm) sweeps, and 2 percent of the fields were broadcast seeded.

There was considerable stubble knockdown in fields sown with 8 to 12 inch wide sweeps. In fact, there was very little stubble left standing in one field that was sown with 12 inch wide sweeps and the winter wheat in this field sustained significant winter damage.

No-till disc drills had difficulty penetrating unspread chaff residues. In one field, the winter wheat establishment was essentially zero in unspread canola residue rows left by a combine that was not equipped with a chaff spreader.

One field was worked with a Noble blade and the winter wheat was broadcast seeded. There was a poor winter wheat establishment in this field.

Improper adjustment and operation of seeding equipment caused major crop establishment problems in 19 percent of the farmers' fields in 1993-94. These problems ranged from fields with only a 10 to 20 percent winter wheat stand in the spring to fields with a large number of drill row misses. In the latter cases, there was often good plant establishment for some drill rows while adjacent rows were missing, or had only a few plants, indicating that there had either been plugging of the delivery system or winterkill due to variable seeding depth, i.e., drill openers that did not all operate at the same depth.

7. Seeding Rate and Plant Counts

Seeding rate for the three years of this study ranged from 60 lbs per acre to 150 Ibs per acre with a mean of 88 lbs per acre. The number of winter wheat plants (plant count = plants per m^2 prior to freeze-up in the fall) generally increased as the seeding rate increased. However, differences in drill adjustments and difficulties with seed placement meant that this relationship was not as close as was expected. As a result, winter wheat performance was influenced more by the number of plants that successfully established than by seeding rate.

Plant counts (plants per m^2) ranged from 51 to 386 with an average of 273. Winter wheat fields with less than 200 plants per m^2 were usually lower yielding than those with higher plant counts. Low plant counts were associated with seeding depths greater than two inches (5 cm) and seeding operations that left a large percentage of the seed on the soil surface with poor seed-to-soil contact.

8. True Seeding Depth

True seeding depth (plant emergence distance) was estimated in the late fall by measuring the distance from the seed to the area on the winter wheat plant where the green chlorophyll was first noticeable.

Seeding depth for all the fields surveyed ranged from less than 0.5 cm (0.2 inches) to 6.4 cm (2.5 inches) with an average of 2.0 cm (0.8 inches). Seeding depth proved to be a critical management factor in this program and all winter wheat fields (a total of three fields in 1992-93) that were seeded 5 cm (2 inches) or deeper were not successfully overwintered and were reseeded to spring crops.

The average winter wheat seeding depth in fields that did not have establishment problems was 1.8 cm (0.7 inches) with a range from 0.9 cm (0.35 inches) to 3.1 cm (1.2 inches).

9. Seeding Date

The average seeding date of the winter wheat fields in this survey fell within the optimum time period for planting in the project area. However, there was an extremely wide range of seeding dates and many fields were seeded later than the recommended seeding dates in all three years. Poor harvest weather meant that the previous crop was often not harvested early enough for farmers to seed their winter wheat during the optimum period. This also meant that many farmers who had intended to seed winter wheat put their seed back into the bin once the optimum seeding date had passed.

	Average Seeding Date	Range
1991	September 3	August 13 to September 20
1992	September 9	August 24 to September 25
1993	September 9	August 20 to September 21

Harvest date of the previous crop determines the earliest date that a field is available for the seeding of winter wheat. Chemical fallow and sweet clover fields were available for seeding early and the seeding date for these fields nearly always fell within the recommended time period for winter wheat.

The falls of 1992 and 1993 were extremely wet and there were many harvest problems. One would expect that Polish canola stubble would be available for seeding winter wheat earlier than cereal stubble. However, wet harvest conditions and the fact that canola does not deteriorate as quickly in the swath may have disrupted the normal harvest patterns thereby delaying the seeding of winter wheat into canola stubble during the years of this study.

	Previous Crop							
	Chem. Fallow	Canola	Barley	Wheat	Sweet Clover	Canary Seed	Couch Grass	Fall Rye
Seeding Date	S2	S15	S9	S9	S1	S15	S17	A31
	S = September A = August							

10. Fall Plant Growth and Development

Ideally, winter wheat seedlings should enter the winter with well developed crowns. However, only 5 1 percent of the winter wheat fields in this study had plants with well defined crowns by freeze-up. The absence of crowns was associated with late seeding dates and deep seed placement.

Crown development usually starts once the plant has three fully developed leaves. The average winter wheat plant in this program entered the winter at Haun stage 3.1 (three fully developed leaves and a fourth leaf just emerged). This is consistent with the observation that 5 1 percent of the winter wheat fields had plants with well defined crowns.

The minimum and maximum Haun stages recorded were 1.2 (second leaf just starting) and 5.8 (sixth leaf just about fully developed), respectively, indicating that there were large differences among fields in the stage of development at which plants entered the winter. As a general rule, the Haun stage at freeze-up was lower for plants in fields where seeding date had been delayed by the removal of the previous crop.

	Previous Crop						
	Chem. Fallow	Canola	Barley	Wheat	Sweet Clover	Canary Seed	Couch Grass
Haun Stage	3.8	2.6	2.5	2.8	4.2	2.2	2.2

11. Winter Damage

There was evidence of minor winter damage in 30 percent of the fields in this program. Most of the winter damage was restricted to small patches associated with exposed hills and headlands adjacent to roads where the stubble was thin or badly knocked down.

Winter wheat fields with poor snow trapping capability due to excessive stubble breakdown suffered the most extensive winter damage. Included in this group were a few chemical fallow fields and a field that had been seeded by an air seeder equipped with 12 inch (30 cm) sweeps. However, even in these fields the winter damage was minor and none of the fields were reseeded to a spring crop or summerfallowed. Certainly, problems that occurred at the time of seeding (poor seed delivery by drills, seed placement that was too deep, and seed that was left uncovered on the soil surface) placed far greater restrictions on crop productivity than did damage caused by winterkill.

12. Problem Soils

Large areas of moderately to severely saline soils were recorded in 3 1 percent of the fields in this program. The winter wheat in severely saline areas was often badly damaged during the winter and most severely saline areas had little or no crop remaining by the end of June. Winter wheat growing on moderately saline soils had reduced vigor and was more susceptible to drought stress. The increased crop stress in saline areas usually resulted in greater tiller senescence (die-back) and floret abortion (head blasting) during periods of drought stress.

Winter wheat production is not recommended on fields that have large areas that are severely or moderately saline. Spring barley and oats have performed better on saline soils and fields where salinity is a major problem should be sown to salt tolerant perennial grasses.

13. Spring Flood Damage

Most of the fields in this program had good surface drainage. Spring flood damage was confined to sloughs where the water stood for an extended period of time. These slough areas are often inaccessible for early spring seeding.

14. Chaff Rows

There was poor winter wheat establishment, suppression of winter wheat growth, increased problems with volunteer crops and/or delayed winter wheat maturity due to unspread chaff windrows in 14 percent of the fields surveyed in this program. In one field, winter wheat failed to establish in unspread canola residue windrows left by a combine that was not equipped with a chaff spreader. However, delayed winter wheat maturity, and therefore harvest, was the most common problem caused by unspread chaff rows. In one chemical fallow field, a delay in winter wheat maturity due to unspread chaff windrows from a crop harvested two years previously demonstrated the long term influence that heavy crop residues have on crop growth and development.

15. Phosphorous Fertilization

Seedplaced phosphorous fertilizer was applied to 83 percent of the fields in this program at an average rate of 21 lb P_2O_5 per acre (a range of 15 to 31 lbs P_2O_5 per acre). Fields that received seedplaced phosphorous fertilizer produced an average of 29 percent more winter wheat spikes per m^2 and a 29 percent higher grain yield than fields that did not receive phosphorous fertilizer. The increase in grain yield with phosphorous fertilization was due entirely to increased production of head-bearing tillers (spikes per m^2).

The importance of phosphorous was dramatically demonstrated by a large visible phosphate fertilizer response in one field with a small strip that did not receive phosphate fertilizer.

16. Nitrogen Fertilization

Cool temperatures and generally good spring soil moisture conditions created a large crop demand for nitrogen in most fields in this program. Winter wheat fields that did not receive an early spring application of nitrogen fertilizer showed symptoms of nitrogen deficiency by early June (light-green plant color). There were also symptoms of severe nitrogen deficiencies in strips that had been missed during fertilizer application in most of the fields where nitrogen fertilizer had been applied.

Nitrogen fertilizer application rates ranged from 0 to 81 lb N per acre with an average of 52 lb N per acre. Eight percent of the fields did not received nitrogen fertilizer. All eight percent were chemical fallow fields. An average of 57 lb N per acre was applied to fields that received nitrogen fertilizer. Nitrogen was applied as a liquid to 21 percent of the fields, 34-O-O (ammonium nitrate) to 50 percent of the fields, and 46-O-O (urea) to 18 percent of the fields. All the nitrogen fertilizer was seedplaced in 3 percent of the fields.

	N rate (lb N/acre)	Spikes/m^2	Grain Yield (bu/acre)	Protein (%)	Protein Yield (lb/acre)
Form					
0^z	3	252	38	10.3	234
Liquid	53	302	43	8.0	207
34-0-0	65	303	43	9.8	254
46-0-0	45	214	30	9.3 ·	167
z - The fields that did not receive nitrogen fertilizer were all chemical fallow fields.					

The 13 bushel per acre increase in gram yield that was obtained with an additional 20 lb N per acre of 34-O-O compared to 46-O-O and the higher protein concentration for the 34-O-O compared to liquid N emphasizes the importance of nitrogen rate and management if high yields and high protein concentrations are to be achieved with winter wheat.

17. Weeds

Cool temperatures and a reasonable supply of available soil moisture favored weed growth and development in all three years of this program. However, the winter wheat provided excellent competition and major weed problems were restricted to areas where the winter wheat stand was thin or nonexistent. Heavy populations of a variety of weeds were often associated with saline areas that produced poor, uncompetitive winter wheat stands. Wild oat was the most obvious weed problem in areas where the winter wheat had been damaged by low winter temperatures or spring flooding.

The following list provides a ranking of the most common weeds based on their level of occurrence in the fields surveyed:

1) Flixweed	11) Kochia
2) Wild oat	12) Green foxtail
3) Stinkweed	13) Blue burr
4) Couch grass	14) Cleavers
5) Canada thistle	14) Russian thistle
6) Volunteer crops	16) Narrow leaf hawksbeard
7) Wild buckwheat	17] Wild mustard
8) Shepherd's purse	18) Wild barley
9) Sow Thistle	18) Night flowering catchfly
10) Dandelion	20) Scentless camomile
	21) Hemp nettle

Lambs quarters, brome grass, rose bush, ragweed, redroot pigweed, cow cockle, and Persian darnel were also reported in a few fields. Downy brome was reported in one field. Downy brome is a winter annual grass that has the potential to become a major weed problem in winter wheat.

Couch grass was one of the main problem weeds in many winter wheat fields in the late summer. Twenty percent of the fields in this program were sprayed with Roundup before the winter wheat was seeded. Couch grass strips from Roundup misses were evident in several fields indicating that the Roundup had been effective in suppressing the growth of couch grass in the winter wheat.

Roundup was the only herbicide used for fall weed control. Herbicides were applied to 90 percent of the fields in the spring. 2,4-D was the most frequently used herbicide. MCPA, Banvel, Refine Extra, Estaprop, Target, and Buctril M were applied less frequently. Herbicides gave good control of the broadleaf winter annuals like flixweed, stinkweeed, and shepherds purse if the herbicide was applied in the early spring. Later herbicide applications did not effectively control the early broadleaf winter annuals. Good thistle suppression by herbicides was evident in many fields.

Volunteer rye was a major problem in two fields. In both instances, a high proportion of rye in the gram sample prevented the winter wheat from grading in the Canada Western (CW) red winter grades.

18. Diseases and Insects

Root Rot symptoms were observed in 67 percent of the fields surveyed in the three years of this program. In most fields, the visible level of Root rot damage was restricted to a few plants scattered throughout the field. However, Root rot infestations were severe enough to cause a significant grain yield reduction in 14 percent of the fields surveyed in 1994. Grain samples from two of these fields had a bushel weight that was 3.5 lbs lighter and a seed weight that was 10 percent less than the 1994 average.

Leaf Spot, probably due to either tan spot or septoria, was observed in 48 percent of the survey fields. Leaf spot was confined to the lower leaves of the winter wheat plants and did not cause significant damage to the flag leaf and flag- 1 leaf. The incidence of leaf spot was heaviest in a field of Norstar seeded into durum stubble. However, even in this field, there was little damage to the upper winter wheat leaves and it is unlikely that the leaf spot caused a significant yield reduction.

There were symptoms of **Physiological Leaf Spot** in all the winter wheat fields that were seeded to CDC Kestrel in 1994. Physiological Leaf Spot is **not** caused by a disease organism.

Wheat Stem Maggot was only noted in the winter wheat fields in this program in 1994. Damage from the Wheat Stem Maggot was never greater than a very light sprinkling of white heads scattered throughout fields.

Delayed seeding and cool growing seasons meant that many winter wheat fields matured later than normal and the risk of stem and leaf rust damage was a factor of concern in the three years of this program. However, leaf and stem rust arrived late in the growing season of all three years and neither disease caused major crop damage. Leaf senescence had already started in most fields before leaf rust had a chance to become established. Consequently, leaf rust was most noticeable on late maturing plants in winter damaged areas or chaff rows. Stem rust may have limited the yield of a few late maturing fields of Norstar in 1993. However, it did not establish early enough to have a measurable affect on seed size or bushel weight.

	Leaf Spot	Root Rot	Stem Maggot	Leaf Rust	Stem Rust
	------------- Percent of Fields -------------			- Date first reported -	
1992	61	40	0	July 27	August 1
1993	70	67	0	August 4	August 5
1994	16	90	85	July 19	None

19. Crop Height and Lodging

Height of the cultivar Norstar ranged from 19 to 50 inches (48 to 127 cm) with an average of 38 inches (97 cm) during the three years of this program. Many fields had winter wheat stands that were variable in height. This lack of uniformity was primarily due to variable soil conditions, especially in fields that had hills and depressions with different moisture reserves or saline patches.

Significant lodging was observed in 36 percent of the fields that were seeded to Norstar. Crop lodging was not observed in any of the CDC Kestrel fields.

There was a positive relationship between crop height, lodging, and grain yield of the cultivar Norstar Significant lodging occurred in 69 percent of the Nor-star fields that had an average height that was greater than 40 inches (102 cm) and 58 percent of the Norstar fields that had a grain yield of greater than 40 bu per acre.

Norstar fields that had a grain yield of greater than 40 bu per acre had an average height of 42 inches (107 cm). This compares to an average height of 36 inches (91 cm) for CDC Kestrel fields that had a yield of greater than 40 bu per acre.

20. Crop Maturity, Harvest Date, and Grain Drying

The average date of winter wheat maturity (ready to swath) was August 24 in 1992, August 30 in 1993, and August 20 in 1994.

Second growth delayed crop maturity in 35 percent of the fields surveyed during the summer of 1993. The second growth ranged from a few late tillers in several fields to 50 percent of the winter wheat stand in one field that was fertilized with 46-O-O at the end of May. Second growth was usually associated with saline areas in fields, late spring nitrogen fertilizer applications, or early season drought followed by wet weather after mid-June. Winter wheat normally loses a significant number of tillers before heading; however, favorable weather after a short period of early season drought prevented the crop from sluffmg-off excess tillers in 1993. These excess tillers got off to a delayed start producing two stages of crop maturity.

Significant second growth was only observed in one winter wheat field in the summers of 1992 and 1994. This field received an application of nitrogen fertilizer on June 3rd.

Wet weather delayed harvest in 1992 and 1993. The average harvest date for the cultivar Norstar was September 15 (range - August 14 to September 26) in 1992, September 12 (range - September 5 to September 23) in 1993, and August 26 (range - August 14 to September 22) in 1994. The average harvest date for the cultivar CDC Kestrel was August 18 in 1994.

Adverse harvest conditions resulted in 84 and 73 percent of the winter wheat being dried artificially in 1992 and 1993, respectively. Harvest weather was more cooperative in 1994 and only 43 percent of the Nor-star and 20 percent of the CDC Kestrel were dried artificially.

21. Grade

Cool, wet weather interfered with harvest and resulted in 77 percent of the winter wheat grading 3 C.W. in the three years of this program. No. 1 C.W. winter wheat had a protein concentration that was more than one percent higher than the Nos. 2 and 3 C.W. winter wheat grades. However, weathering was by far the most important degrading factor and winter wheat that was harvested soon after it was mature had the best chance of ending up in the top two grades.

	GRADE (CWRW) DISTRIBUTION		
Year	1	2	3
	%		
1992	11	0	89
1993	0	0	100
1994 Norstar	15	31	54
1994 CDC Kestrel	60	0	40
Average	15	8	77

	Protein (%)	Bushel Wt. (lb)	Average Harvest Date
Grade			
1 CW	10.7	62.8	August 16
2CW	9.5	62.9	September 2
3CW	9.4	61.0	September 10

22. **Grain Protein Concentration**

The average grain protein concentration of the winter wheat produced in this program was 9.6 percent. This is considerably lower than the 12 percent protein concentration target of the Canadian Wheat Board.

	GRAIN PROTEIN (%)	
Year	Average	Range
1992	10.2	8.3 to 12.1
1993	8.7	7.4 to 10.1
1994	9.4	8.4 to 11.5

23. Grain Yield

Soil class and amount of nitrogen fertilizer applied were the main variables responsible for differences in winter wheat grain yield in the first three years of this program. Winter wheat grown on productive soils that were supplemented with high levels of nitrogen fertilizer (up to 76 lb N per acre) and a minimum of 15 lb P_2O_5 fertilizer per acre produced the highest gram yields. Grain protein concentrations of less than 11 percent also indicated that higher, more profitable winter wheat yields could have been achieved if higher nitrogen fertilizer rates had been used on most of the fields in this program.

Number of head-producing tillers (spikes per m^2) was the main yield component responsible for the differences observed in grain yield.
Note: Grain Yield (bu/acre) = spikes per m^2 x kernels per spike x kernel weight x .000146

	SOIL CLASS					
	F	G	H	J	K	M
Grain Yield (bu/acre)	45	42	33	36	28	29

	Q_1^z	Q_2	Q_3	Q_4
Grain Yield (bu/acre)	22	36	41	51
Fertilizer N (lb/acre)	29	42	53	59
Kernels per Spike	26	32	32	33
1000 Kernel Wt. (g)	30	32	32	32
Spikes per m^2	191	241	279	330
Grain Protein Concentration (%)	10.1	10.2	9.2	9.7
Protein Yield (lb/acre)	128	218	221	302

z Q_1 - Average performance of the lowest yielding 25 percent of the winter wheat fields in the program.

Q_4 - Average performance of the highest yielding 25 percent of the winter wheat fields in the program.

In the Black and higher rainfall areas of the Dark Brown soil zones, the 1994 average grain yield of well managed Norstar and CDC Kestrel were 44 and 53 bu per acre, respectively.

Norstar winter wheat had a grain yield that approached 60 bu per acre and a grain protein concentration of 11.6 percent when nitrogen fertilizer rate was not a yield limiting factor in Crop Development Centre research plots in the survey region. A farmer cooperator also produced an average yield of 62 bu per acre Norstar with a grain protein concentration of 11.5 percent when 76 lb N per acre was applied to winter wheat grown on several chemical fallow fields in 1994. This achievement demonstrates that the high grain yields and protein concentrations produced in research plots were realistic targets for commercial winter wheat growers given the favorable growing season moisture received from 1992 to 1994.

ACKNOWLEDGEMENTS

Financial support from Ducks Unlimited Canada is gratefully acknowledged. The assistance of B.A. Collins and T. Plews in coordinating the activities of this project and B.T. Fowler and S.P. Fowler in organizing and conducting the field surveys are also gratefully acknowledged. This program would not have been possible without the support of farmer cooperators. The willingness of farmer cooperators to share information on their winter wheat failures and successes is acknowledged with gratitude.

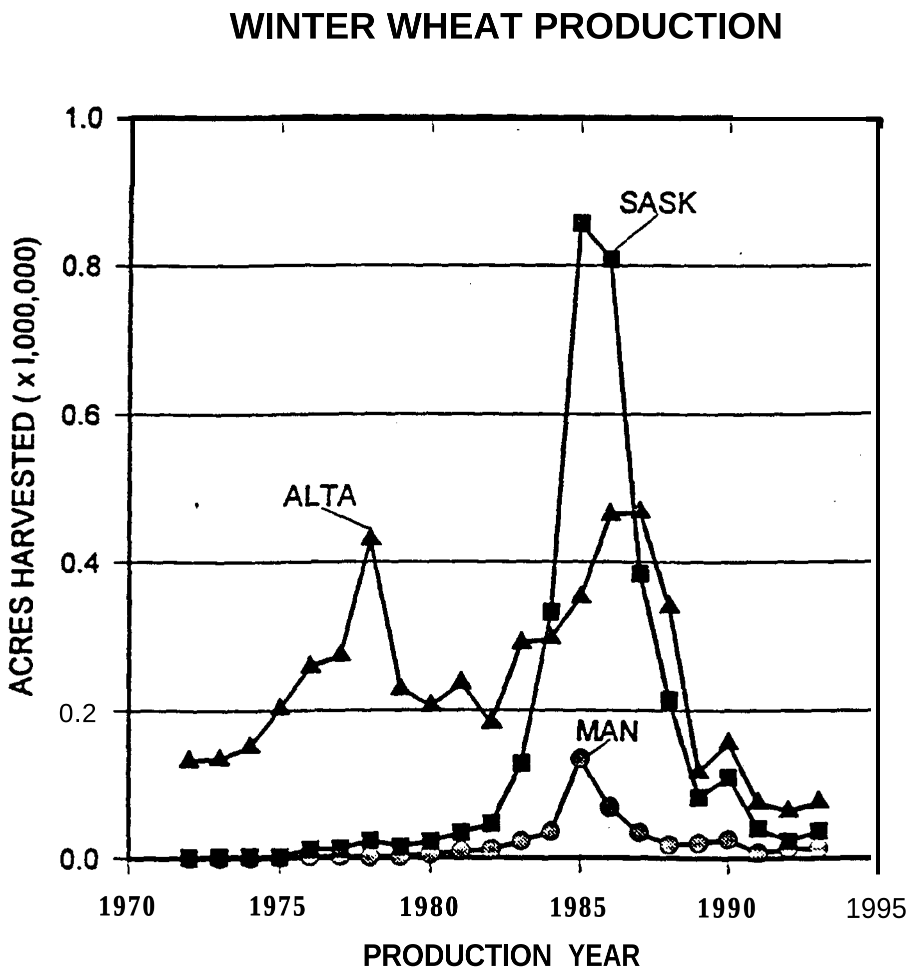

Figure 1. Winter wheat production in Alberta, Saskatchewan, and Manitoba.