Factors Affecting Post Harvest Changes in Grain Prices Received By North Dakota Producers

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Many factors affect timing of marketing decisions by grain producers. These include storage availability, opportunity costs of grain storage, taxes, cash-flow needs, participation in farm programs, and expectations of future trends in prices. The latter includes price changes due to both expected changes in fundamental market variables and the normal seasonal pattern. Similar factors also affect marketing decisions by processors. Likewise, the demand for marketing services (i.e., transportation, elevation, etc.) is derived from and responds positively to changes in grain prices. Understanding seasonal price behavior is important to each of the above participants making effective marketing decisions.

Seasonal price behavior refers to intra-year price variability which is recurrent over many years. At the beginning of the crop marketing year, supplies are abundant and generally known. Prices increase, or decrease, throughout the marketing year to allocate given supplies among competing demands. Generally, the normal seasonal pattern in prices is for the low to occur at and immediately post harvest, increasing thereafter. In several of the recent marketing years however, prices have not followed their normal seasonal pattern; and as a result, there has been more uncertainty in marketing decisions

The general purpose of this study is to describe seasonal behavior of wheat and barley prices received by North Dakota producers.[1] Specific objectives are:

1) to calculate seasonal indexes of prices for hard red spring and durum wheat and barley received by North Dakota producers,
2) to examine variability in intra-year price trends,
3) and to evaluate the extent changes in fundamental market variables during the year cause seasonal price variables to deviate from the expected.

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[1]The concepts and results developed in this paper are a synopsis of a longer report published by the Department of Agricultural Economics, North Dakota State University (2). Copies are available on request.

Sources of Seasonality in Grain Prices

A characteristic of grain commodities is that a surplus exists at harvest which is consumed throughout the marketing year. To induce storage, prices increase and approximately cover the costs incurred in holding grain. Price appreciation throughout the marketing year is the return to storage. Prices are typically low during and immediately post harvest and generally increase thereafter, peaking 3 to 4 months later. High prices in November, December, and January generally occur just prior to closing of the Great Lakes and Upper Mississippi Waterways. In any particular year, prices may increase more than the cost of storage, or even decrease. These anomalies are due to changes in fundamental supply and demand estimates as the marketing year progresses.

Empirical Procedures and Results

Two procedures were used to analyze intra-year price variability. First, time series analysis was used to describe seasonal and irregular variation in prices.

Generally, price movements through time are affected by four components. **Trend** is the long term direction of price movement and occurs over many years. It can be either increasing, decreasing, or constant. **Cyclic** movements are also longer term but refer to a wave-like movement which is recurrent. Cycles are generally attributable to a response to changes in fundamentals which is lagged. Cycles are generally more common in livestock than in grains because of the implicit lagged supply response in the former. **Seasonal** price movements refer to intra-year price variations which occur every year in generally the same patterns. Seasonal price movements are due to events which happen annually at about the same time. Grain in the upper midwest is harvested during the late summer and early fall and much of the logistical system for export freezes soon after. The **irregular** component of time series data refers to variations which are unexpected and do not occur on a regular basis. These are due to unexpected events which are sporadic such as strikes, unseasonal weather, embargoes, etc. Price movements through time are affected by all four components. The purpose of time series analysis is to decompose a series of data so that individual components can be examined. Of particular importance in this study is the seasonal-irregular ratio and the seasonal factor. Both have a base of 100 and can be interpreted as the per cent of the average an-

nual price. Thus, if S_t (or SI_t) were 95, prices in month 5 would be 95 per cent of the marketing year average. If S_t is more refined as an indicator of seasonality than SI_t because the irregular component has been removed in the former. Examination of SI_t is important because it illustrates the relative variability in price for each month over the time series. The specific procedure used in this study was the X-11 Seasonal Adjustment Program. (1) The above procedures were applied to prices received by North Dakota producers for hard red spring wheat, durum wheat, and all barley. The study period was the 1967-68 crop year through 1980.

The average seasonal-irregular ratio for hard red spring wheat prices for each month over the time series is a general indicator of seasonality and is shown in Figure 1. The marketing year low price, on average, occurred in May, at 96.9 per cent of the marketing year average, and increased thereafter. Prices in August were 99.1 per cent of the marketing year average and those in October and November were 103.0 and 102.9 per cent of the marketing year average, respectively. Prices remained above the marketing year average from September through February. Analysis of variance was used to test whether these differences were statistically significant, and they were. Standard deviations were calculated for each month and were used to derive confidence intervals which are also shown in Figure 1. The results indicate that prices are relatively more irregular during May, June, July, and August. Irregularity in prices during the remaining months was relatively less, especially in October and March.

Seasonal indexes were calculated from the seasonal-irregular ratios by removing the irregular observations. Implicit trends in the seasonal indexes for each month also were computed and used to calculate indexes one year ahead. Irregular observations were removed or weighted and trends were incorporated to calculate the seasonal index for each month. For example, observations such as January to September of 1973 were replaced by an average because they were under the influence or large export sales and thus were abnormally irregular. The results are shown in Table 1. Prices increase after harvest and reach a peak in October and November. Seasonal indexes for October and November are expected to be 103.0 and 103.1, respectively, during the 1981/82 marketing year.

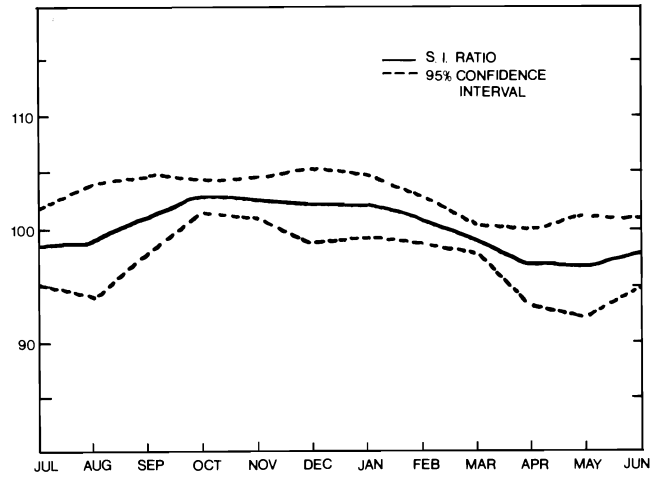

FIGURE 1. Seasonal-Irregular Ratios for Hard Red Spring Wheat Prices Received by North Dakota Producers, 1967/68-1980

Time series analyses were also applied separately for the first half and second half of the series. The results indicate there was less seasonality and more variability during the latter period relative to the former. Differences between months were significant in the 1967/68 to 1972/73 period. The seasonal-irregular ratio averagd for August was 93.7 and subsequently increased to a peak of 103.8 in December and 103.4 in January. During the period containing the most recent 6 years, the seasonal-irregular ratio averaged in August was 102.1. It increased slightly in September and October to 102.8 and 102.6, respectively, and then decreased. The seasonal-irregular ratios were not statistically different than each other during the latter period.

TABLE 1. Seasonal Indexes for Hard Red Spring Wheat Prices Received by North Dakota Producers, 1967/68 to December 1980.

Marketing Year	July	August	September	October	November	December	January	February	March	April	May	June
1967/68	98.1	93.9	97.8	101.9	103.0	101.5	102.2	101.1	100.8	100.2	100.3	99.0
1968/69	98.1	93.8	97.8	101.9	103.2	101.8	102.4	101.3	100.6	99.9	99.9	98.7
1969/70	97.7	93.8	98.2	102.1	103.6	102.4	103.3	101.5	100.1	99.2	99.0	97.9
1970/71	97.6	94.2	98.9	102.5	103.5	103.3	104.7	101.4	99.5	98.2	97.5	96.3
1971/72	97.6	95.2	99.8	103.4	103.4	104.2	105.7	101.1	98.8	97.4	96.0	94.7
1972/73	98.3	96.7	100.7	104.3	102.5	104.4	105.7	100.8	98.7	96.9	95.4	93.7
1973/74	99.2	98.1	101.4	104.8	101.6	103.6	104.8	100.6	98.9	97.1	95.6	93.7
1974/75	100.3	99.1	101.9	104.4	100.6	102.1	103.2	100.5	99.4	97.9	96.8	94.9
1975/76	101.1	99.3	101.7	103.7	100.4	100.7	101.2	100.1	99.6	98.6	98.1	97.1
1976/77	101.4	99.2	101.5	102.9	100.6	99.5	99.5	99.8	99.4	98.8	99.3	99.4
1977/78	101.6	98.8	101.0	102.3	101.3	99.0	98.6	99.4	98.9	98.5	99.9	101.1
1978/79	101.6	98.8	101.0	102.3	102.1	99.0	98.4	98.7	98.1	98.0	100.0	101.9
1979/80	101.8	98.7	100.7	102.5	102.8	99.4	98.3	98.1	97.5	97.8	99.9	102.1
1980/81	101.7	98.9	100.7	102.8	103.0	99.5	--	--	--	--	--	--
Seasonal Indexes One Year Ahead												
1981/82	101.7	99.0	100.7	103.0	103.1	99.6	98.3	97.8	97.1	97.6	99.9	102.2

Seasonal-irregular ratios for durum wheat prices received by North Dakota producers and monthly averages are shown in Figure 2. On average, prices are lowest during June and increase after that, peaking in October. Prices in August were greater than the marketing year average. Analysis of variance was used to test whether the monthly seasonal-irregular ratios were statistically different. The analysis indicated that these differences were not significant at the 1 per cent level. Despite the means being different, irregularity in the monthly prices was great enough that no evidence of stable seasonality was found. Variability in prices as indicated by the confidence intervals was large during the May through September period and relatively less in the remaining months. An important point is that 100 is included in the confidence intervals for each month, thereby reinforcing the absence of significant seasonality. Consequently, in light of the irregularity in durum prices, seasonal price movements have not been recurrent over the time series.

Seasonal indexes are better indicators of seasonal price behavior and are shown in Table 2. In the recent marketing year, prices in August were 98.2 per cent of the average and increased to 105.4 per cent in November. In other words, prices appreciated 7.2 per cent during the immediate post harvest period. The results indicated that the seasonal pattern has been changing. Indexes for August increased in the latter 1970's relative to the 1960's. Similar increases occurred in September and November. Indexes for January, February, and March have tended to decrease in the 1970's relative to the 1960's. Generally, the seasonal low in recent years has not been as low as it was in the late 1960's and early 1970's.

Similarly, the seasonal high is slightly higher than during the earlier period, but it occurs earlier in the marketing year. In recent years it has occurred in October or November. Based on the trends in monthly indexes, those for August and November of 1981 are expected to be 98.3 and 105.6, respectively.

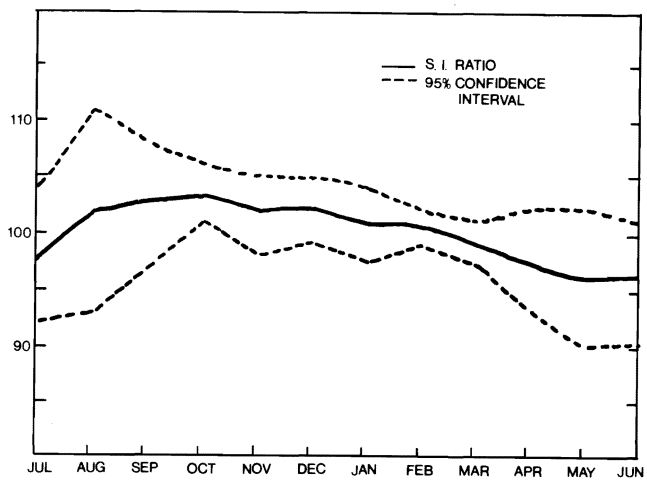

FIGURE 2. Seasonal-Irregular Ratios for Durum Wheat Prices Received by North Dakota Producers, 1967/68-1980.

Seasonal-irregular ratios were calculated separately for the periods July 1967 to June 1973 and July 1973 to December 1980 to demonstrate changes which have taken place in intra-year durum prices. Ratios in the earlier period were at a low in August at 94, increased thereafter, and peaked at 103.2 in January. The seasonal pattern was stable and significant during that period. In the latter period ratios for August and January were 105.5 and 97.2, respectively. There was more irregularity in the latter period and the differences were not statistically different.

Barley is interesting because it exhibits less irregularity and more seasonality. Consequently, the risk of adverse price changes are less and returns to storage are greater relative to wheat. Seasonal-irregular ratios were calculated and the monthly averages are shown in Figure 3. Lows occurred inAugust at 94.1 and later increased. Peaks occurred in October and again in February at 102.4 and 102.8, respectively. Analysis of variance was used to test whether these differences were statistically significant, and they were. Large increases in prices occur after August and generally stay about the same between October and February.

TABLE 2. Seasonal Indexes for Durum Wheat Prices Received by North Dakota Producers, 1967/68 to December 1980.

Marketing Year	July	August	September	October	November	December	January	February	March	April	May	June
1967/68	98.7	94.0	97.3	100.2	101.5	100.5	101.1	102.3	102.1	102.2	101.1	98.8
1968/69	98.6	94.0	97.4	100.3	101.6	100.9	101.5	102.3	101.7	101.7	100.7	98.5
1969/70	98.1	94.4	97.7	100.5	101.8	102.1	102.8	102.2	101.0	100.1	99.8	97.9
1970/71	97.5	95.4	98.5	100.9	101.5	103.8	104.5	102.2	100.2	97.9	98.3	96.4
1971/72	97.2	96.8	99.6	101.8	101.5	105.8	105.3	102.0	99.0	96.1	97.3	94.4
1972/73	97.1	98.6	101.3	102.8	101.0	106.7	104.9	101.6	98.6	95.5	96.9	93.1
1973/74	97.5	99.8	102.5	103.6	100.8	106.4	103.2	101.0	98.5	96.2	97.5	92.9
1974/75	97.9	100.3	103.4	103.8	100.3	104.8	101.2	100.5	99.0	97.7	98.4	94.0
1975/76	98.5	99.9	103.1	103.8	100.8	103.0	98.9	99.8	99.0	99.4	99.4	96.1
1976/77	99.0	99.1	102.8	103.5	101.7	101.2	97.5	99.0	98.8	100.4	99.4	98.8
1977/78	99.8	98.3	102.1	103.1	102.9	100.3	97.0	98.3	98.1	100.5	98.7	100.9
1978/79	100.4	97.9	101.9	102.9	104.0	100.4	97.2	97.8	97.2	99.8	97.7	102.0
1979/80	101.1	97.9	101.7	102.8	105.0	101.0	97.3	97.6	96.3	99.4	97.2	102.1
1980/81	101.1	98.2	101.8	102.8	105.4	101.3	--	--	--	--	--	--
Seasonal Indexes One Year Ahead												
1981/82	101.2	98.3	101.9	102.9	105.6	101.4	97.3	97.4	95.9	99.2	97.0	102.2

Seasonal indexes are a more refined indicator of seasonality because the ratios are averaged and extreme values have been replaced. Seasonal indexes for barley prices are shown in Table 3. In the 1980/81 marketing year, the seasonal index was 95.6 in August and peaked at 103.8 in November. Similar patterns occurred in other years except the peaks may have been in later months. Barley prices have become somewhat less seasonal in recent years. Indexes forAugust, November, and December have increased since the earlier years of the time series. Likewise, indexes for January, February, and March have decreased in recent years. Thus, months with low indexes are not quite as low as in the late 1960's and early 1970's. Also, the seasonal high occurs in November, as opposed to January, February, and March, which were traditionally the months with high prices.

Seasonal-irregular ratios were also calculated separately for the two periods July 1967 to June 1973, and July 1973 to December 1980. Seasonal-irregular ratios in the former period ranged from a low in August of 88.4 to a high in February of 104.7.

Irregularity was minimal and seasonality was significant. Seasonal-irregular ratios for the 1973-1980 period indicated the low occurred in July at 93.7 and increased to 104.3 in October. In the latter period the observed monthly difference was not statistically significant.

The second procedure was to estimate the relationship between variability in intra-year price appreciation and intra-year changes in supply and demand projections. The methodology and results are discussed more fully in Wilson (2) and only the results and interpretation are presented here. The model is used as a complement to the time series analysis discussed above and was intended to explain factors affecting variability in intra-year price appreciation. Prices change in the post harvest period for two reasons. One is the opportunity cost of holding grain. The second is that changes in fundamental market variables within the marketing year affect the extent prices appreciate during the post harvest period.

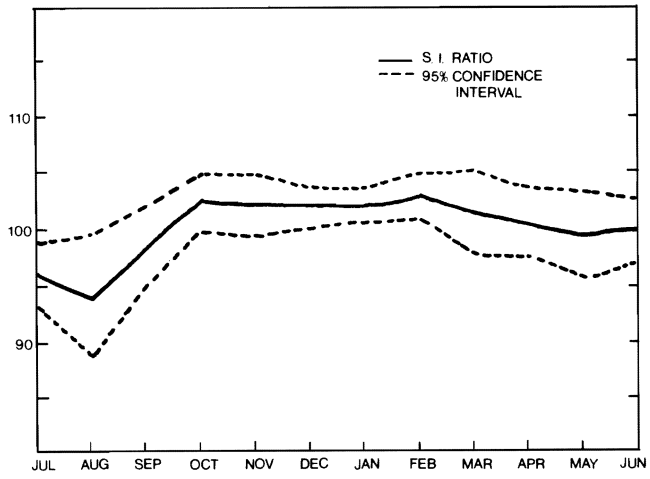

FIGURE 3. Seasonal-Irregular Ratios for All Barley Prices Received by North Dakota Producers, 1967/68-1980.

Carryovers are projected at the beginning of the marketing year and are the difference between projections of supply and demand. If actual carryovers turn out to be less than projected, prices would be expected to increase within the marketing year due to the bullish changes in fundamentals, and vice verssa. The relationship between intra-year changes in hard red spring wheat prices and carryover are shown in Table 4. Generally, prices appreciate, but appreciate by a larger amount if projections of carryovers decrease within the marketing year. Particularly large price increases occurred in 1972/73 and 1977/78 and these were associated with bullish changes in carryovers.

Regression analysis was used to estimate the relationship between price changes from harvest to the normal high, and changes in fundamental market variables within the marketing year. Changes in supply and demand estimates were used as explanatory variables rather than carryover levels. The model estimated for each of the three grains is as follows:

$$CHPR_t = a_0 + b_1 CHTS_t + b_2 CHTD_t + e_t$$

TABLE 3. Seasonal Indexes for All Barley Prices Received by North Dakota Producers, 1967/68 to December 1980.

Marketing Year	July	August	September	October	November	December	January	February	March	April	May	June
1967/68	97.7	90.5	95.3	98.7	101.1	100.7	102.0	103.6	102.8	102.3	103.2	102.7
1968/69	97.8	90.5	95.2	98.8	100.3	100.9	102.1	103.9	102.7	101.9	102.7	102.3
1969/70	97.9	90.6	95.4	99.2	100.3	101.6	102.7	104.4	102.4	101.2	101.3	101.3
1970/71	97.8	90.9	96.1	100.4	100.5	102.4	103.1	105.1	101.8	100.0	99.5	99.5
1971/72	97.3	92.2	97.3	102.2	100.4	103.5	103.3	105.3	101.2	98.7	97.9	97.4
1972/73	96.9	93.7	98.8	104.5	100.5	103.9	102.9	105.1	100.8	97.7	97.0	96.1
1973/74	96.4	95.3	100.1	106.0	100.2	103.7	102.9	104.0	100.8	97.7	97.2	95.9
1974/75	96.1	96.2	100.7	106.4	100.0	102.6	102.4	103.0	101.0	98.4	98.5	97.0
1975/76	95.7	96.6	100.3	105.4	100.0	101.7	101.5	101.7	101.3	99.8	100.3	98.6
1976/77	95.7	96.1	99.1	101.4	100.6	101.0	101.0	100.8	101.1	100.8	101.6	100.4
1977/78	95.9	95.7	97.7	102.5	101.3	100.8	100.7	100.1	100.8	101.5	102.4	101.2
1978/79	96.0	95.4	96.6	101.8	102.4	101.1	101.2	101.1	99.9	101.4	102.7	101.4
1979/80	95.8	95.5	95.9	101.5	103.3	101.7	101.3	99.9	99.3	101.4	102.9	101.1
1980/81	95.7	95.6	95.6	101.6	103.8	102.1	--	--	--	--	--	
Seasonal Factors, One Year Ahead, 1981/82	95.6	95.6	95.5	101.7	104.0	102.3	101.5	99.9	99.1	101.4	103.0	100.9

Where $CHPR_t$ is the percentage change in price from the harvest period to the normal high (November for hard red spring wheat and October for durum wheat and barley) in marketing year t; $CHTS_t$ and $CHTD_t$ are the percentage change in projections of total supply and total demand within the marketing year. In each case it was the third quarter projection (i.e., July or August) less than the actual divided by the third quarter projection. Thus, these variables indicate the extent projected fundamental data deviated from what actually evolved. In other words, they indicate the extent the projections were reflective of changes in the fundamental situation within the marketing year. e_t is the random error term. Data from the 1962/63 to 1980/81 crop years were used in the analysis. a_0, b_1, and b_2 are coefficients to be estimated. The intercept term is of particular importance in this study. Its value represents the percentage change in prices if the values of the two exogenous variables are zero — i.e., if there were no changes from the projected supply and demand estimates within the year. It thus represents the normal price rise from the harvest period to the normal high. If changes in fundamentals occur, i.e., an unexpected change in projected exports, the actual price change would be greater or less than a_0.

Estimated intercept terms were 5.61, 5.68, and 12.96 for hard red spring wheat, durum wheat, and barley, respectively. These indicate the percentage increase in price from the harvest period — to November for hard red spring wheat and October for durum wheat — assuming the fundamental market variables do not change. Therefore, they approximate the normal returns to storage and can be used for basing expectations on post harvest price behavior. However, the extent prices appreciate would be different if changes occur in projected supply and demand. For example, if demand estimates decrease between August and November, prices would appreciate less than the normal price change.

Conclusions

Marketing decisions by agricultural producers are affected by many factors. Storage costs and availability, tax situations, and expectations of future price movements all affect marketing decisions. A factor of particular importance which affects expected future price movements is the seasonal pattern of prices. Seasonal price patterns are those which are recurrent year after year. During harvest, prices are depressed because of the surplus during that period. As the marketing year progresses, prices generally increase reflecting positive returns to storage. Prices for hard red spring wheat are at a low in August and peak in October and November. Irregularity (not accounted by recurrent seasonal patterns) was more important in durum wheat prices, and monthly differences were not significant. All barley prices are at a low in August and increase, on average, to peak in October.

Each of the three grains experienced a slightly different seasonal price behavior between the periods 1967/68 to June 1973 and 1973/74 to December 1980. The latter period differed from the former in the case of wheat because it was dominated by the international market more than by the domestic market. The results indicate there was relatively more variability and less seasonality in the latter period. Similar conclusions were made for durum prices. Generally, the seasonal low has not been as low in recent years as in the earlier period and the seasonal high is slightly higher and occurs sooner in the marketing year. In recent years it has been occurring in October and November. Similar changes in intra-year barley prices were observed.

Post harvest price changes are related to 1) the normal seasonal price change, and 2) changes in fundamental market variables within the marketing year. Thus, post harvest price changes are related to changes in estimates of demand and supply within the marketing year. A model was specified and estimated to examine this rela-

continued on page 16

TABLE 4. Intra-year Changes in Hard Red Spring Wheat Prices and Carryovers.

Crop Year	Percentage Change in Hard Red Spring Wheat Prices, August to November	Carryover for All Wheat (million of bushels) Beginning of year	
		Projection	Actual
1967/68	0.67	545	539
1968/69	7.69	689	819
1969/70	12.31	857	885
1970/71	12.50	810	731
1971/72	5.69	849	863
1972/73	22.67	812	438
1973/74	6.84	298	339
1974/75	15.85	417	435
1975/76	-9.65	586	664
1976/77	-18.40	760	1,112
1977/78	17.61	1,277	1,177
1978/79	8.36	1,133	925
1979/80	0.56	860	901
1980/81	8.21	965	907[a]

[a] November estimate of carryovers.

TABLE 4

Levels of Sunflower*, Stabilizer**, Dextrose, and Salt

Sample #	O***	1	2	3	4	5
% Sunflower	100	94.0	93.5	93.0	92.5	92.0
% Dextrose	0	4.0	4.0	4.0	4.0	4.0
% Salt	0	0.5	1.0	1.5	2.0	2.5
Sample %		6	7	8	9	10
% Sunflower		93.5	93.0	92.5	92.0	91.5
% Dextrose		4.5	4.5	4.5	4.5	4.5
% Salt		0.5	1.0	1.5	2.0	2.5
Sample %		11	12	13	14	15
% Sunflower		93.0	92.5	92.0	91.5	91.0
% Dextrose		5.0	5.0	5.0	5.0	5.0
% Salt		0.5	1.0	1.5	2.0	2.5
Sample %		16	17	18	19	20
% Sunflower		92.5	92.0	91.5	91.0	90.5
% Dextrose		5.5	5.5	5.5	5.5	5.5
% Salt		0.5	1.0	1.5	2.0	2.5
Sample %		21	22	23	24	25
% Sunflower		92.0	91.5	91.0	90.5	90.0
% Dextrose		6.0	6.0	6.0	6.0	6.0
% Salt		0.5	1.0	1.5	2.0	2.5

*For all treatments, sunflower kernel was roasted at 330°F. for 20 minutes.

**Stabilizer was added at the 1.5% concentration to each treatment.

***Underlined samples were selected for organoleptic testing.

continued from page 12

tionship. The results indicated how changes in supply and demand estimates affected post harvest price changes and allowed for identification of the normal seasonal price rise. The latter occurred when changes in fundamentals were assumed nil. The results indicated that the normal seasonal price rise was 5.6 per cent from August to November for hard red spring wheat, 5.7 per cent from August to October for durum wheat, and 12.9 per cent from August to October for barley. A revealing conclusion from these results is that returns to barley storage are greater than returns to wheat storage. Thus, if cash is needed or storage space is limited, storage of barley would be preferable to wheat. In any particular year, these may not evolve because of changes in fundamental market variables. Resuts presented in this study approximate the returns to storage or the appreciation in revenues which accrue from storage. These must be balanced against individual situations regarding taxes, storage costs, etc. in making storage decisions.

References

1. United States Bureau of the Census. 1967. **The X-11 Variant of the Census Method II Seasonal Adjustment Program.** U.S. Government Printing Office, Washington, D.C.

2. Wilson, W. W. 1981. **Factors Affecting Post Harvest Changes in Grain Prices Received by North Dakota Producers.** Agricultural Economics Report No. 146, Department of Agricultural Economics, North Dakota State University.