Recent Improvements in Winter Wheat Production Potential

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Abstract

The Crop Development Centre (CDC) winter wheat breeding program at the University of Saskatchewan has released eight highly adapted winter wheat cultivars in the 1990's. As a group, they represent the first semidwarf, rust resistant winter wheat cultivars with superior winter hardiness that have been developed in western Canada, or, for that matter, the world. Their short, strong straw allows for the use of higher nitrogen fertilizer rates thereby providing the farmer with the opportunity to achieve both a much higher grain protein concentration and greatly increased grain yield. When combined with the management package that the CDC winter wheat program has developed, they have allowed farmers in higher moisture areas to increase their yield targets from 45 to 50 bu/acre to 60 to 90 bu/acre while maintaining or improving grain protein concentration. As a result, they have been widely accepted by farmers and, according to Canadian Wheat Board surveys, accounted for more than 95 percent of the western Canadian winter wheat acreage in 1999 and 2000.

The improved rust resistance, lodging resistance, and high yield potential of recent CDC cultivar releases makes them highly adapted to the rust hazard area of the prairies. Winter wheat is also of particular interest to farmers in this area because it avoids most of the of problems they have been experiencing with Fusarium Head Blight, Orange Blossom Wheat Midge, herbicide resistant weeds, and seeding delays due to excess spring moisture. In addition to the traditional Canadian Wheat Board markets, the expansion in livestock production across western Canada has increased demand for high-energy low fibre feed grains such as wheat. This has become an important alternate market for winter wheat and demand for this purpose and in other niche markets is expected to continue to grow in the future. Improved cultivar performance, effective extension programs, experienced growers, and new opportunities have resulted nearly a four fold increase in winter wheat production (bushels harvested) in western Canada in the last six years.

Introduction

The northern part of the North American Great Plains and Siberia have the coldest climates for crop production of any large agricultural region in the world. Extreme temperatures, which often fall below -35^{o}C, limit winter annual and perennial crop production in western Canada to only the most cold hardy species unless some means of cold avoidance is exploited. In order to be successful, winter wheat producers in this region must select cultivars with a high level of winter hardiness and adopt management practices that maintain a uniform snow cover on fields to prevent soil temperatures from falling below critical levels.

This paper presents a brief summary of the performance of the ten winter wheat cultivars that have been released for production in western Canada from 1991 to 2000. The CDC program was responsible for seven of the ten western Canadian releases plus Morgan, which was released

through Western Plant Breeders for production in the northern Great Plains region of the USA. An application for plant variety protection in the USA is also being processed for CDC Falcon.
* 1999 - CDC Raptor and CDC Ptarmigan
* 1998 - CDC Falcon (Canada and USA)
* 1997 - CDC Harrier
* 1995 - CDC Clair, CDC Osprey, Morgan (USA)
* 1991 - CDC Kestrel

Canadian Wheat Board Variety Surveys show that cultivars released by the CDC occupied 90.2, 95.2 and 96.4 percent of the prairie winter wheat acreage in 1998, 1999 and 2000, respectively (Table 1). These cultivars have provided major agronomic improvements and not the small incremental changes that we have come to expect in other crop classes. As a result, they have provided the opportunity for winter wheat to be successfully grown outside of the traditional production area in southern Alberta and they have become the keys to establishing the true potential of properly managed winter wheat in western Canada.

Cultivar Performance

Norstar occupied essentially all the winter wheat acres on the Canadian prairies in 1991. It was released in 1977 by Agriculture Canada, Lethbridge and soon became the dominant winter wheat cultivar in western Canada. Norstar represented the successful combination of good yield potential and baking quality of an adapted parent (Winalta) with superior winter hardiness of an introduced parent (Alabaskaja). It was particularly well adapted to conditions of drought stress. Its two major weaknesses were susceptibility to lodging and rust.

CDC Kestrel was the first semidwarf wheat cultivar with good winter hardiness to be released in western Canada and it provided the largest increase in winter wheat cultivar yield potential for the Canadian prairie region since the release of Kharkov 22MC in 1912. Its shorter, stronger straw made it highly adapted to favourable moisture environments and irrigation and it provided winter wheat growers with an extra week or two of protection from stem rust. It essentially eliminated the lodging problem that plagued Norstar and by 1997 it claimed nearly all of the winter wheat acreage outside of southern Alberta and a significant part of the traditional winter wheat production area in southern Alberta.

CDC Kestrel allowed farmers in higher moisture areas to increase their yield targets from 45 to 50 bu/acre (approx. three tonnes/ha) to 60 to 90 bu/acre (four to six tonnes/ha). As a result, CDC Kestrel became the key to establishing the true potential of properly managed winter wheat in western Canada. The grain protein concentration of CDC Kestrel was lower than the target levels for the Canadian export market. However, Hard Red Winter Wheat (82 percent CDC Kestrel in 1998) maintained its Canadian Wheat Board price position relative to spring wheat.

Agriculture Canada, Lethbridge, released a selection from the Montana cultivar Redwin as AC Readymade in 1991. AC Readymade is a medium tall cultivar with good straw strength and excellent grain protein concentration. It has performed best under favourable moisture conditions in southern Alberta. Poor winter hardiness and a very susceptible stem rust reaction have restricted production of this cultivar to southern Alberta.

Table 1. Western Canadian seeded acres (%) by cultivar for the 1998, 1999, and 2000 crop years - Canadian Wheat Board statistics.

1998	Alberta	Saskatchewan	Manitoba	Prairie
CDC Kestrel	33.7	88.6	95.9	81.6
AC Readymade	52.0	0.7	0.0	9.8
CDC Clair	12.5	10.2	3.4	7.8
CDC Osprey	1.3	0.0	0.0	0.5

1999	Alberta	Saskatchewan	Manitoba	Prairie
CDC Kestrel	49.7	65.5	64.1	61.4
AC Readymade	21.7	0.0	0.0	4.8
CDC Clair	22.9	34.5	35.9	32.5
CDC Osprey	5.7	0.0	0.0	1.3

2000	Alberta	Saskatchewan	Manitoba	Prairie
CDC Kestrel	18.9	31.4	43.9	35.0
AC Readymade	24.3	0.1	0.0	3.5
CDC Clair	45.6	66.3	46.1	54.6
CDC Osprey	11.1	0.0	0.2	1.7
CDC Harrier	0.0	1.8	8.8	4.6
CDC Falcon	0.0	0.4	0.9	0.6
AC Bellatrix	0.0	0.0	0.2	0.1

CDC Clair and CDC Osprey are tall semidwarf cultivars that were released by the Crop Development Centre, University of Saskatchewan in 1995. Their agronomic performance has been similar to CDC Kestrel, but they have a higher grain protein concentration. Indications are that CDC Clair will quickly replace CDC Kestrel. Seed distribution of CDC Osprey, which was made a winter wheat grain quality standard for western Canada in 1998, has been a major disappointment. Distribution rights of CDC Osprey were transferred from Proven Seeds to Canterra Seeds.

CDC Harrier is a winter-hardy semidwarf with excellent straw strength and a higher average grain yield than CDC Kestrel. It was the first winter wheat cultivar with a high level of stem rust resistance to be registered for production in western Canada. The grain protein concentration of CDC Harrier was not at target levels for the export market; however, the bulk of the winter wheat grown in the eastern prairies has been going into the domestic feed market where winter wheat is now recognized as a quality product. CDC Kestrel and CDC Harrier quality types are also in demand by the commercial alcohol production industry. CDC Harrier has performed as expected and in 1999 it laid claim to the highest commercial dry land winter wheat yield (nearly 100 bu/acre) in the eastern prairies.

AC Tempest is a selection from the Montana cultivar Redwin that was released by Agriculture Canada, Lethbridge in 1997. Its agronomic performance and disease reactions are similar to AC Readymade, but a higher flour yield makes AC Tempest more attractive to millers. As with AC

Readymade, poor winter hardiness and a very susceptible stem rust reaction will restrict production of this cultivar to southern Alberta.

Release of CDC Harrier represented a significant step towards achieving target leaf and stem rust objectives for the rust hazard area of western Canada and the release of CDC Falcon realized these objectives. CDC Falcon provided farmers in the high winter stress regions of the North American Great Plains with the first winter wheat option with leaf and stem rust resistance in the range of adapted spring wheat cultivars. It is also seven to 10 days earlier maturing than other registered cultivars in seasons that are cool, wet, and late. Short, strong straw, early maturity, and high grain yield potential make CDC Falcon a particularly attractive option for farmers in the higher moisture and irrigation areas who direct seed and direct-combine harvest. CDC Falcon has performed well under good moisture conditions with Manitoba seed growers realizing grain yields as high as 105 bu/acre on dry land increases in 2000.

Agriculture Canada, Lethbridge, released AC Bellatrix in 1999. AC Bellatrix is resistant to common bunt. Due to its susceptibility to rust, AC Bellatrix has not been tested extensively outside of Alberta. As a consequence, a comprehensive database has not been available for consideration in Saskatchewan.

CDC Raptor is a winter-hardy, semidwarf hard red winter wheat with strong straw and good yield potential. The primary advantage of CDC Raptor is stem and leaf rust resistance that is similar to CDC Falcon and superior to all of the other winter wheat cultivars registered for production in western Canada. High grain yield potential and protein concentration combine to give CDC Raptor an average grain protein yield that is higher than all of the currently registered cultivars.

MAIN CHARACTERISTICS OF CDC CULTIVARS COMPARED TO NORSTAR

	----------Resistance to [z] ----------					
Cultivar	Lodging	Winter Damage	Stem Rust	Leaf Rust	Yield [y] Potential _(%)_	Protein _(%)__
Norstar	P	G	VP	P	100	11.8
CDC Kestrel	G	G	P	P	141	11.3
CDC Clair	G	G	P	P	138	12.0
CDC Osprey	G	G	P	P	125	12.0
CDC Harrier	G	G	G	P	151	11.4
CDC Falcon	VG	G	G	G	161	12.4
CDC Raptor	VG	G	G	G	149	12.2
CDC Ptarmigan	G	F	VP	P	N/A	10.3

[z] Resistance ratings: VG - Very Good; G - Good; F- Fair; P - Poor; VP - Very Poor.
[y] Good moisture and a low rust load.

CDC Ptarmigan is a short strawed soft white winter wheat line that represents a new winter wheat quality class for western Canadian farmers. It has a very low protein concentration, which is a plus in the soft white wheat market. Field trials indicate that the grain yield advantage of CDC Ptarmigan over other winter wheat cultivars could be as high as 25 percent in the target production area, which is similar to the current soft white spring wheat production region. A three-year interim registration has been supported for CDC Ptarmigan to allow time for pedigreed seed production, market evaluation, and a CWB Identity Preserved production system to be put into place to accommodate this new winter wheat market class in western Canada.

As a group, the CDC releases represent the first agronomically adapted, winter hardy, high yielding, semidwarf winter wheat cultivars developed in western Canada, or, for that matter, the world. Morgan was the top performing entry in Montana interstate trials following the high stress winter of 1996/97 and the superior cold hardiness of CDC lines and cultivars has been established in European trials. CDC Osprey and CDC Falcon have been registered for production in eastern Canada. There was strong interest in CDC Clair and CDC Falcon in the northern USA Great Plains states and CDC Falcon will soon be under plant variety protection in the USA.

It should be emphasized that an average of only 0.2 professional person years have been devoted to the CDC winter wheat breeding program over the last 10 years. In addition, these plant breeding accomplishments have been achieved by a program that has been forced to operate with resources most plant breeders would consider to be less than a maintenance level and without separate support programs for advanced and regional testing or winter increases.

Commercial Results

In the last ten years, the CDC winter wheat breeding program has released winter hardy cultivars that have a 2, 25, and 61 percent yield advantage over Norstar under drought, good moisture, and minor rust conditions, respectively. The tall plant type of Norstar and its susceptibility to lodging limited the grain yield potential, compromised grain quality due to harvest problems, and limited farmer acceptance of winter wheat in high yield potential environments. The reduced height and increased straw strength of CDC cultivars make them attractive options for farmers who direct-seed and straight-cut harvest and gives them the opportunity to more effectively capitalize on agronomic inputs, such as nitrogen fertilizer. The increased straw strength means farmers now have access to cultivars that can produce grain yields of 9 tonnes/ha (135 bu/acre) without lodging. In contrast, Norstar will start

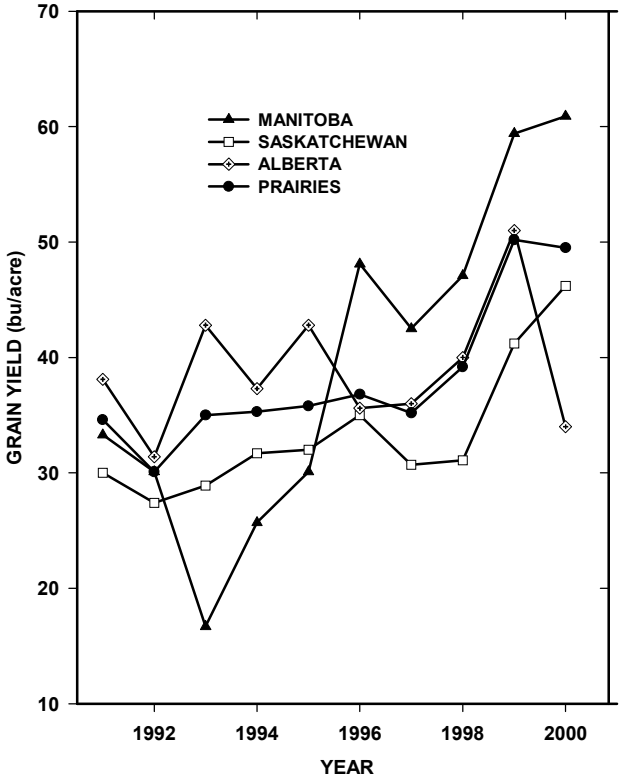

Figure 1. Grain yield of winter wheat in western Canada from 1991 to 2000. Statistic Canada data.

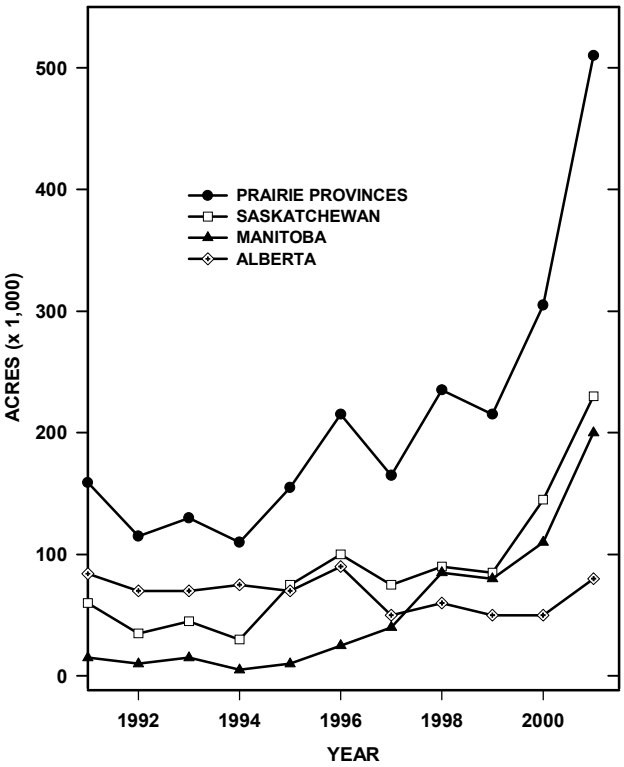

Figure 2. Acres of winter wheat in western Canada from 1991 to 2000. Statistics Canada data.

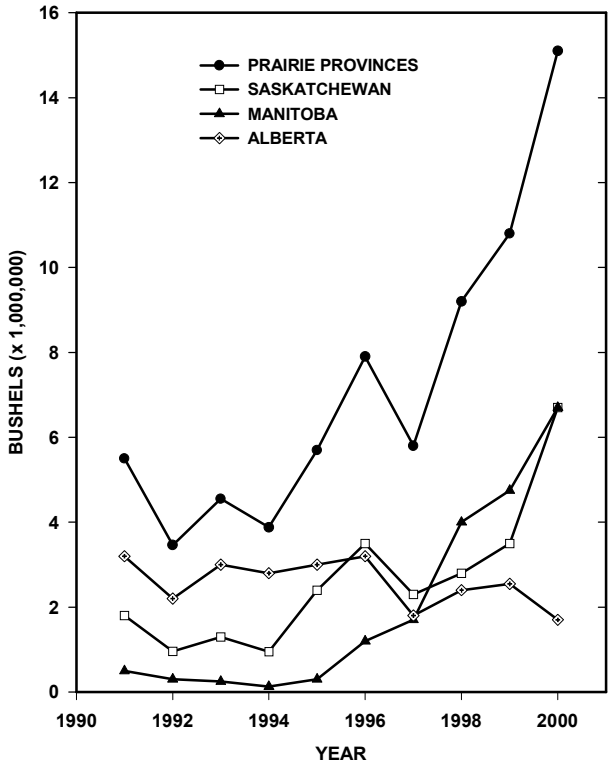

Figure 3. Winter wheat production in western Canada from 1991 to 2000. Statistics Canada data.

to lie down once grain yields reach 3 tonnes/ha (45 bu/acre). The protein concentration of recent CDC cultivars has been higher than Norstar. However, when compared to Norstar, their short, strong straw allows for the use of higher nitrogen fertilizer rates thereby providing the farmer with the opportunity to achieve both a much higher grain protein concentration and greatly increased grain yield. In some of the higher moisture regions of the eastern prairies, experienced winter wheat growers now manage for target grain yields of 80 bu/acre. As mentioned earlier, CDC Falcon and CDC Raptor have given western Canadian farmers the first winter wheat options with leaf and stem rust resistance in the range of adapted spring wheat cultivars.

Recent evidence that farmers are generally employing management practices that have allowed them to capture the yield advantage of the semidwarf cultivars can be drawn from Statistics Canada grain yield estimates for the last 10 years (Figure 1). Manitoba provides the most dramatic example, where average grain yields increased from 16.7 bu/acre in 1993 to 60.9 bu/acre in 2000. Although less dramatic, an increase from 28.9 to 46.2 bu/acre over the same period indicates that a similar trend is being experienced in Saskatchewan. Improved cultivar performance, effective extension programs, and a high level of crop management have combined to produce these success stories. Higher per acre returns and low input costs have been reflected in increase seeded acres of winter wheat. More acres (Figure 2) and higher per acre yields have in turn resulted nearly a four fold increase in winter wheat production (bushels harvested) in western Canada in the last six years (Figure 3).

Replacement of Norstar by the CDC semidwarf winter wheat cultivars has

provided farmers in the higher moisture, rust hazard area of the eastern prairies with the opportunity to raise their yield targets by at least 30 bu/acre on an average year. Even if one only assumes $3.00/bu wheat, this represents a $90/acre value-added benefit to the farmer. This example clearly demonstrates the economic impact that this program has had on the winter wheat grower's bottom line.

Opportunities

In 1997, the PRRCG - Wheat, Rye and Triticale Quality Evaluation Team noted that the marketing of the winter wheat class has been difficult due to several problems with existing cultivars and inherent limitations in the small amount of CWRW grown. All four winter wheat breeding programs in western Canada have made grain quality a priority. However, with the present price structure it is clear that grain yield will have to continue to be the major priority if winter wheat is going to be a viable cropping option for western Canadian farmers. We must also recognize that a large proportion of the winter wheat grown in the eastern prairies has been going into the domestic feed market where winter wheat is now recognized as a quality product. CDC Kestrel and CDC Harrier quality types are also in demand by the commercial alcohol production industry. Support for the interim registration of the soft white winter wheat cultivar CDC Ptarmigan provides a new winter wheat quality option for western Canadian farmers that is similar to the soft white spring wheat class. This cultivar provides a here-to-fore unexplored opportunity to capitalize on the high grain yield potential of winter wheat and its associated low protein concentration. Low protein concentration is required for high soft white wheat quality and shifting winter wheat breeding objectives in this direction would turn a long term negative factor (low protein concentration) into a positive advantage for winter wheat. By combining the soft white spring and winter wheat quality types into one class the problem of market supply would also be reduced for both wheat types. These opportunities demonstrate that there are a number of market options that need to be investigated for winter wheat. Low production has provided a severe limitation to the export potential of this crop and until winter wheat becomes more widely accepted it would seem advantageous to expend some effort exploring the potential of smaller niche markets.

The outstanding winter hardiness of the lines and cultivars developed by the Crop Development Centre winter wheat program combined with their exceptional productivity and wide adaptation has been widely recognized. As a consequence, this program has become a primary source of high performing, cold-hardy genes for use in breeding programs around the world. This is a very important development because it increases the probability that improved lines from other programs will start to provide germplasm that can be more easily and quickly incorporated into western Canadian winter wheat breeding programs. (Note: many of the parents used to develop the CDC cultivars could not even be evaluated in Saskatchewan because of their poor winter hardiness). Their widespread use has also greatly increased the likelihood that cultivars from other programs will be winter hardy enough for release in western Canada for the direct benefit of western Canadian winter wheat growers.

Morgan, which is a sister line of CDC Clair, was the top performing entry in Montana interstate trials following the high stress winter of 1996/97, but its yield performance fell back to the average of the cultivars under evaluation following the low stress winter of 1997/98. These

observations together with the yield advantage shown by CDC Ptarmigan in low moisture environments indicate the yield potential of winter hardy wheat cultivars can be further improved. Winter wheat strains have been identified with superior winter hardiness, greater yield potential, more diverse grain quality, and improved resistance to diseases and insects compared to the cultivars that have been registered for production in western Canada in the 20th century. Successful selection for these traits has established that the necessary genetic resources are available for the creation of better-adapted, more productive cultivars for a wide variety of wheat quality classes. Basic germplasm has been developed, networks have been established, credibility is at an all time high, and new, effective tools are waiting to be used. The opportunity for rapid winter wheat cultivar improvement has never been greater. However, before we make the investment that will be necessary to seize this opportunity, funding agencies and farmers must be convinced that winter wheat has a significant role to play in the future of northern prairie agriculture.

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Winter crops have a widely recognized role to play in multiple land use and sustainable farming systems. When combined with no-till seeding methods, they provide the most environmentally friendly cropping option available in the Canadian prairies and Northern Great Plains. No-till winter cereals create a production system that embraces the philosophy of conservation farming by providing for erosion control, reduced pesticide requirements, more efficient crop moisture utilization, reduced summerfallow, lower energy requirements due to less tillage, and higher productivity. The absence of tillage operations in the spring results in less disturbance to wildlife and, as a result, winter crop production is actively being promoted by conservation groups.

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