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Factors Affecting the Supply of High Quality Spring Wheats: Comparisons Between the United States and Canada

Bruce L. Dahl and William W. Wilson

During the late 1980s and 1990s, exports of higher quality hard wheats from the United States and Canada have been increasing and importers are becoming more differentiated (Dahl and Wilson 1996). One of the driving forces in this trend has been that in many countries, firms which had previously purchased wheat primarily through state agencies now purchase privately. This is fundamentally important because it allows importing firms to communicate desired quality characteristics more efficiently to exporting firms. In addition, as buyers become more discriminating, they become more concerned with the levels of specific quality factors and consistency. Many buyers of U.S. wheat have voiced concerns over consistency (Minnesota Wheat and Mercier p. 15). This increased demand for higher quality wheat has focused attention on factors influencing the supply and consistency of hard wheats.

Hard red spring wheat is a higher quality wheat produced in the Northern Prairies of the United States (primarily North Dakota) and Canada. Agronomic conditions and practices are similar across these regions (Wilson, 1989). Supplies of high quality hard red wheat are affected by a number of factors, including environment, varieties planted, and intervarietal differences. Differences exist between the United States and Canada in how varieties are released and these affect the supply of high quality wheats from each country. The distribution of varieties within production areas is important because intervarietal differences can account for inconsistency in end-use performance.

OBJECTIVES

This paper summarizes a larger report that examined issues related to supply of high quality spring wheats (Dahl and Wilson 1997). Specific issues examined include: differences in varietal development and release procedures, grades and standards, incentives, variety adoption, yield and protein tradeoffs, and factors affecting varietal selection between the North Dakota and Canada.

FACTORS AFFECTING SUPPLY AND CONSISTENCY OF WHEAT QUALITY

Important differences exist between the United States and Canada in variety development and release, grades and standards, and incentives. These differences have an impact on the number and quality of wheat varieties released, which in turn affect the quality and consistency of wheat produced.

Varietal Development and Release

Varietal development and release mechanisms in Canada are different from those in the United States. In Canada, varietal development and release is controlled by law. In the United States, varietal development and release is a less formal process. Variety release mechanisms are not regulated nationally or on a state basis, but are subject to intense examination from breeders and industry and are influenced to some extent by land grant universities. These differences have affected the development and release of varieties in Canada and the United States. As evidence of the importance of this difference, from 1974 to 1995, twice as many varieties were released in North Dakota than for the Canadian provinces (Figure 1).

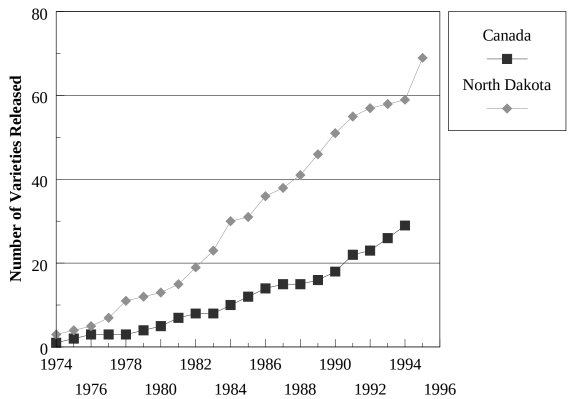

Figure 1. Cumulative Varieties Released, Canada and North Dakota, 1974-1995.

Development and release requirements in Canada

The Canada Grain Act and the Canada Seed Act are the basis for varietal control in western Canada. The objective of variety control is to provide a means to regulate quality for characteristics that are not easily measured in the market system. In Canada, varieties are registered by class and location. Thus, variety approval is essential in determining which class of wheat can be marketed. Varieties can have either a national or provincial registration. In addition, registered varieties of wheat of any class must be visually distinguishable from registered varieties of any other class of wheat. This requirement allows rapid recognition of wheat of specific classes throughout the grain handling system and allows segregation of wheat by class (Joint Commission p. 26-27). However, this requirement also imposes restrictions on new variety development which has resulted in fewer varieties being released. Use of this type of regulation also has the added benefit of reducing variability in end use (Wilson 1995).

New varieties are registered after recommendations from a regional recommending committee. To be registered, varieties must be equal to or better than existing varieties within their class. Varieties are evaluated using four criteria: agronomic, disease resistance, end-use quality, and kernel visual distinguishability (KVD). New varieties are evaluated in these four areas and may be rejected for failing in any of the four criteria.

Development and release requirements in the United States

In the United States, new varieties are developed and released from both public and private breeding programs. Public breeding programs receive guidance on release of new varieties from state agricultural experiment stations, who in turn base their recommendations on the national policy adopted by the Experiment Station Committee on Policy. This national policy provides guidance on release, and states may and do vary from it.

Release of varieties through private breeding programs are subject to decisions of breeders, administrators, and marketing departments. End-use characteristics are evaluated by the firm’s lab, private or public agencies, or a cooperative facility.

Grades/Standards

In Canada, varieties are included in official grade definitions for top grades of wheat. Only varieties equal to or superior in quality to the variety standards for a class of wheat are eligible to be registered for top milling grades. Unlicensed varieties are relegated to the lowest grade for the class (CWAD5 for durum and Canadian Feed for all other Canadian common wheat classes). These regulations introduce minimum end-use performance standards in addition to agronomic performance (CWB and CGC).

Protein is included in Canadian grain standards as a factor requirement. Canada segregates grain within a grade into different lots based on protein levels. Protein segregations were added for selected grades of wheat in 1980, 1988, 1994, 1995, and again for 1996/97.

In the United States, grade standards include definitions for class and subclass where subclasses are determined by the amount of vitreous kernels. Varieties and protein for wheat are not part of the grade standards in the United States. These practices result in fewer grades traded and exported, but greater differentiation within grades..

Protein level is a very important component of the U.S. marketing system. Grades, standards, associated trading practices, and prices customarily determine quality parameters through buyer-seller negotiation. Factors are identified as being important by the placement of limits and/or premiums and discounts on grade/non-grade factors.

Incentives

Incentives exist within the marketing system for production of higher quality wheats. However, mechanisms differ between the United States and Canada. In the United States marketing system, premiums and discounts for grade and non-grade characteristics are used to adjust prices in individual transactions throughout the marketing system. In Canada, premiums and discounts are paid when buying from farmers for grade segregations, and have been introduced for protein segregations. . In addition, the inclusion of variety standards in grade specifications in Canada provides an important incentive to produce registered varieties in Canada as unregistered varieties must be sold as lower grades (CWAD5 or Canada Feed). Spreads/incentives in the U.S. have been larger than in Canada in the 1980s and early 1990s.

VARIETY ADOPTION

The end-use quality of varieties and the extent they are adopted by farmers affect the potential quality of wheat produced. For example, as the number of varieties grown increases, intervarietal differences are magnified. The magnitude of this effect depends on the range of end-use qualities across varieties and the degree to which they are blended throughout the marketing system.

The adoption of varieties was examined and compared for hard red spring and durum wheat varieties in North Dakota, Manitoba, Saskatchewan, and Alberta. Adoption characteristics for varieties were examined using several measures.

Number of Varieties Grown

Variety shares of planted acres for wheat were gathered from a range of sources (North Dakota Agricultural Statistics Service, Alberta Pool, Saskatchewan Wheat Pool, Manitoba Pool Elevators, and Manitoba Crop Insurance Corporation). The number of varieties with 1 percent or more of planted hard red wheat acres and durum was calculated for each state/province from 1974 to 1995.

The number of hard red spring wheat varieties grown in North Dakota were consistently greater than the number of varieties grown in Manitoba, Saskatchewan, or Alberta during the 1980s and early 1990s (Figure 2). North Dakota farmers planted a low of 9 varieties of spring wheat in 1979, 1980, and 1982 to a high of 16 varieties in 1988. The number of hard red spring wheat varieties grown in North Dakota has declined since 1988 to a low of 10, in 1995 and 12 in 1996.

Manitoba ranged from a low of 4 varieties in 1980 and 1981 to a high of 12 varieties in

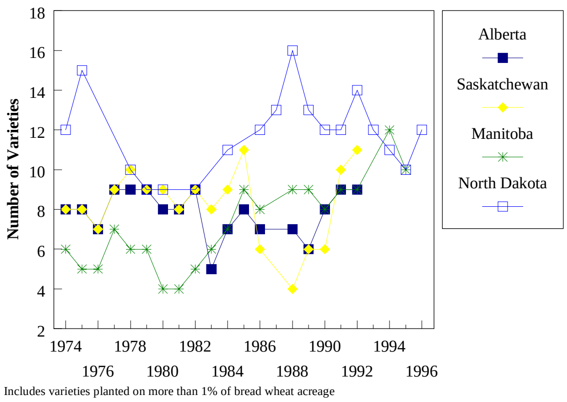

Figure 2. Number of Hard Red Spring Wheat Varieties by State/Province, 1974-1996.

1994. The number of varieties grown in Manitoba have been increasing since the middle 1980s. Increased numbers of varieties grown in Saskatchewan and Alberta are not as apparent. During the later 1980s, the number of varieties grown in Saskatchewan ranged from 4 to 6, significantly lower than the 10 to 11 varieties grown in 1985, 1991, and 1992.

The number of durum varieties in North Dakota was consistently greater than Manitoba, Saskatchewan, or Alberta from 1974 to 1995 (Figure 3). The number of durum varieties grown in North Dakota increased from 8 in the middle 1980s to 13 varieties in 1992 and declined to 10 varieties in

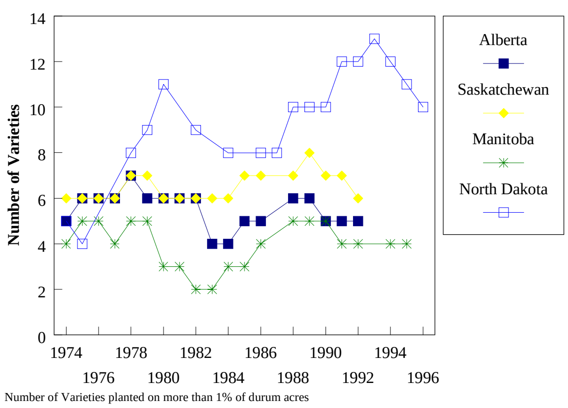

Figure 3. Number of Durum Wheat Varieties by State/Province, 1974-1996.

1995. However, this is still nearly twice as many varieties of durum as were grown in Manitoba in 1995. Canadian provinces varied from 2 to 8 varieties of durum grown from 1974 to 1995 with the lowest number of varieties grown in Manitoba, followed by Saskatchewan and Alberta.

Other measures of variety adoption were examined than included shares of planted acres by dominant variety, four largest varieties, and a measure of concentration that was used to compare the distribution of shares of planted acres across varieties. These measures all indicated that durum and hard red spring wheat acres in Canada are concentrated in fewer dominant varieties. In North Dakota, there is less reliance on dominant varieties. Shares of planted acres were spread out over more varieties with smaller acreages. Trends in the measures indicated that both countries were becoming more similar. Canada was reducing concentration of variety shares and North Dakota was increasing concentrations on fewer varieties. To the extent that there are inter-varietal differences in quality that end up being combined within the marketing system, one would expect quality in Canada should be more consistent than in the United States.

COMPARISON OF AVERAGE YIELD/PROTEIN RELATIONSHIPS

Increases in protein for wheat varieties generally comes at the cost of higher yields. In Canada, an increase in protein of 1 percent is thought to come at the cost of 10 percent in yield (CWB and CGC). Conceptually, the protein/yield tradeoff can be described by an "efficient frontier." As new improved varieties are released, this frontier shifts up and outward. This section analyzes yields and protein to discern the size and shape of the frontier for spring wheat production areas in Canada and the United States.

Average yield and protein levels were derived for the northern spring wheat production areas of the United States and Canada. The United States region included the individual states of North Dakota, Minnesota, South Dakota, and Montana. Canada included the provinces of Manitoba, Saskatchewan, and Alberta. Yields in the United States were gathered on a crop reporting district level from publications by the state agricultural statistical services. Protein levels in the United States were collected from regional annual crop quality surveys (Moore et al.). In Canada, yields and protein values were gathered from annual crop quality surveys (Canadian Grain Commission-Grain Research Laboratory) and statistical annuals (Canadian Grain Commission). Canadian protein levels were converted to a 12 percent moisture basis to be consistent across countries.

For comparison, yields and protein were averaged for two periods: 1980-1982 and 1993-1995 (Table 1). In 1980-1982,

Table 1. Average Yield and Protein, Growth Rates, and Yield Protein Tradeoffs, by State/Province for Hard Red Spring Wheat

	Average Yield			Average Protein		
	1980-1982	1993-1995	Change	1980-1982	1993-1995	Change
	------ (Bu/A) ------			----- (Percent) ------		
North Dakota	24.7	31.6	6.90	14.6	14.0	-0.60
Minnesota	38.1	32.0	-6.10	13.6	14.1	0.50
South Dakota	21.8	26.0	4.20	14.6	14.1	-0.50
Montana	27.8	33.6	5.80	13.8	13.5	-0.30
Manitoba	29.0	30.5	1.50	13.8	13.5	-0.30
Saskatchewan	27.1	29.2	2.10	13.7	12.3	-1.40
Alberta	33.0	38.0	5.00	13.5	12.1	-1.40
	Growth Rates					
	Yield			Protein		
	(Percent per Year)					
North Dakota	1.69	*		-0.27	*	
Minnesota	-1.21	ns		0.49	*	
South Dakota	1.36	ns		-0.20	ns	
Montana	2.43	*		-0.25	*	
Manitoba	1.29	ns		0.18	ns	
Saskatchewan	0.47	ns		-0.14	ns	
Alberta	1.28	*		-0.18	ns	
	Yield Protein Trade-off					
	1980-1982	1993-1995		1980-1982	1993-1995	
	(Bu/A)/Percent Protein)			(Percent Yield/Percent Protein)		
North Dakota	-6.06	-5.81		-24.5	-18.4	
Minnesota	-7.65	-7.85		-20.1	-24.6	
South Dakota	-4.68	-4.48		-21.4	-17.2	
Montana	-5.72	-5.61		-20.6	-16.7	
Manitoba	-5.74	-5.61		-19.8	-18.4	
Saskatchewan	-5.67	-5.12		-20.9	-17.5	
Alberta	-5.62	-5.02		-17.0	-13.2	

* Significant at 95 percent confidence interval.
ns - not significant.

Minnesota had the highest average yield followed by Alberta, Manitoba, Montana, Saskatchewan, North Dakota, and South Dakota (Table 1). Average yields increased for all states/provinces from the earlier period to 1993-1995, except for Minnesota which declined from 38.1 bu/a to 32.0 bu/a.[1] In 1980-1982, average protein levels ranged from 13.5 to 14.6 percent with the highest average protein levels in North and South Dakota followed by Manitoba, Montana, Saskatchewan, Minnesota, and Alberta. Average protein levels for most states/ provinces were lower in 1993-1995 than for 1980-1982, except for Minnesota which was higher in 1993-1995. These results are consistent with yield increases experienced during the same intervals and traditional trade-off of protein for yield. Average protein levels declined the most for Alberta and Saskatchewan which both had protein levels 1.4 percentage points lower in 1993-1995 than in 1980-1982.[2] Other areas experienced changes in average protein levels of +.5 to -.6 percentage points.

Trade-off between protein and yield

The trade-off between yield and protein was examined to determine which areas have a comparative advantage (lower yield penalty) for producing higher protein wheat and to ascertain changes in the trade-off over time. The trade-off between yield and protein was examined by comparing average protein levels and yields for North Dakota, Minnesota, South Dakota, Montana, Manitoba, Saskatchewan, and Alberta from crop quality surveys.[3]

Results indicate that the frontier for the trade-off between yield and protein has shifted up with more yield possible at the same protein level. Yields for a given protein level increased at the rate of .23 bu/a/year from 1980-1995 for many of the states/provinces. However, the increase in yields for a given level of protein was lower for South Dakota and Saskatchewan than for the other states/provinces (Table 1).

The frontier, or slope of the trade-off between yield and protein, was highest for North Dakota and Minnesota (Figure 4). In contrast, Saskatchewan had the lowest slope followed by South Dakota for protein levels less than 13 percent and Alberta, Manitoba, and Montana for protein levels over 14 percent. This indicates that North Dakota and Minnesota should be able to produce 1) more wheat, 2) higher protein wheat, or 3) some combination of higher yielding, higher protein wheat than Saskatchewan.

Coefficients for protein/yield trade-offs were derived for 1980-1982 to 1993-1995.[4] Estimated tradeoff coefficients for 1980-1982

[1] One possible explanation for the decline in yields is the incidence of unfavorable growing conditions which included outbreaks of wheat scab/vomitoxin in the 1993-1995 crop years.

[2] Lower protein numbers for the Canadian Provinces in 1993-1995 reflect three years with lower-than-average protein levels. Levels for 1993 represented a 40-year low for average protein levels (CGC).

[3] The relationship between yield and protein was examined to determine if a fixed effects model or a random effects model best fits the data. Results indicate that a fixed effects model with dummy variables for location and time was applicable. Models were then developed where yield = f ($protein^2$, location, year) and yield = f (protein, $protein^2$, location, year). The relationship between protein and yield was estimated using binary variables for both slope and interaction effects for region, protein, and year.

[4] The trade-off coefficients were derived by taking the derivative of regression results with respect to protein and multiplying by average yields.

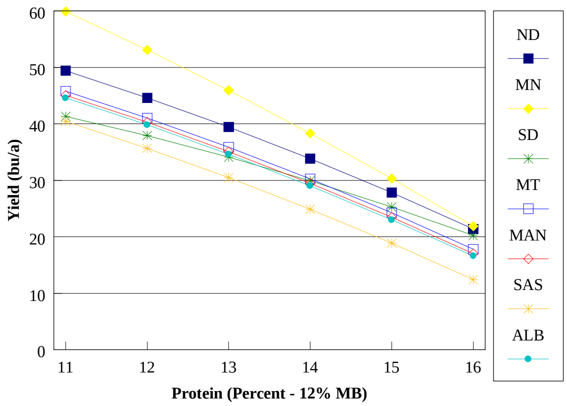

Figure 4. Estimated Relationship Between Protein and Yield, by State/Province, 1995.

ranged from a low of 4.48 bushels per acre per percent of protein in South Dakota to a high of 7.85 bushels per acre per percent of protein in Minnesota. This indicates that increasing protein levels by 1 percent would result in yield losses of 4.48/A in South Dakota compared to losses of 7.85/A in Minnesota. Trade-off coefficients declined from 1980-1982 to 1993-1995, except for Minnesota which increased. This indicates that the penalty (yield forgone) for increasing protein has declined over time, except for Minnesota where the penalty has actually increased.

These coefficients indicate that increases in protein could be achieved with a lower penalty for reduced yields in South Dakota, Alberta, Montana, Saskatchewan, and Manitoba. These regions have a comparative advantage when increasing protein in wheat since yield sacrificed to gain higher protein wheats would be less.

Comparison of yield losses with an increase in protein on a percentage basis indicates that Alberta has a comparative advantage over the remaining regions (Table 1). Farmers in Alberta would sacrifice 17 percent yield in 1980-1982 to 13.2 percent of yield in 1993-1995 to increase protein 1 percent. This represents a smaller percentage of total yield lost to increase protein in Alberta than in the other regions. The range of protein/yield trade-offs on a percentage basis represent 13.2 to 20.9 percent yield reductions per 1 percent increase in protein for the Canadian provinces and are larger than the 10 percent yield reduction per 1 percent increase in protein reported by CWB and CGC, 1996, for Canada.

FACTORS INFLUENCING VARIETAL SELECTION

Two different types of models were developed to analyze factors affecting varietal selection. Both models indicate that many agronomic factors are important for varietal selection in North Dakota, Saskatchewan, Manitoba, and Alberta. Agronomic factors appeared to have larger impacts on shares of planted acres in Canada than in North Dakota. Relative yields were significant for all regions and models except for the double truncated model for North Dakota.

Parameters were included that represent the life cycle of varieties because of the difference in adoption over time between the Canadian provinces and North Dakota (Figures 5-6). These parameters were significant in all

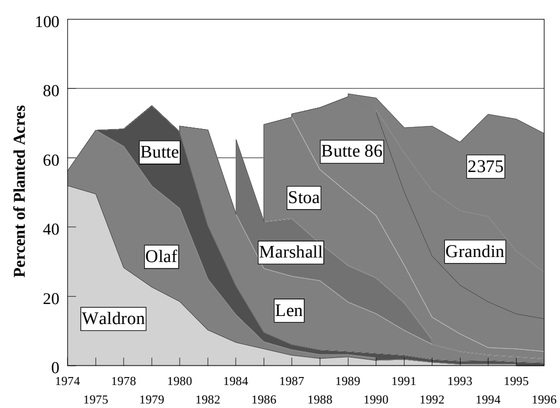

Figure 5. Percent of Planted Acres for Selected Hard Red Spring Wheat Varieties, North Dakota, 1974-1996.

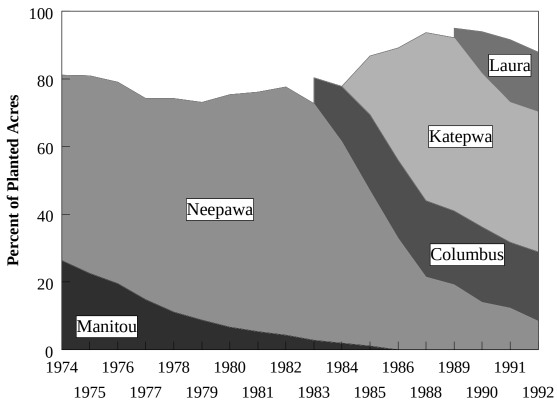

Figure 6. Percent of Planted Acres For Selected Canadian Western Red Spring Wheat Varieties, Saskatchewan, 1974-1992.

models and suggest a shorter life cycle for varieties grown in Manitoba and North Dakota (5-7 years to maximum adoption) than for Alberta and Saskatchewan (15 years or more to maximum adoption). This suggests that Alberta and Saskatchewan should have lower variability in end-use quality due to the long period that single varieties are planted and dominate. This is primarily evident due to the long adoption periods for the varieties Neepawa and Katepwa in these provinces.

ADOPTION OF VARIETIES BY END-USE

To examine the extent that the quality of varieties has impacted wheat production, adoption of varieties across North Dakota was compared using varieties overall quality ratings (Helm). This ranking is an assessment of overall end-use quality and is categorized as 4 = good quality, 3 = average quality, 2 = poor quality, and 1 = very poor quality. However, no varieties were classified as very poor quality.

Shares of planted acres by end-use quality categories were compared for North Dakota as a whole and across crop reporting districts. Shares of planted acres for each of the categories from 1978-1995 have varied (Figure 7). Poor end-use quality varieties increased from 1978 to the middle 1980s and have fallen in the 1990s. Since the middle 1980s, the proportion of wheat planted to end-use quality ratings 3 and 4 (average and good) have increased, with the largest shares planted to average (3) quality varieties.

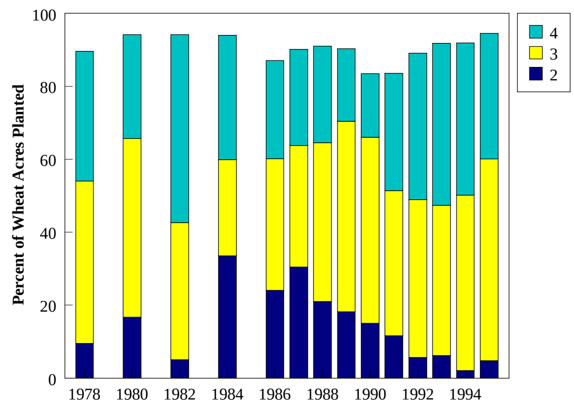

Figure 7. Variety Adoption by End-use Quality Rating, North Dakota, 1978-1995.

Adoption of varieties of different end-use quality has varied across North Dakota CRDs for 1978-1995. During the 1980s, farmers in all the CRDs increased their production of poor end-use quality varieties but, have since reduced acres to minimal levels in the 1990s. This increase in production of poor end-use quality varieties was most prevalent in the eastern CRDs (Regions 3, 6, and 9). Farmers in the northwestern regions of North Dakota are likely to plant more of their wheat acres to varieties that have good end-use quality characteristics, as evidenced by the large shares of planted acres devoted to quality group 4 in Crop Reporting Districts 1, 2 and 4. This trend toward higher production of good end-use quality varieties increased during the 1990s for these three northwestern regions. Farmers in the eastern portions of the state favor planting varieties with average or poor end-use quality. All three of the eastern regions have decreased planting of poor end-use quality varieties in the 1990s in favor of average end-use quality varieties. Crop Reporting Districts 5, 7, and 8 have varied over time. The only apparent trend in these three districts is toward higher use of average end-use quality varieties in the central portion of the state (CRD 5). Thus, there is higher tendency toward production of good end-use quality wheat in the western portions of North Dakota than in the eastern portion of the state, though in both regions there has been a shift away from poor quality.

CONCLUSIONS AND IMPLICATIONS

The demand for wheat has been changing which has focused attention on the supply and consistency of high quality wheats. The supply of higher quality wheat in Canada and the United States is affected by the types of varieties grown, their inherent quality, the extent that they are adopted, the degree that intervarietal differences are blended within the marketing system, and agronomic practices and environment.

There are differences in the varietal release process between the United States and Canada. The process is less regulated in the United States than in Canada. Processes in Canada are designed to control varietal release and the class/grade in which a variety can be marketed to maintain quality and extend the period when varieties are grown. This has resulted in fewer varieties released and grown in Canada than in North Dakota.

Grade standards and incentives are also different between the U.S. and Canada. In Canada, varieties are included in grade definitions. Only licensed varieties in Canada can be sold for the top grades of milling wheats. This relegates unlicensed varieties to CWAD5 or feed for all other wheat classes. In the U.S. variety definitions are not used to determine grades.

Incentives for grade separations (price spreads) between grades 1 and 2 are larger in the U.S. than in Canada. In the U.S. protein is a non-grade factor and incentives for protein are paid throughout the marketing system. In Canada, protein segregations within a grade have been specified and premiums are paid to farmers, although the realization of the full incentive payment can be delayed until the final payment is made.

Lower numbers of varieties are grown in Canada than in North Dakota. This phenomenon is more prevalent for durum wheats than for spring wheats. However, the trend in numbers of spring wheat varieties are toward equal numbers. In the middle 1990s, Manitoba has increased the number of varieties grown to levels equal to or greater than those in North Dakota.

Results for other measures of adoption indicated that during the 1980s and early 1990s, production of hard red wheat and durum in Canada was more concentrated in fewer varieties. This concentration in fewer varieties planted suggests that end-use variability should be lower in Canada than in North Dakota. However, the extent and degree of any changes also depends on other factors (end-use characteristics of individual varieties involved, quality variability between varieties, effects of environment on specific varieties, etc). One possible explanation for the recent increase in concentration for North Dakota is that few varieties released have disease resistance/tolerance for wheat scab/vomitoxin which was a significant problem in North Dakota in 1993-1995. Therefore, planted varieties with resistance/tolerance are adopted on more acres.

Trade-offs of protein and yield were compared across Alberta, Saskatchewan, Manitoba, North and South Dakota, Minnesota, and Montana. Results indicated that the Canadian provinces, South Dakota, and Montana have a comparative advantage over North Dakota and Minnesota in increasing protein in hard red wheats. In terms of yield forgone, producers in these areas should be able to increase protein with less yield loss than in North Dakota and Minnesota. This is strictly a comparative advantage in terms of yield forgone to increase protein; it doesn't say anything about the level of protein (eg. N.D. greater than S.D.).

Adoption of varieties by end-use quality was examined for North Dakota. Differences in the variety adoption indicate that crop reporting districts in the northwest portion of North Dakota planted a higher proportion of wheat acres in varieties with good end-use quality. Farmers in the eastern crop reporting districts planted higher proportions of wheat acres in varieties with average to poor end-use quality. The trend in the eastern portions of the state has been toward production of wheat varieties with average end-use quality.

Overall, comparisons of variety adoption among North Dakota, Saskatchewan, Alberta, and Manitoba indicated a number of important observations.

- The number of HRS and durum wheat varieties grown in North Dakota is greater than in the Canadian Provinces.

- In the Canadian provinces, varieties grown have been concentrated in fewer varieties with larger shares of planted acres than in North Dakota.

- The life cycle for varieties in Alberta and Saskatchewan are longer than for North Dakota and Manitoba.

All of these factors suggest that the variability of end-use quality characteristics of HRS wheat and durum grown in Canada should be lower than for production in North Dakota. The extent and degree of lower variability would also depend on other factors (end-use characteristics of individual varieties involved, intervarietal differences and the extent that they are blended throughout the marketing system, effects of environment on specific varieties, etc). If no intervarietal differences exist, then these conclusions do not hold.

- The trend primarily in hard red spring wheat is toward more fewer varieties grown. Farmers in North Dakota have been reducing the numbers of varieties grown and have increased reliance on fewer varieties with larger shares of planted acres; while the Canadian provinces are increasing the numbers of varieties grown and are spreading planted acres over more varieties with smaller shares of planted acres.

- South Dakota, Alberta, Montana, and Saskatchewan have a comparative advantage over North Dakota and Minnesota for increasing protein in wheat production. This is strictly a comparative advantage in terms of yield forgone to increase protein and doesn't say anything about the level of protein.

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