A New Sampling Plan For the North Dakota Wheat Quality Survey

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An annual crop quality survey is conducted by the Department of Cereal Chemistry and Technology and the Cooperative Extension Service of NDSU to inform grain buyers of the quality of North Dakota wheat. A study was made to design a statistical sampling plan which would improve the efficiency of the crop surveys. The proposed plan was compared for accuracy against the old method on the data from the past five years. Statistics showed that 10 hard red spring wheat and 12 durum samples per county must be collected to have a 90 per cent probability of the county averages falling within the test weight and protein content limits. These limits are ± 0.5 lbs/bu test weight and ± 0.4 per cent protein.

Introduction

To inform grain buyers of the quality of North Dakota wheat, an annual crop quality survey is conducted by the Department of Cereal Chemistry and Technology and the Cooperative Extension Service, North Dakota State University. Throughout the harvest season, samples are drawn from the major wheat producing counties and sent to the Department of Cereal Chemistry and Technology for quality evaluation. Reports of the quality are distributed to the wheat industry.

The first annual hard red spring wheat survey was conducted in 1960. The following year, durum was added to the North Dakota State University wheat survey program. In the early years of testing, only protein, test weight and grading information were reported. In recent years, however, the survey has been expanded to include quality characteristics which are of major importance in the industrial utilization of North Dakota hard red spring and durum wheat.

The North Dakota State Wheat Commission has supported the annual quality surveys as part of its program to inform prospective buyers of the quality of North Dakota wheat. The survey is distributed to all countries which buy substantial amounts of U.S. wheat. The North Dakota Wheat Commission distributes the reports to foreign buyers through Great Plains Wheat, Inc. and Western Wheat Associates. Buyers around the world have come to depend on these annual quality reports for information on hard red spring and durum wheat quality. The reports are circulated to millers, cereal chemists, wheat buyers, government officials and key U.S. and foreign government agencies which control the sales and purchases of wheat.

Past annual crop surveys have used a variable plan where counties were sampled on the basis of wheat production. An average of 349 samples of durum and 893 samples of hard red spring wheat were tested with this plan. With the new plan, 348 durum and 510 hard red spring samples will be tested. This represents a 31 per cent savings in the total number of samples to be analyzed while maintaining the needed accuracy of the crop quality survey.

The present method of crop sampling uses a variable number of samples among the counties. Samples are collected on the basis of wheat production and submitted by cooperating elevators from all of the counties producing substantial amounts of hard red spring and durum wheat. At least two elevators in each county participate. The number of collected samples reflects the anticipated wheat production of each county. Elevator operators collect a sample from each truck load of wheat and place it in a large container. Twice a week the samples are thoroughly mixed, and a three-pound portion is drawn and sent in a moisture proof plastic bag to the Department of Cereal Chemistry and Technology at North Dakota State University, Fargo, for a complete grade and quality evaluation. These samples are uncleaned and reflect the average condition of the grain delivered to the elevator during the sampling period.

From a statistical viewpoint, the accuracy of the survey depends on obtaining representative samples of the wheat from each county. The accuracy of the testing procedures and the absolute number of samples obtained from each

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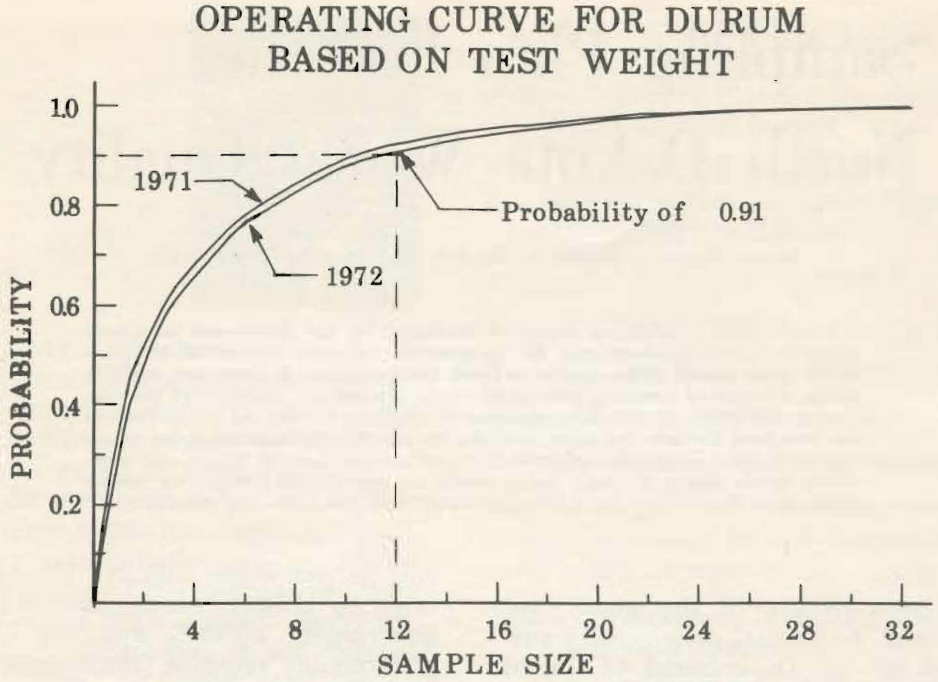

Figure 1. The operating curve shows that collecting 12 durum samples per county gives a 90 per cent probability that the county averages will fall within ± 0.5 lbs/bu of the actual test weight.

county also influence the results. Since it is assumed that the elevator-drawn samples are representative of the crop and that the test methods are reasonably accurate, this leaves only the number of samples in each county where possible changes might be made to improve the survey. An area of concern is to decrease the time lag between the harvest and the release of the quality report. To be of greatest value, the report must be in the hands of the buyers at harvest time when wheat buying decisions are usually made.

According to theories of statistics (Grant, 1964), the accuracy of the average (mean) for a determination is dependent on the absolute size of the subgroup. Based on this, an accurate picture of the crop could be obtained by drawing the same number of samples from each county regardless of its wheat production. This procedure would prevent over-sampling of large wheat producing counties and eliminate unnecessary, time consuming tests which delay the release of the report.

A study was made to design a statistical sampling plan which would improve the efficiency of the crop surveys. The objective of this study was to evaluate the present sampling method and design a statistical sampling plan. The proposed plan was compared for accuracy against the old method.

Methods and Results

A sampling plan was designed by a statistical technique to determine the minimum number of samples which must be collected to have an average test weight and protein content within prescribed limits. An average of ± 0.5 lbs/bu and ± 0.4 per cent protein were considered reasonable limits for accurate testing of wheat. The probability of the county averages falling within the test weight and protein content limits was determined for sample sizes of one to 32 (Figure 1). As the sample size increases, the chance of falling within the limits increases until a maximum of 100 per cent (or a probability of 1.0) is reached. When the sample size is large, an increase in the size of sample will not affect the accuracy of the results to any great extent. The probability of falling within the limits for test weight is 0.51 if two samples are drawn, 0.67 if four samples are drawn, 0.83 if eight samples are drawn, and 0.91 if 12 samples are drawn. If the number of samples drawn is increased to 16, the probability of falling within the limits increases only to 0.95. This slight gain in accuracy is not worth the extra time and cost involved in quality evaluation. The two curves are so close together because there was little variance in the test weight of durum from 1971 to 1972.

Statistics showed that 10 hard red spring wheat samples and 12 durum samples per county must be collected to have a 90 per cent probability of the county averages falling within the test weight and protein content limits. This means that if 12 durum and 10 hard red spring wheat samples were collected from each county, 90 per

cent of the time the county average would be within ± 0.5 lbs/bu test weight and ± 0.4 per cent protein of the actual county average.

The proposed statistical sampling plan was tested for accuracy against the annual crop quality survey. From past data cards, a sample of 10 for HRS and 12 for durum was randomly drawn for each wheat producing county. The county sample average test weight and protein content was determined. Not all counties were evaluated since certain counties did not have as many data cards as needed to compose the random sample. Within the set limits, the sample average (new plan) did not differ from the actual average (old plan) for both test weight and protein content in the last five years (Tables 1 and 2).

Table 1. Comparison of Yearly Averages for the Two Sampling Plans for the Hard Red Spring Wheat Survey.

Year	Test Weight		Protein Content	
	New Plan	Old Plan	New Plan	Old Plan
1969	60.32	60.40	14.08	14.10
1970	59.26	59.32	14.81	14.82
1971	61.16	61.02	13.43	13.45
1972	60.10	60.07	13.94*	13.38
1973	59.52	59.52	14.54	14.48

* *Not within the control limits. (Control limits are ± 0.5 lbs/bu for test weight and ± 0.4% for protein content).*

Table 1 shows a comparison of the 1969-1973 yearly state HRS averages for test weight and protein content as determined from the quality data and the data for the proposed statistical sampling plan. In 1969 through 1973, the proposed sampling plan showed an average test weight within ± 0.5 lbs/bu of the actual state test weight. In the five years studied, only once (in 1972) was the average protein content outside the limits (± 0.4 per cent protein).

Table 2 shows a comparison of the 1969-1973 yearly state averages for durum test weight and protein content as determined from the quality data and the data for the proposed sampling plan. In all five years, the proposed sampling plan showed averages for test weight and protein contents within the limits (± 0.5 lbs/bu and ± 0.4 per cent protein). In 1971, for example, the actual average test weight was 62.38 lbs/bu; while the sample of 12 showed a test weight of 62.18 lbs/bu. This 0.2 lbs/bu difference in test weight is within the ± 0.5 lbs/bu limit.

Table 2. Comparison of Yearly Averages for the Two Sampling Plans for the Durum Wheat Survey.

Year	Test Weight		Protein Content	
	New Plan	Old Plan	New Plan	Old Plan
1969	62.40	62.50	13.05	13.20
1970	61.21	61.19	13.74	13.82
1971	62.18	62.38	12.51	12.58
1972	62.12	61.84	13.31	13.38
1973	61.13	61.13	13.89	14.01

The data in Tables 1 and 2 indicated that the proposed sampling plan gives an accurate picture of the North Dakota hard red spring and durum wheat crops.

To further evaluate the proposed statistical sampling plan, the special HRS Wheat Survey conducted in 1973 was studied. For the special survey, the samples were collected by a trained technician in the field while being harvested. All the samples for a county were collected in one day. Due to limited time, only three counties were included in the survey. These counties (LaMoure, Ransom and Traill) were assumed to represent the spectrum of growing conditions in the state.

The special survey was compared with the annual crop quality survey on the basis of test weight and protein content. The special survey samples did not agree, within the set limits, with the quality survey samples.

Table 3 shows a comparison of the 1973 special HRS survey data and the 1973 quality survey data. Two of the three counties in the special survey

Table 3. Comparison of the 1973 Special HRS Survey with the 1973 Quality Survey.

County	Sample Size		Test Weight (lbs/bu)		Protein Content (%)	
	Quality Survey	Special Survey	Quality Survey	Special Survey	Quality Survey	Special Survey
LaMoure	13	10	57.72	58.20	16.25	15.79*
Ransom	8	21	59.06	58.43*	14.86	14.97
Traill	24	31	59.12	58.60*	14.24	14.11

* *Not within the control limits. (Control limits are ± 0.5 lbs/bu for test weight and ± 0.4% for protein content).*

were outside ± 0.5 lbs/bu of the test weight for the actual quality survey data. For example, the special survey showed Ransom county had a test weight of 58.43 lbs/bu. This was more than 0.5 lbs/bu lower than the actual test weight of 59.06 lbs/bu. Furthermore, when protein content was considered, one of the counties in the special survey was outside the limits (± 0.4 per cent protein).

The variance within a county for the special survey was more than the variance for the quality survey. This was due to the fact that each sample in the special survey represented only one field, while for the quality survey each sample was a composite of several fields. Collecting a composite sample gives a better picture of the crop than selecting samples from a few fields.

Also, it was determined that 23 field-collected samples should be drawn for each county, while only 10 elevator-collected samples are necessary with the proposed statistical sampling plan.

Conclusions

It is possible to design a statistically based sampling plan which minimizes the size of sample required to obtain a valid picture of wheat crop quality. Based on wheat quality data for the past five years, the proposed plan compared favorably with the old sampling plan (Tables 4 and 5).

Table 4 shows a comparison of the average quality between the actual 1969 - 1973 HRS surveys and data for the proposed sampling plan. In 1969 through 1973, for the proposed sampling plan a total of 167 county averages were within ± 0.5 lbs/bu of the test weight average for the actual survey data. Only 10 out of the 177 samples were outside these limits. When protein content was used as a test factor, only five counties out of the 177 sampled were outside the limits (± 0.4 per cent protein). These data indicated that the proposed plan was operating successfully with the predicted statistical limits for test weight and protein.

Table 4. Comparison of the Quality Survey with the Proposed Plan for the Hard Red Spring Wheat Survey.

Year	Number of Qualifying Counties*	Using Test Weight as a Factor		Using Protein Content as a Factor	
		Number of Counties that agreed with the survey.	Number of Counties that disagreed with the survey.	Number of Counties that agreed with the survey.	Number of Counties that disagreed with the survey.
1969	25	25	0	25	0
1970	40	36	4	38	2
1971	42	41	1	42	0
1972	35	34	1	34	1
1973	35	31	4	33	2
Total	177	167	10	172	5

* *To qualify, a county needed more samples than the size of the random sample.*

Table 5. Comparison of the Quality Survey with the Proposed Plan for the Durum Wheat Survey.

Year	Number of Qualifying Counties*	Using Test Weight as a Factor		Using Protein Content as a Factor	
		Number of Counties that agreed with the survey.	Number of Counties that disagreed with the survey.	Number of Counties that agreed with the survey.	Number of Counties that disagreed with the survey.
1969	12	12	0	12	0
1970	13	13	0	13	0
1971	10	10	0	10	0
1972	10	9	1	10	0
1973	13	13	0	13	0
Total	58	57	1	58	0

* *To qualify, a county needed more samples than the size of the random sample.*

Table 5 indicated similar results for the durum surveys. However, 57 counties out of the 58 sampled were within ± 0.5 lbs/bu of the test weight average for the actual survey data. Furthermore, all 58 counties sampled were within the limits (± 0.4 per cent protein) when protein was used as a test factor.

To improve the effectiveness of the quality report, it is proposed that the North Dakota State University Wheat Crop Quality Survey be conducted by drawing an equal number of samples from each wheat producing county. This sampling would require 10 and 12 samples per county for hard red spring wheat and durum wheat, respectively.

Since at present as many as 45 samples per county are drawn for the wheat survey, several months are needed to prepare the quality report that is sent to buyers of North Dakota wheat. This over-sampling delays the release of the report. With the new plan, requiring fewer samples per county, the information about the quality of North Dakota wheat may be collected more rapidly, releasing the quality report to prospective wheat buyers much sooner. This would give North Dakota wheat an advantage on the grain market, since the wheat buyer will have information on the quality of North Dakota spring wheat and durum when wheat buying decisions are made.

Reference

1. Grant, Eugene L. 1964. **Statistical Quality Control, 3rd ed.** McGraw-Hill Book Company, Inc., New York.