Wheat and Barley Varietal Replacement In Western Canada

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Abstract

This paper looks at varietal replacement of wheat and barley by province in western Canada with respect to the rate of varietal replacement and varietal concentration. A varietal replacement index (VRI) is calculated to represent the rate of varietal replacement using Canadian Wheat Board annual variety survey data for the years 1998-99 to 2004-05. It was hypothesized that the province of Manitoba would have the highest rate of varietal replacement followed by Saskatchewan and then by Alberta. This is based on the claim by researchers that, due mainly to higher rainfall and humidity, the incidence of crop disease is greater in that part of the prairies east of a line drawn through Moose Jaw and Melfort Saskatchewan, and therefore farmers change their varieties more often. The VRIs for the three provinces confirm the hypothesis for Canada Western Red Spring (CWRS) wheat and for malting barley varieties. The hypothesis does not hold for Canada Western Amber Durum (CWAD) and Canada Prairie Spring Red (CPSR) wheat but holds for Canada Western Red Winter (CWRW). This was expected given the relative importance of these markets and corresponding research budgets compared to CWRS. However, a relatively high concentration ratio for CWAD was not expected given the importance of the CWAD market and the varietal research budgets devoted to this class of wheat.

Introduction

Farmers change wheat and barley varieties for a number of reasons. The major reasons for change are yield advantage, yield loss avoidance from crop diseases and pests, and specific characteristic advantage. Characteristics such as protein content, days to maturity and lodging resistance are considerations when making varietal selection. Varietal change is also a function of seed availability and cost (seed/grain price ratio).

Because of these varied reasons, the rate of varietal replacement differs by country, by region and by crop.

Tracking varietal replacement is an important source of information; (i) the information can be used as an indicator of the economic impact of plant breeding and extension programs; a higher rate of replacement is likely to have a positive correlation with higher returns to plant breeding research and extension activities; (ii) the information can be used to assess the vulnerability of a crop to disease epidemics by comparing the expected longevity of varieties with the make-up of the varieties actually used in farmers' fields; (iii) it can be used as a guide to target the frequency of varietal release based on the expected longevity of varieties in the field; and (iv) as an assessment of genetic diversification over time (adapted from Brennan and Byerlee 1991).

This paper looks at varietal replacement of wheat and barley by province in western Canada with respect to (i) the rate of varietal replacement, and (ii) varietal concentration. A varietal replacement index is calculated to represent the rate of varietal replacement. The western Canada rates of varietal replacement are also compared with available rates of varietal replacement from other countries. Data for the analysis comes from the Canadian Wheat Board (CWB) 1998-99 to 2004-05 annual variety surveys.

One hypothesis to be tested is that the rate of varietal change in the eastern part of the Canadian prairies is higher due to a higher incidence of disease than in the western part of the prairies. It is claimed that, due mainly to higher rainfall and humidity, the incidence of crop disease is greater in that part of the prairies east of a line drawn through Moose Jaw and Melfort Saskatchewan, and therefore farmers change their varieties more often. Thus it is hypothesized that Manitoba will have the highest rate of varietal replacement followed by Saskatchewan with Alberta having the lowest rate of varietal replacement.

METHODOLOGY

Varietal Replacement Index

The analysis uses the Brennan and Byerlee (1991) index of the weighted average age of varieties.[1] The varietal replacement index (VRI) is a measure of the rate of varietal replacement that takes into consideration the age of the varieties and their relative sown area:

$$VRI_t = \sum_i P_{it} (t - y_i), \text{ where;} \quad (1)$$

VRI_t = the weighted average age of varieties in year t,
P_{it} = the proportion of area sown to variety i in year t,
y_i = year of release of variety i.

The larger the VRI, the slower the varietal replacement and the older is the stock of the varieties being planted. There is a theoretical optimum replacement rate that reflects yield advantage, varietal longevity with respect to disease susceptibility, and other desired characteristics. The desired optimum replacement rate can be compared with the actual replacement rate as calculated by equation (1)[2]. Also, the trend in the actual replacement rates can be estimated.

Varietal Concentration

Variety area shares are calculated as the percentage area sown in a given year to (i) the most popular or dominant variety, (ii) the most popular two varieties (two-variety share) and (iii) the most popular four varieties (four-variety share).

The Data

The CWB has conducted an annual wheat and barley variety survey since 1998-99.[3] The survey is mailed to all permit book holders but farmers can also fill in the survey questionnaire on the CWB web-site where a copy of the questionnaire can be found. Past CWB variety survey results can also be found on the CWB web-site. All wheat types are included in the survey as are the malt, feed and hulless barley classes. The feed barley information, although collected, has only been analyzed by the CWB for 2002-03 to 2004-05.

On average, about 20% of CWB permit book holders respond each year to the survey. In 2003-04, there was a total of 12,829 respondents; Manitoba 2,745 (21.4%) Saskatchewan 6,485 (50.5%) and Alberta and B.C. 3,599 (28.1%). Of the 3,599 from Alberta and B.C., only 29 respondents were from B.C. The number of respondents by province closely reflects the average number of permit book holders in each province – Manitoba 15%, Saskatchewan 59% and Alberta 26%.

The CWB variety survey data is the best available although sample size may be a problem for some of the wheat and barley categories (Table 1). Sample size calculations using standard sample size methodology (Poate and Daplyn 1993) suggest that a minimum sample would be about 385 farmers per category.[4] The numbers of Canada Western Extra Strong (CWES), Canada Prairie Spring White (CPSW, and Canada Western Soft White Spring (CWSW) respondents are likely too small to use the results with any degree of certainty on a provincial basis. The two-row hulless barley (Hulless-2r) and the six-row hulless barley (Hulless-6r) sample sizes are definitely too small to use even on a western Canada basis. There is also the question of randomness. The respondents are not randomly chosen and the raw CWB data has not been researched to determine the randomness of the sample. Although, the respondent distribution by province closely reflects permit book holders by province, it is not known for example, if the survey adequately covers all sub-regions (i.e., soil zones, crop districts) within each province or if all farm sizes, which may have a bearing on varietal choice, are represented.

Nevertheless, the sample sizes are fairly robust, with the exceptions noted above, especially for Canada Western Red Spring (CWRS), Canada Western Amber Durum (CWAD), Canada Prairie Spring Red (CPSR), Canada Western Red Winter (CWRW), and for both the two row (Malt-2r) and the six row (Malt-6r) malt barleys and for the feed barleys.

Table 1. CWB survey responses and wheat and barley acreage by class

	CWB Survey	Western Canada [z]		Manitoba		Saskatchewan		Alberta	
Varietal Class	2003-04	Acres	Percent by Class	Acres	Percent by Class	Acres	Percent by Class	Acres	Percent by Class
		---------- (1998-2003 average, thousand acres) ----------							
Wheat									
CWRS	11,718	16,114	67.5%	3,053	89.9%	8,621	61.7%	4,355	68.0%
CWAD	3,208	5,600	23.4%	71	2.1%	4,523	32.4%	1,006	15.7%
CPSR	546	1,129	4.7%	40	1.2%	323	2.3%	750	11.7%
CPSW	55	245	1.0%	6	0.2%	202	1.4%	37	0.6%
CWES	61	340	1.4%	56	1.6%	134	1.0%	149	2.3%
CWSW	74	45	0.2%	1	0.0%	4	0.0%	40	0.6%
CWRW	545	316	1.3%	138	4.1%	122	0.9%	55	0.9%
Other		190	0.8%	61	1.8%	102	0.7%	26	0.4%
Total		23,884	100%	3,397	14.2%	13,979	58.5%	6,405	26.8%
Barley [y]									
Malt-2r	4,432	4,226	48.4%	225	24.7%	2,508	61.5%	1,469	39.9%
Malt-6r	1,277	1,427	16.3%	446	48.8%	880	21.6%	70	1.9%
Feed [x]	2,415	2,937	33.6%	200	21.9%	624	15.3%	2,114	57.4%
Hulless [w]	48	140	1.6%	43	4.7%	66	1.6%	30	0.8%
Total		8,730	100%	915	10.5%	4,077	46.7%	3,683	42.2%

Source: Survey Responses from CWB. Acreage data from "Seeded Acreage Statistics", CWB.
[z] Acreage numbers do not add up, as the area for B.C. Peace River is not shown.
[y] CWB collects barley acreages by class designation Two-Row, Six-Row, Hulless 2-R and Hulless 6-R. Malt and Feed Barley acreages are estimated using the percentage area seeded by barley class from CWB variety survey results. Also, the percentages were checked for consistency with crop insurance data.
[x] Number of respondents by Feed-2r (1,520) and Feed-6r (895).
[w] Number of respondents by Hulles-2r (32) and Hulless-6r (16).

RESULTS
Varietal Replacement

Wheat Varietal Replacement

The wheat varietal replacement indexes for western Canada and by prairie province for four of the seven wheat types are presented in Table 2. The information for B.C. is not presented because of the small number of respondents. For the same reason, information is presented for CWES, CPSW and CWSW only on a western Canada basis.

Table 2. Wheat varietal replacement indexes [z] 1998-2004, Western Canada

	98-99	99-00	00-01	01-02	02-03	03-04	04-05	Average VRI	Time Trend [y]
CWRS									
Western Canada	8.7	8.3	8.1	8.5	8.9	9.3	9.4	8.8	0.17**
Manitoba	5.4	5.6	6.2	7.0	8.6	9.1	8.8	7.2	0.69*
Saskatchewan	9.4	8.7	8.3	8.5	8.7	9.2	9.5	8.9	0.06
Alberta	10.2	9.4	9.4	9.3	9.3	9.6	9.7	9.6	-0.04
CWAD									
Western Canada	12.9	14.1	13.7	12.5	12.3	13.1	12.7	13.0	-0.14
Manitoba	11.8	10.7	7.3	8.8	11.0	14.6	15.1	11.3	0.77***
Saskatchewan	13.1	14.4	14.1	12.8	12.5	13.2	13.1	13.3	-0.14
Alberta	12.4	13.2	12.7	11.6	11.7	12.5	11.5	12.2	-0.18***
CPSR									
Western Canada	6.9	7.1	6.7	6.6	7.4	7.9	7.9	7.2	0.19*
Manitoba	6.3	5.4	6.9	8.3	9.7	10.7	10.0	8.2	0.88*
Saskatchewan	6.1	6.0	5.9	5.9	7.1	7.3	7.3	6.5	0.26*
Alberta	7.2	7.6	6.9	6.9	7.5	8.1	8.0	7.5	0.15***
CWRW									
Western Canada	6.6	6.6	6.4	6.6	6.2	7.1	7.1	6.7	0.02
Manitoba	6.8	6.6	6.6	6.2	5.7	5.7	6.1	6.2	-0.16**
Saskatchewan	6.6	6.6	6.2	6.6	7.0	7.6	7.9	6.9	0.14**
Alberta	6.4	6.9	6.7	7.8	6.4	8.5	8.2	7.3	0.20***
CWES									
Western Canada	20.6	19.9	19.0	18.7	18.3	17.7	18.0	18.9	-0.47*
CPSW									
Western Canada	5.4	6.1	6.4	6.4	7.2	8.6	10.2	7.2	0.72*
CWSW									
Western Canada	9.3	9.0	8.8	6.7	9.0	6.5	3.7	7.6	-0.77**

[z] Varietal replacement indexes calculated using equation 1.
[y] *, **, *** denotes significance at 1%, 5% and 10% levels, respectively. Estimated by OLS linear time trend regression.

For western Canada, the weighted average age of CWRS varieties is 8.8 years and has marginally increased by an average of 0.17 years each year over the 1998-99 to 2004-05 period. In Manitoba, there is a highly positive trend of 0.69 years each year while for Saskatchewan it is positive but not significant. Alberta shows a slight negative VRI trend. The weighted average age of CWRS varieties are the lowest in Manitoba followed by Saskatchewan and then by Alberta. The results conform to the hypothesis that Manitoba has the highest rate of varietal replacement followed by Saskatchewan and Alberta in that order. However, the yearly difference in the VRI between Manitoba and Saskatchewan has considerably narrowed over time with almost all the movement coming from Manitoba (Figure 1). AC Barrie (1994 release) and AC Domain (1993 release) continue to be two of the most popular Manitoba varieties with a two-variety share of 60.2% in 2004-05. AC Barrie has an FHB rating of Fair[5] but is acknowledged to have a higher resistance to FHB than the other current varieties, which may be the reason it has remained popular

(Western Grains Research Foundation 2004). In addition, both AC Barrie (14.5%) and AC Domain (15.6%) have high protein levels. Of the nine varieties used by farmers in Manitoba that were released after 1994, six have a FHB rating of Poor. None of the three post 1994 varieties with a FHB rating of Fair have a higher protein level than AC Barrie. The above may in part explain why the Manitoba VRI is increasing but it is clear that at present, farmers have a preference for the characteristics of the older varieties.

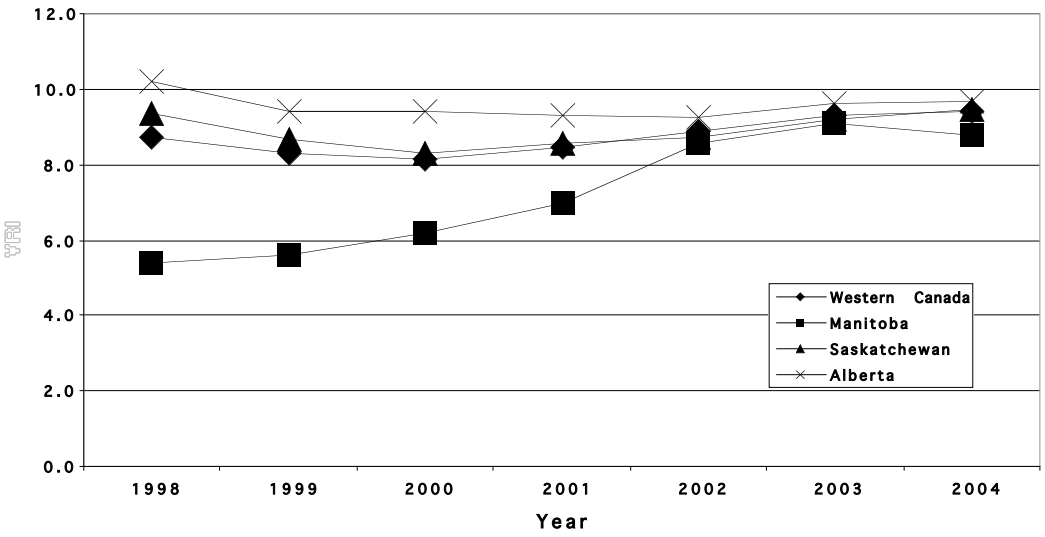

Figure 1: CWRS Varietal Replacement Index 1998-2004

The weighted average age of CWAD varieties are considerably higher than those of CWRS indicating that farmers do not change durum varieties as often as CWRS varieties. This may in large part be due to the fact that about 75% of the durum acreage in western Canada is grown west of the Moose Jaw/Melfort line where disease pressure is considerably less. With only about 25% of the market, there may be little incentive for plant breeders to produce new varieties for specific conditions east of the Moose Jaw/Melfort line, in particular for Manitoba, which only accounts for about 3.0% of western Canada durum acreage. The western Canada VRI trend is slightly negative as are the VRIs for Saskatchewan and Alberta.[6]

On a western Canada basis, the weighted average age of both CPSR and CWRW varieties are slightly lower than CWRS. The western Canada VRI trend is slightly positive for both CPSR and CWRW. The Manitoba CPSR VRI trend is highly positive increasing at about .88 years each year. AC Taber (1991 release) is the dominant Manitoba variety (40.1% in 2004-05 as presented in Table 5) with a FHB rating of Very Poor, as are the ratings for all the post 1991 released varieties. However, AC Taber yield is higher than all but one release (5700PR). There are also only two seed growers growing two varieties at present in Manitoba thus giving little choice for farmers. For Manitoba,

farmers growing CWRW have been switching from CDC Clair (1995 release) and CDC Harrier (1997 release) to CDC Falcon (1998 release) and CDC Raptor (1999 release).

The average age of CWES varieties is quite high at 18.8 years; however, the VRI trend is negative (-0.47). CWES is a relatively new wheat class in terms of market development with new varieties only recently been made available to farmers, which are slowly replacing the once dominant industry standard Glenlea (1972 release) and the now dominant Bluesky (1987 release). However, their 2004-05 two-variety share is still high at 68.4% as presented in Table 5. None of the post 1987 released CWES varieties have superior characteristics to Glenlea or Bluesky and all have a FHB rating of Poor. The newly released variety CDC Rama has a FHB rating of Fair and some seed for commercial production was available in 2004. If farmers rapidly adopt CDC Rama, the CWES VRI should rapidly decrease.

The average age of CPSW varieties is 7.2 years but the VRI trend is highly positive and has increased on average by 0.72 years each year over the study period. Only four varieties are grown. The dominant variety is AC Vista (1996 release) with 48% of the area in 2004-05. The only post-1996 release variety grown by farmers is AC 2000, which as yet, has not replaced the older varieties to any significant extent. The average age of CWSW varieties is 7.6 years and the VRI trend is negative (-0.77). AC Andrew (2001 release) went from zero area in 2002-03 to 85.6% of the area in 2004-05 replacing a large proportion of each of the three older varieties grown. AC Andrew has a higher grain yield and earlier maturity. The switch from a high VRI in 2000-2001 to a low VRI in 2001-02 back to a high VRI in 2002-03 is because farmers switched from AC Reed (1991 release) to AC Nanda (1998 release) and AC Phil (1996 release) but then switched back to AC Read.

A comparison of wheat varietal indexes can be made between western Canada (Table 2) and selected developed countries (Table 3). Unfortunately, the latest information in Table 3 is dated. With the exception of CWAD and CWES, the VRIs in Table 2 are similar to the developed countries VRI of 7.1 years in Table 3. The Kansas, USA VRI of 6.7 is somewhat lower than the CWRS VRI of 8.6; however, the two time periods make the comparison less useful.

The information from Tables 2 and 3 indicate that VRIs from developed countries with mature research, seed production and extension programs are consistent across countries and regions. In contrast, developing country VRIs can be quite variable. For example, for similar time periods as given in Table 3, Brennan and Byerlee (1991) calculate the following wheat VRIs: Pakistan Punjab (11.1), India Punjab (5.3), and the Yaqui Valley, Mexico (3.1).[7] For Bangladesh, Nagy and Alam (2000) calculate a 1999 VRI of 17.5 for wheat (the variety Kanchan, released in 1983, was sown to 80% of wheat area in 1999).

Table 3. Wheat varietal replacement indexes, developed countries

	Data Period	Average VRI	Time Trend [z]
Kansas, USA	1970-1986	6.7	0.06**
NSW, Australia	1970-1985	7.6	-0.11**
Argentina (North)	1970-1980	6.8	-0.06
Developed Countries	1970-1986	7.1	-0.01

Source: Brennan and Byerlee, 1991, Table 2 and Heisey et al., 1993.

[z] *, **, *** denotes significance at 1%, 5% and 10% levels, respectively. Estimated by OLS linear time trend regression

Barley Varietal Replacement

The malt barley varietal replacement indexes for western Canada and by prairie province are presented in Table 4. For western Canada, the weighted average age of Malt Barley-2-r varieties is 11.7 years, which is in contrast to the weighted average age of Malt Barley-6-r varieties of 7.6. This is not surprising, as generally, 2-row barley varieties have not been recommended for production in eastern Saskatchewan and Manitoba due to greater disease susceptibility and greater susceptibility to sprouting. Thus two-row varieties have a higher longevity because they are mostly grown in the western prairies where disease pressure is less. Most of the malt demand has been for 2-row varieties. In 1999-2000, 2-row varieties made up 93% of the domestic malt market and 58% of the export malt market (Saskatchewan Agriculture, Food and Rural Revitalization 2004). Moreover, the malt barley industry tends to stay with a proven variety until a new variety either meets or exceeds the current industry standard and this information is passed on to farmers. The industry standard has been the variety Harrington (1981 release) that is over twenty years old but was grown on 67.1% of the 2-row area in 1998-99 and is still grown on 14.4% of the area in 2004-05. The Manitoba VRI average is lower than Saskatchewan and Alberta because Harrington has all but been replaced in Manitoba by CDC Stratus (1994 release) and AC Metcalfe (1997 release).

Table 4. Barley varietal replacement indexes[z] 1998-2004, Western Canada

	98-99	99-00	00-01	01-02	02-03	03-04	04-05	Average VRI	Time Trend [y]
Malt Barley-2r									
Western Canada	14.0	13.6	12.2	11.2	10.3	10.6	9.8	11.7	-0.73*
Manitoba	8.9	7.8	6.1	5.9	6.9	8.3	7.7	7.4	-0.05
Saskatchewan	13.3	13.3	12.1	10.5	9.8	10.0	9.3	11.2	-0.75*
Alberta	14.9	14.5	13.2	13.1	12.0	11.9	10.8	12.9	-0.66*
Malt Barley-6r									
Western Canada	5.6	6.4	6.7	8.0	8.4	9.4	8.9	7.6	0.49*
Manitoba	3.8	5.2	6.1	7.3	8.1	9.5	7.0	6.7	0.72*
Saskatchewan	6.7	6.3	6.7	8.1	8.0	9.1	7.6	7.5	0.34**
Alberta	8.7	10.2	9.1	11.6	10.9	11.2	10.6	10.3	0.34**

[z] Varietal replacement indexes calculated using equation 1.

[y] *, **, *** denotes significance at 1%, 5% and 10% levels, respectively. Estimated by OLS linear time trend regression.

The Malt Barley-2-r VRI trend in western Canada is highly negative (-0.73), which is a reflection of Harrington being gradually replaced, primarily by AC Metcalfe (1997 release) and to a lesser extent by CDC Kendall (1995 release). Both these varieties also have a FHB rating of Fair.

The Malt Barley-6-r VRI trend is highly positive (0.49), which is a reflection of Robust (1994 release) and Excel (1994 release) having become the industry standard as they have not been replaced to any great extent by post 1994 released varieties. Their popularity is in spite of the fact that both varieties have an FHB rating of Very Poor. However, most post-1994 variety FHB ratings are also rated as Very Poor. The western Canada two-variety market share for 2004-05 was 66% (Table 6) and has not deviated much over the analysis period. The Alberta VRI is highest and the variety mix differs from Manitoba and Saskatchewan in that the variety B1602 (1989 release) is the dominant variety in Alberta and has been over the analysis period. There have been specific market programs for B1602 and Robust for export to the USA. The B1602 FHB rating is also Very Poor and little is grown in Manitoba (4.4% area) while more is grown in Saskatchewan (16.3% area).

The average VRI for both Malt Barley-2-r and Malt Barley-6-r are the lowest in Manitoba followed by Saskatchewan then Alberta. The results conform to the hypothesis that Manitoba has the highest rate of varietal replacement followed by Saskatchewan and Alberta in that order. However, the Manitoba VRI trend for Malt Barley-6-r has been highly positive and the Manitoba VRI surpassed the Saskatchewan VRI in 2002-03 and 2003-04.

Varietal Concentration

Wheat Variety Concentration

The number of varieties by wheat class that have been planted to 1% or more of the area sown in 2004-05 is presented in Table 5. Of the 32 CWRS varieties listed as being used by farmers in the CWB survey, only 16 were planted to 1% or more of CWRS area. With the exception of CWRW, farmers plant two to three times more CWRS varieties than for other wheat classes. Manitoba farmers plant less CWRS varieties than either Saskatchewan or Alberta, which again may relate to higher disease susceptibility.[8] For western Canada, 14 of the 16 CWRS varieties are planted to less than 10% of total CWRS area. The two varieties sown to more than 10% (AC Barrie and AC Superb) have a two-variety share of 40.2%. For all other wheat classes, 2 to 4 varieties are planted to more than 10% of their respective areas with the exception of CWSW.

The number of CWRS varieties grown by farmers has increased dramatically since the early 1980s. Dahl and Wilson (1997) report that for CWRS in 1980, Manitoba farmers grew four varieties, Saskatchewan farmers grew nine and Alberta farmers grew eight. For CWAD, they report that in 1980, Manitoba farmers grew three varieties and Saskatchewan and Alberta farmers each grew six. In contrast, for the same year, North

Dakota farmers grew 11 durum varieties. Dahl and Wilson (1997) suggest that Canada's variety development and release requirements are more stringent than in the USA. Canadian Plant Breeder's Rights enacted in 1990 along with the establishment of the Western Grains Research Check-off on wheat and barley in 1993 may account for some of the increase in the number of varieties grown.

Table 5. Concentration of wheat varieties

	Number of Varieties Grown in 2004-05		Dominant Variety in 2004-05		Variety Area Shares in 2004-05	
	Area > 1%	Area > 10%	Variety	% Area	Two-Variety Shares	Four-Variety Shares
CWRS						
Western Canada	16	2	AC Barrie	25.8	40.2	54.5
Manitoba	11	3	AC Barrie	43.1	62.1	82.6
Saskatchewan	15	3	AC Barrie	28.8	40.2	59.4
Alberta	15	3	AC Superb	16.2	28.0	46.7
CWAD						
Western Canada	5	2	Kyle	41.2	80.9	94.5
Manitoba	7	2	Kyle	58.4	81.1	92.8
Saskatchewan	5	2	Kyle	44.0	82.2	94.5
Alberta	5	3	AC Avonlea	45.2	76.4	94.5
CPSR						
Western Canada	5	3	AC Crystal	51.8	77.8	97.7
Manitoba	4	4	AC Taber	40.1	66.2	100
Saskatchewan	4	2	AC Crystal	67.4	91.8	99.9
Alberta	5	4	AC Crystal	46.4	73.0	96.9
CWRW						
Western Canada	10	2	CDC Falcon	41.2	58.0	71.5
Manitoba	6	1	CDC Falcon	75.2	83.4	95.5
Saskatchewan	9	4	CDC Clair	40.1	54.2	79.0
Alberta	8	4	AC Bellatrix	28.7	51.2	83.5
CWES						
Western Canada	5	3	Bluesky	41.5	68.4	97.4
CPSW						
Western Canada	4	3	AC Vista	48.0	78.4	99.9
CWSW						
Western Canada	5	1	AC Andrew	85.6	90.8	98.9

Barley Variety Concentration

Of the 12 Malt Barley-2-r varieties listed as being used by farmers in the CWB survey, 8 were planted to 1% or more of Malt Barley-2-r area in 2004-05 (Table 6). For six-row, 9 are listed but only 7 planted to 1% or more of Malt Barley-6-r area. The same variety of Malt Barley-2-r (AC Metcalfe) is dominant in each province unlike Malt Barley-6-r where a different dominant variety exists in each province. The three six-row varieties dominant in each province have a FHB rating of Very Poor thus farmers are choosing the varieties based on other characteristics more suited to their location. AC Metcalfe has stable high

demand, since only 25% to 30% of the 2-r malt that is grown is accepted; a farmer can increase the possibility of acceptance by growing a variety that has a large market (Saskatchewan Agriculture, Food and Rural Revitalization 2004). Robust is the only malt variety to be rated good for lodging resistance in Manitoba over this period. In Alberta, the malt variety B1602 is being actively promoted by Agricore United so as not to rely on the more fusarium prone areas of the Prairies. Excel in Saskatchewan has consistently higher yields in the Parkland Region and stable market demand, the only variety to have a very good rating for lodging.

Table 6. Concentration of barley varieties

	Number of Varieties Grown in 2004-05		Dominant Variety in 2004-05		Variety Area Shares	
	Area > 1%	Area > 10%	Variety	% Area	Two-Variety Shares	Four-Variety Shares
Malt Barley-2r						
Western Canada	8	3	AC Metcalfe	47.8	62.3	85.1
Manitoba	8	2	AC Metcalfe	61.5	78.2	88.3
Saskatchewan	7	4	AC Metcalfe	44.9	64.5	86.7
Alberta	7	2	AC Metcalfe	48.6	69.5	85.5
Malt Barley-6r						
Western Canada	7	3	Robust	35.1	66.0	88.0
Manitoba	5	2	Robust	59.8	81.3	96.2
Saskatchewan	7	3	Excel	42.3	64.8	87.8
Alberta	7	2	B1602	35.4	49.9	64.0

CONCLUSION

It was hypothesized that Manitoba would have the highest rate of varietal replacement followed by Saskatchewan and then by Alberta. This was based on disease pressure that increases in a west to east direction in the prairies and that farmers would change to newer varieties more often where disease pressure was highest. The VRIs for the three provinces confirm the hypothesis for CWRS although the Manitoba VRI has steadily increased. Manitoba farmers have a preference for the characteristics of the older varieties over newly released varieties, especially FHB resistance, and have not changed to the newer varieties as rapidly. Disease pressure combined with the market incentives to produce high quality will continue to drive CWRS variety selection and the rate of varietal turnover in the eastern region of the Prairies. The hypothesis basically holds for CWAD although Saskatchewan has a higher VRI than Alberta. However, the Manitoba CWAD VRI can be largely discounted, as only 3% of prairie CWAD is grown in Manitoba. The hypothesis holds for CWRW but not for CPSR where Manitoba has the highest VRI.

The malt barley VRIs for the three provinces also confirm the hypothesis for both two-row and six-row barley varieties. However, the Manitoba VRI trend for Malt Barley-6-r has been highly positive and the Manitoba VRI has surpassed the Saskatchewan VRI in 2002-03 and 2003-04.

The market for CWRS varieties in western Canada can be segmented into two distinct markets. The relatively high turnover rate of CWRS varieties in eastern Saskatchewan and Manitoba suggests that varieties that meet the agronomic requirements of this region have the potential for a rapid uptake of the variety but it may have a short market life. In general, CWRS varieties more suited for Alberta and western Saskatchewan would have a slower uptake but greater longevity.

The increase in identity preserved (IP) or variety specific markets could change the rate of varietal replacement and concentration ratios of varieties grown in western Canada. This has implications for plant breeders as the market for replacement varieties may become more fragmented; however, a variety that meets the IP specifications may have a longer market life. This is the case with AC Domain being contracted for Warburton's Bakery in the United Kingdom. Seeded area of AC Domain in Manitoba has ranged between 15% and 19 % of CWRS area, while in Saskatchewan and Alberta it has been below 1% since 1998.

The calculation of varietal replacement indexes together with identifying varietal concentration indexes and the estimation of their trends may offer research scientists and the industry another source of information on varietal replacement in western Canada. The indices are simple to calculate and make use of available data from the Canadian Wheat Board. Much of the value of both the varietal replacement indices and the concentration indices is in explaining their relative magnitudes and the reasons for positive or negative trends. The varietal replacement indices also provide a snapshot of the age of the stock of varieties being planted from which an assessment can be made of disease vulnerability and longevity. The concentration indices provide a snapshot of varietal (genetic) diversification. It would be a simple task to provide research scientists and the industry with this information on an annual basis in addition to the raw data from the Canadian Wheat Board annual variety surveys.

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[1] Brennan and Byerlee (1991) explored several measures of varietal replacement, which included the Johnson and Gustafson (1963) Index of Varietal Newness (IVN), an adaptation of the IVN by Brennan (1984) and the Weighted Average Age Index. They adopted the Weighted Average Age Index primarily because the parameters were less arbitrary than the other two indexes and it was simpler to calculate.

[2] An optimal replacement rate would be one identified by crop researchers and the industry based primarily on yield, disease susceptibility and other characteristics in relation to the economic benefit of growing the variety.

[3] The Prairie Pools Inc. conducted a varietal survey on all 'major' crops from 1974 to 1992. There is thus a 5-year gap in the varietal survey data for wheat and barley although limited varietal information can be obtained from Provincial crop insurance corporations.

[4] Sample size n = ((z * c)/x)^2 where: z = confidence interval (standard normal deviate), c = coefficient of variation (Std/mean), and x = required precision as a proportion of the mean. Sample size n = 384 given: z = 1.96 (95% confidence level), c is assumed = 0.5 and x =.05. The sample size n may be less for those wheat and barley classes where n > 5% of the population in which case a finite population correction would be used. If multi-stage or cluster sampling is used, then a sample size of 2n or 768 is required (Poate and Daplyn 1993).

[5] Fusarium head blight (FHB), which attacks all major grain crops, has immerged as a serious disease in the last decade. Resistance to disease is rated as: VG = Very Good, G = Good, F = Fair, P = Poor, and VP = Very Poor. Manitoba Agriculture, Food and Rural Initiatives, 2003.

[6] Unlike Saskatchewan and Alberta where Kyle was the dominant CWAD variety in each year over the 1998-99 to 2003-04 period, the dominant variety in Manitoba changed four times: Sceptre (1998-99), Kyle (1999-00), AC Morse (2000-01 & 2001-02) and back to Kyle (2002-03, 2003-04 & 2004-05).

[7] CIMMYT rapidly developed varieties for both India and Mexico for the data period in question and these were rapidly taken up by farmers. A similar study today would likely find higher VRIs.

[8] Alberta has the greatest range of soil climate zones in western Canada, followed by Saskatchewan, which may also account for the larger number of varieties being grown. The agriculture departments for Alberta, Saskatchewan and Manitoba recognize nine, four and three crop production areas, respectively, when making varietal recommendations.