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Findings from the 1983 Winter Wheat Validation Study

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ABSTRACT

Yield and acreage indications from a sample of fields in the 1983 Winter Wheat Objective Yield (OY) Survey of the Statistical Reporting Service, USDA, were studied in Kansas and Washington. In Kansas, the OY estimate of net yield significantly exceeded both the net yield derived from weighed production and digitized acreage values (by 2.9 bu/acre, or seven percent) and the net yield reported by farmers in personal interviews (by 2.8 bu/acre, or seven percent). However, in Washington and the combined states, these comparisons of net yield did not show significant differences. The following results were obtained for the individual and combined states: the OY net yield estimate was not significantly changed by using additional data from a small subset of the study fields, which were resampled to ensure that all fields were sampled within seven days of harvest; the "most accessible corner" was probably a valid starting point for locating OY samples; and net yields and harvested acreages reported by farmers in personal interviews did not significantly differ from values derived from weighed production and digitized acreage figures.

Due to problems with certain data and limitations of the experimental design, the results of this study should be cautiously interpreted and applied. Future validation studies should include controlled experimentation.

Washington, D.C. September 1984

CONTENTS

SUMMARY

In 1983, the Statistical Reporting Service (SRS), USDA, studied aspects of its Winter Wheat Objective Yield (OY) Survey. The general purpose was to examine yield and acreage indications from this survey, especially in relation to yield values derived from weighed production and digitized acreage figures. The study was conducted in Kansas and Washington. The results which were obtained are useful for getting a general idea of the relationship between various yield and acreage indications. However, these results should be interpreted cautiously, because there were problems with certain data (especially in Washington), and because of limitations in the experimental design.

The major findings were:

1. When data were combined for the two states, there were no significant differences between any of the following four net yield figures:

   a. "Regular" OY estimate, obtained by usual survey procedures at physiological maturity of the crop.

   b. "At-harvest" yield, the estimate using the data that went into (a), plus additional data collected in "mirror unit" plots in some fields to ensure that all fields were sampled within seven days of farmer harvest.

   c. "Actual" yield, derived from weighed production and digitized acreage figures.

   d. Postharvest farmer-reported yield.

2. When these four net yield figures were compared at the state level in Washington, there were again no significant differences, but there are concerns that the test was influenced by nonsampling errors.

3. However, in Kansas, the regular OY net yield estimate was seven percent above the actual yield and the farmer-reported yield. These margins were both significant. Certain sources for these differences can be eliminated as causes, but this study simply was not designed to isolate particular sources of error. The at-harvest yield estimate was not significantly different from the regular OY estimate, but it was significantly higher than both actual yield and farmer-reported yield. Actual yield and farmer-reported yield were not significantly different.

4. At the combined, two state level, estimated acreage for harvest, as reported by farmers, was not significantly different from actual, digitized acreage. This was true for each state, too.

5. The use of the "most accessible corner" as the starting point for locating plots was not found to be inappropriate, because gross yield estimates were not significantly different when other corners were used for locating plots.

6. With the possible exception of (5) above, this study did not show the validity or lack of validity of OY survey procedures.

RECOMMENDATIONS

Care should be taken in concluding from this report that winter wheat OY procedures are "valid" or "not valid." The work done in this study is only a beginning of what is needed to validate OY procedures. Future studies must be more carefully designed and include controlled experiments on components of the OY procedures, such as plot size and location, counting procedures, and effects of delays before and after harvest.

A major concern in the preparation of this report was the uncertain quality of some of the data. Future validation studies must have better quality control measures. Also, considering that the data for this study were probably collected by the better enumerators, questions are raised about the quality of the regular OY survey data. Apparently, even more supervisory review of data collection is needed in the regular OY survey.

FINDINGS FROM THE 1983 WINTER WHEAT VALIDATION STUDY.

By Fred B. Warren and Douglas C. Bond

INTRODUCTION

The overall purpose of this study was to examine yield and acreage indications produced by the Winter Wheat Objective Yield (OY) Survey, which is conducted annually by the Statistical Reporting Service (SRS), USDA. Specifically, the objectives were:

Objectives and Definitions of Terms

(1) To study relationships among four indications of net yield, of which several were derived from OY survey data. These indications are defined below, and will be referred to later in the paper with the same terminology.

a. "Regular" OY estimate - the estimate of net yield based on data collected in plots when the wheat was first observed to be physiologically mature. Because the data collection and summarization procedures in this study were essentially the same as for the operational SRS survey, this estimate is comparable to the final preharvest net yield estimate produced by the SRS survey.

b. "At-harvest" yield estimate - the net yield estimate derived from data collected in plots within seven days of farmer harvest. Usually the data were simply the same data used for the regular OY estimate, since most fields were farmer-harvested within seven days of the regular OY field visit. If farmer harvest was more than seven days after this visit, data were collected from additional plots, called "mirror" units because they were only five feet from the regular OY units and hence had similar characteristics. The data from these mirror units replaced the data from the regular OY units when "at-harvest" yield was estimated.

c. "Actual" yield - the net yield derived by weighing at an elevator the wheat actually harvested by the farmer from his field and by digitizing the field's acreage for harvest.

d. Farmer-reported yield - the estimate of field-level yield reported by the farmer in a postharvest personal interview. This interview was part of the regular OY survey.

(2) To see if the normal OY survey procedure of locating plots in relation to the "most accessible corner" of a field is acceptable for estimating gross yield.

(3) To compare farmer-reported harvested acreage, obtained in the postharvest personal interview of (1d) above, with "actual" harvested acreage, determined by digitization.

To address the above objectives, data were collected in conjunction with the 1983 winter wheat OY survey in Kansas and Washington. The next section of this report will describe the methods used. Problems found in a review of the data will then be discussed. Next, detailed findings will be presented. A discussion section will complete the report.

METHODS

This study was conducted in 1983 in Kansas and Washington. Thirty fields were selected in each state. These fields were systematically selected from a list of fields, already in the OY survey sample, for which the farmer previously indicated willingness to cooperate with this study.

The experimental design was as follows. Each of the selected fields was assigned a total of eight pairs of sample units, including the regular OY sample. (See the SRS Enumerator's Manual (5) for details on the size and location of these samples.) Two pairs of these sample units were located with respect to each of four "corners" of each field. "Corners" is in quotes since not all fields were rectangular.

The field procedure was as follows. In each field, a regular OY preharvest sample consisting of two units was laid out at the time of the first monthly OY preharvest survey visit. (This was the last week of April for Kansas and the last week of May for Washington.) Then, when in the course of the regular monthly OY survey, or when notified by the grower, the field was found to be ripe and ready for harvest, the additional seven pairs of sample units were laid out. The heads in all eight pairs of sample units were clipped and sent to the SRS laboratory to be threshed. The grain was weighed and tested for moisture with a Motomco moisture meter. If the entire field was not harvested by the farmer within seven days of these observations, additional preharvest observations were taken in the unharvested portions of the field. These additional observations were obtained from "mirror units" which were five feet beyond each of the original units. These observations were taken just before actual farmer harvest of those portions of the field. One or more mirror units were needed in three fields in Kansas and nine fields in Washington.

After the area around each pair of sample units had been harvested by the farmer, unharvested grain was gleaned from similar sample plots located a fixed distance from each of the original preharvest plots. The gleanings were sent to the SRS laboratory for grain weight and moisture determination with a Motomco moisture meter. All gleanings were taken within three days of actual harvest.

Field-level net yield estimates were derived in the following way. Data from the two units in each sample were combined, corrected for moisture, and expanded to estimate gross yield in bu/acre. (See the SRS Supervising and Editing Manual (6) for details on how yield estimates are derived.) Then field-level gross yield was estimated by computing a simple average of the sample-level estimates. Harvest loss was estimated at the field level in a similar way. Estimated net yield at the field level was calculated by subtracting harvest loss from gross yield. It was adjusted for moisture content based on the moisture meter determination.

To compare gross yields at the field corners, sample-level gross yields in bu/acre were computed as above and corrected for moisture. Corner gross yields were then derived by computing simple averages, in each corner of each field, of these sample-level figures.

To get "actual" net yield for each field, production and acres for harvest were determined essentially by a total enumeration process. Production was determined by weighing each truckload of grain from a field at a commercial elevator. A sample was taken from each truckload of grain to determine moisture, using a Motomco moisture meter, in an SRS lab. Percent foreign matter was to have been determined for each truckload, but apparently this was not usually done. This was perhaps because the amount of foreign matter was negligible. In Kansas, foreign matter usually makes up on average about 0.1 to 0.3 percent of total weight (3). Truckload net weights were accumulated for each field and corrected for moisture and, where possible, foreign matter. Apparently no correction was made for dockage, which in Kansas, on average, usually makes up two to three percent of total production (3).

"Actual" acres for harvest were measured by digitization of current-year color slides by ASCS. The acreage figures were reviewed by the enumerators assigned to the field.

Farmer-reported field-level acres for harvest and net yield were obtained in a postharvest personal interview. All farmers had access to the field-level weighed production figures before the interview. They were not asked for grain moisture content (they are not asked for this in the usual SRS wheat survey), so their reported yields could not be corrected for moisture.

This study was designed for inference at the individual state level, but not for the combined states. However, for additional comparison purposes, estimates from Kansas and Washington were combined by weighting on the basis of the number of fields in each state.

DATA REVIEW

Field Level Estimates

Various field-level net yield and harvested acreage indications are shown in Appendix Tables Ia and Ib. There is one indication in these tables which has not been defined yet. This is preharvest farmer-reported acreage. It was collected in a personal interview at the start

of the regular OY survey. It was not analyzed in this study. The digitized acreage for field 116, Washington, was not obtained. Therefore, data from this field were excluded from this study. Also, the digitized acreage and weighed production for Washington field 39 were for a field which extended beyond the defined field boundaries, while the preharvest and postharvest interview acreages were within the defined boundaries. Therefore, data from this field were excluded from harvested acreage comparisons.

The large difference in acreage between the preharvest and postharvest farmer-reported acreages for field 19, Washington, resulted because 35 acres of barley were not deducted from the preharvest farmer-reported acreage.

There was nothing in the data to explain the large differences between the farmer-reported yields and the other yield indications for Kansas fields 137 and 207, nor for fields 46 and 54 in Washington. Therefore, no corrections were made for these data.

Missing Values

Four different types of missing values were identified in this data review. The first involved the case where clipped wheat heads sent to the SRS laboratory for grain weight determinations were "lost" somewhere. In the operational OY survey, the standard practice is to substitute the historical average head weight whenever the laboratory data are not available. In the case of this study, the average head weight for the other samples in that particular field were substituted.

A second problem was with the farmer-reported yields. Two of the extreme differences shown in Table 1a are for fields where the postharvest interview questionnaire was completed in the Kansas State Statistical Office (SSO). The source of the data was unknown. A third postharvest interview questionnaire was completed in the Kansas SSO, presumably from the elevator weight information, but the total production arrived at was less than half the total shown on the form for recording elevator weights. For this case, actual yield based on weighed production was substituted for farmer-reported yield.

A third problem was with field 19, Washington. At the time of the final regular OY visit, both units in a sample were reported as containing no heads or stalks. Mirror units were sampled only for this sample, and they had normal head counts for both units. A review of the field observation record form showed that (a) entries had been erased and a notation entered that both units were "blanks," and (b) there was a notation that the laboratory samples had been lost. A further review revealed that the counts erased from the form for the sample were exactly the same as those recorded for another sample. The action taken was to use the observation for the mirror unit visit for the regular final OY visit.

Still another peculiarity of Washington field 19 was that all row space measurements (distance across five row spaces) were uniformly 5.0 feet, except for the regular OY preharvest sample (7.4 feet). The postharvest gleaning sample row space measurements were also

uniformly 5.0 feet. The OY estimated yield for this field was considerably above both the farmer-reported and actual yields. If five-row space measurements of 7.4 feet (the five-row space measurements for the regular OY preharvest sample) had been used for all samples in that field, then the regular OY estimate based on all eight samples would have been about 52 bushels per acre. This would still be above the other indications, but it would have been within sampling error range. Since there was no clear justification for changes, however, no corrections were made in these data.

A review of several questionnaires and forms identified four fields in Washington as having acreage problems. Three of these (fields 39, 84, and 116) were fields where the actual field extended beyond the field boundaries as defined in this study. For two of these fields, weighed production and digitized acreages for the entire field were used in comparisons with other yield and acreage indications. However, a digitized acreage comparable to the weighed production was not obtained for field 116, so it was removed from most analyses. The fourth field included 13 acres of barley. It was not clear from the forms as to whether or not the 13 acres were included in the digitized acres for grain. Therefore no corrections were made in this field's data.

A side issue here, but of importance to the operational program, is the question, "How were these fields, and others like them, handled in the summarization of the original enumerative surveys?" That is, when a field extends across the defined boundaries, is this taken into account in the summarization of the enumerative survey, and in selecting the objective yield sample fields?

The possible impact if these fields are not identified and steps taken to correctly estimate the acreage of the field is two-fold. First, the expanded acreage estimate for that particular survey will be too high. Secondly, these fields will receive too high a probability of selection in drawing the samples for the OY survey.

Head Weight

Two fields in Washington had extremely large differences between the estimated yields for the regular OY and mirror units. These extremely large increases in gross yield were tied to extremely large increases in the estimated average weight of grain per head. In both cases, the average weight per head for these samples was much lower than the average of the other samples in the same fields at the time of the regular OY final visit. This may indicate that these particular fields had ripened unevenly, so that the part of the field where the samples were located was much less mature than the rest of the field. Other possibilities are that there was extreme variability in head weight within the Washington wheat fields, or that there may have been errors (particularly in counting heads) in the SRS laboratory. However, no corrections in data were made, due to lack of factual information.

Yields

A review of the yields in Appendix Tables Ia and Ib shows that the differences between the actual yields and the OY estimates for four fields in Washington were much larger than should be expected if the differences were due only to sampling errors. (The differences for all fields of both states, expressed in terms of their own standard errors, are displayed in Figure 1.)

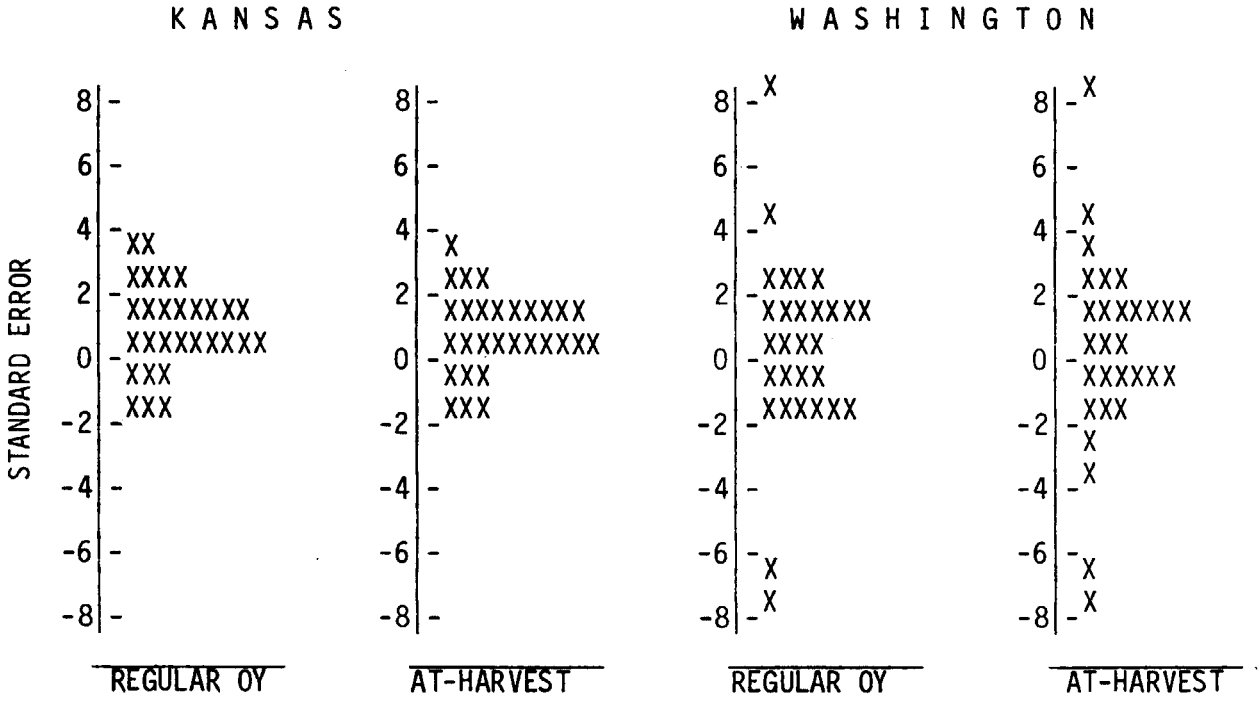

FIGURE 1 -- Differences, in standard errors, between regular OY yield estimates and actual yields, and between at-harvest yield estimates and actual yields, 1983 winter wheat validation study.

NOTE: Each 'X' represents one field.

Given that the above differences appear to be excessively large, there is a possibility that they could have occurred as a result of repeated sampling (30 fields in each state). If so, then the differences should be distributed approximately as a "t" distribution with seven degrees of freedom. A chi-square goodness of fit test rejected the null hypothesis that these differences could have resulted from sampling error, at the 0.001 level for Washington. However, this hypothesis was not rejected for Kansas.

Other possibilities include nonrandom plot locations, improper row space measurements, inability of the plot location tables to adequately

cover large fields (particularly fields as variable in size as those in Washington), and confusing samples in the SRS lab.

An allied problem is the matter of the extremely large differences for the mean square error (MSE) of the F-tests used to analyze data in Table 1. (See the section entitled, "Detailed Findings.") The MSE for Washington was 105.1, more than ten times larger than the MSE of 9.2 for Kansas. This had the immediate effect of establishing a critical value of 7.1 bu/acre for the Tukey test in Washington, but only 2.0 bu/acre in Kansas. The use of variances that may be unequal in the analysis of variance at the combined state level can violate the F-test assumptions that the errors are a set of uncorrelated random variables with mean zero and common variance. However, there was no clear basis for suspecting unequal variances in the F-test used in this study, and no analysis for inequality of variances was performed. Since the F-test for equal means is known to be quite robust in the face of unequal variances, especially for equal cell sizes (as in this study), it was not considered inappropriate for analysis in this study.

The next questions are "What kinds of nonsampling errors might have contributed to the large differences mentioned above?" and "What effect might this have on the evaluation of the study results?" While the study was not designed to identify specific nonsampling errors, one possibility is that the weighed production may not have been recorded properly for all fields.

DETAILED FINDINGS

Due to the data problems already discussed and limitations in the experimental design (see the "Discussion" section), the findings in this section should be cautiously interpreted and applied.

Net Yield Estimates

Net yield indications were compared by treating them as if they came from a randomized complete block design. Fields were the blocks and the four estimation and measurement methods used to derive the indications were the treatments. If the hypothesis that the four treatment means were equal was rejected, pairwise comparisons were made with Tukey's test.

To enhance comparison with another SRS report, on corn OY survey validation (8), six paired t-tests were also performed to make comparisons among the four treatment means. Results are presented in Appendix Table 2, but they are not discussed in this report; the F-test was used to draw conclusions. The reader is cautioned that, because six t-tests were performed within each state and within the combined states, the probability of rejecting at least one true hypothesis was considerably higher than 0.05, the significance level of each test.

The results of the F-test (Table 1) showed no significant differences between the four methods when data from Kansas and Washington were combined. When the data were broken down to the state level, there were still no significant differences in Washington. However, in Kansas the regular OY method significantly overestimated actual net yield by 2.9 bu/acre (seven percent) and postharvest farmer-reported yield by

2.8 bu/acre (seven percent). There was no significant difference between the regular OY estimate and the at-harvest estimate. This is not surprising, since mirror unit data were collected in only three of the 30 Kansas fields. (Mirror unit data were collected in nine of the 29 Washington fields.)

TABLE 1 -- Mean net yield (bu/acre) estimated by different methods, 1983 winter wheat validation study

Method	Kansas 30 fields 1/	Washington 29 fields 2/	Combined states 59 fields 2/
Regular Objective Yield	41.8[a]	75.2	58.2
At-harvest yield	41.5[a]	74.8	57.8
Actual yield	38.9[b]	76.0	57.2
Postharvest farmer-reported yield	39.0[b]	73.0	55.7

1/ Values in column with different letters are significantly different at the 0.05 level.

2/ Values in column are not significantly different at the 0.05 level.

It is possible to eliminate certain sources of error as causes of the differences in Kansas. For example, there were no apparent problems in the models to expand plot yields to the acreage level in the computer summary program, or in the procedure of locating plots in relation to the "most accessible corner" (this is shown later in the report). However, this study simply was not designed to isolate sources of error. There are numerous possibilities for why there were differences, such as errors due to preharvest and/or postharvest plot size and location, time lag between the regular OY visit and farmer harvest, errors in elevator weighing, and so forth. The limitations in the design of this study, which make it difficult to draw conclusions about sources of errors, are dealt with in more detail in the "Discussion" section.

There were thus mixed results. At the combined state level, the OY method, with or without mirror unit data, was apparently capable of estimating "actual" yield. However, at the individual state level, this result was true for one state, and false for the other. At any level of data aggregation used in this study, the regular OY net yield estimate and the at-harvest net yield estimate were not significantly different.

Thus, under the conditions of this study, the estimate of net yield did not seem to be affected by sampling some of the fields more than seven days before farmer harvest.

Farmer-reported net yield significantly differed from other net yield indications only in Kansas. It was different from the regular OY estimate and the at-harvest estimate, but it was not different from "actual" yield. It is interesting to see how farmer-reported yield compared with other yield indications, because it is an important indication in many SRS surveys. However, these comparisons provide only a beginning for assessing the validity of OY procedures, and tell little about the accuracy of farmer-reported yields. Reasons for these limitations are in the "Discussion" section.

Harvested Acreage Estimates

The accuracy of the postharvest farmer-reported estimate of harvested acreage was evaluated by comparison with the "actual" acreage figure, based on digitization by ASCS.

A paired t-test was used for this comparison. Pairs were formed for each field. The results (Table 2) showed no significant differences at the combined state level or the individual state level.

TABLE 2 -- Mean acres for harvest estimated from different sources, 1983 winter wheat validation study

Source	Kansas 30 fields	Washington 28 fields	Combined states 58 fields
Postharvest Farmer-reported	72.4	138.6	104.4
Actual digitized	72.2	137.8	103.9
Difference	0.2	0.8	0.5
S.E. of difference	0.5	1.9	1.0
Paired t-statistic	0.3	0.4	0.5

NOTE: t-tests were not significant at the 0.05 level.

Postharvest farmer-reported acreage for harvest therefore appeared to be an accurate estimate. This finding has nothing to do with the validity of the OY net yield estimate, since field acreages are not used

to derive this estimate. However, farmer-reported acreage is used by SRS to estimate harvested wheat acreage, which is multiplied by net yield to estimate production. Therefore, it is important to know that the farmer-reported estimate of acreage is accurate.

Choice of Corner for Locating Plots

To study the acceptability of locating plots in relation to the "most accessible" field corner, regular gross yield estimates (without any mirror unit data), based on data collected in relation to three other field "corners," were prepared. Gross yield estimates from these corners and the "most accessible corner" were then compared using a randomized complete block design, where fields were the blocks and corners were the treatments.

For either state and for both states combined, there were no significant differences between corner gross yields, on the basis of the F-test at the 0.05 level (Table 3). It can be concluded that it made no significant difference in estimated gross yield which corner was used. Therefore, using the "most accessible corner" should probably be continued, since it is the easiest way to locate plots.

TABLE 3 -- Mean gross yield (bu/acre) estimated from data collected in relation to different field corners, 1983 winter wheat validation study

Corner	Kansas 30 fields	Washington 30 fields	Combined states 60 fields
1 (Most accessible)	42.1	76.3	59.2
2	42.7	75.9	59.3
3	42.4	75.1	58.8
4	45.1	75.8	60.4

NOTE: Values in columns are not significantly different at the 0.05 level.

DISCUSSION

In this section, the main conclusions will be briefly reviewed. Then the usefulness and limitations of these conclusions will be discussed. Recommendations for future research will also be made.

The major findings were that some significant differences were found among four methods of estimating or measuring net yield in Kansas, but none were found with Washington data or with Kansas and Washington data combined. Thus, regular OY methods may be capable of accurately estimating net yield and farmer-reported yield for certain groupings of data. Also, at each level of data aggregation (state and two state), farmer reporting was an accurate source of harvested acreage and net yield figures, and the "most accessible corner" was an acceptable choice for the plot location procedure.

The relationships among the various indications of net yield and harvested acreage found in this study are useful to know, both for users of reports published by SRS and for SRS staff who must derive official estimates from these indications. However, these relationships should be carefully interpreted, because of limitations inherent in the experimental design of the study, and because of the data errors that were discovered. Also, the reader should not jump to the conclusion that objective yield procedures are "valid" or "not valid," on the basis of the results in this report. With the possible exception of the corner gross yield comparisons, this study did not demonstrate the validity or lack of validity of OY procedures. This latter point will be discussed first. Then the limitations of the experimental design will be discussed.

Deming (1, Ch. 5) has a good presentation on the validity of sample survey procedures. Some of his ideas are used in this discussion.

Comparison of a sample with a complete enumeration only "raises a question mark." It indicates that further study may be needed. This was the case in Kansas, for example. The comparison does not mean that the sample is right or wrong, and often, as in Deming's experience, the complete enumeration is wrong. Certainly this could be the case with the complete enumeration in this study. Grain was carried out in trucks from fields (one Washington field required 95 truckloads, but most fields in either state required ten to 30), and weighed at an elevator. The weight was corrected for moisture, which was determined by a moisture meter on one small sample from the top of each truckload. The weight was also corrected for foreign matter, which was rarely estimated (but which may have been negligible). Over 1100 truckloads of wheat were transported and analyzed in this study. Considering the large size and design of this study, do we really believe that "actual" production was determined without error?

The regular OY estimate and "actual" weighed yield may have been incomparable, because the weighed yield may or may not have included foreign matter or other dockage, and because moisture meters were used to correct these indications for moisture content. (See Hunt and Neustadt (2) for an example of possible problems from using a moisture meter.)

A quote from Deming (p. 76) motivates the next point: "The precision of a sample is not established by comparison against a complete census unless the complete census is the equal complete coverage for this

sample. Simultaneous trials of complete count and sample, just to see whether sampling will give the same result, is in my opinion a woeful waste of funds. In my own practice, I have steadfastly refused to engage in such tests. ... Moreover, we know by theory, in advance, better then any number of comparisons could possibly establish, what the performance of a sampling procedure will be, provided we really carry it out according to plan."

The last sentence of Deming's quote says we can know how well our sampling procedure performs, if we carry it out correctly. With perhaps one exception (the comparison of corners), this validation study did not find out if the OY procedures were correct or incorrect. It was only a first step in assessing the validity of procedures. Controlled experiments are needed, such as Mahalanobis (4) performed over 40 years ago in India. Other controlled experiments on the validity of objective yield procedures, such as a series of Swedish studies, have been documented; Zarkovich (9, ch. 13) is a good source on this topic. An example of a controlled experiment is motivated by the following discussion. Sukhatme (7) stated in 1946 that small plots, which then were about 1/4,000th of an acre in the United States, probably led to biased yield estimates. (He didn't say which crop he was talking about, but it was probably wheat.) The current SRS OY wheat plots are about 1/10,000th of an acre. Does this plot size lead to biases in yield estimation? This question could be answered by sampling various sizes of plots, as described by Mahalanobis, to see which size optimally minimizes nonsampling error. Other steps in the OY procedures should be evaluated and optimized (to reduce nonsampling errors) with controlled experiments. Examples are plot location, counting procedures, and effects of delays before and after harvest. There are many other procedures which should be evaluated.

The final part of this paper will deal with several limitations inherent in the experimental design of this study. The first was in the evaluation of sampling mirror units, as needed, within seven days of harvest. This was a useful study, as far as it went. It indicated how net yield estimates might change, in a typical survey, if steps were taken to ensure that all samples were cut within seven days of farmer harvest. The problem is that the results from this experiment can not be generalized. In another year, the OY survey will undoubtedly have a different proportion of samples that need to be resampled within seven days of harvest, and the time lag from the regular OY visit at physiological maturity to the mirror unit visit will undoubtedly be different. Experimentation is needed with complete control over the time lag and the number of mirror units to be cut.

The other limitations concern the study of relationships with farmer-reported yield. Farmer-reported yield is a very important indication in many SRS surveys, and in no way is this discussion critical of its usefulness for that purpose. The criticism is strictly in the way it was used and evaluated in this study. The first problem is with the comparison of the regular OY net yield estimate and farmer-reported yield. While it is interesting to know how these are related, this comparison does not contribute to assessing the validity of OY

procedures. Farmer-reported yields simply are not comparable to OY estimates. They are collected by personal interview, and thus are subject to the well-known problems of personal interviewing and human reporting, such as biases caused by sex of the interviewer, recall problems, rounding, concept problems (for example, reporting net yield corrected for dockage when uncorrected net yield is desired), deliberate falsification, and so forth. Farmer-reported yields may lack the objectivity that a comparison with OY estimates requires.

The second problem is with the comparison of farmer-reported yields and "actual" weighed yields. This can be a useful comparison, if it is done correctly. It was not done correctly in this study. The reason is that all the farmers already knew what their weighed field-level net production was. Since they also knew their harvested acreage quite accurately, it was obvious they would know their weighed net yield, before any statistical tests were made. In the regular OY survey, many (not all) farmers would know their farm production accurately at the time of the postharvest personal interview. However, it is doubtful that all would know the field-level weights exactly. The point is that the farmer-reported yields were artificially accurate and not representative of what would normally be expected from the OY survey. Thus, any inferences from this study about the performance of farmer-reported yields would be questionable. However, because of the importance of farmer-reported indications, they should be studied more. One possible method would be the re-interview technique.

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APPENDIX

Field Level Estimates of Acreage and Yield
Paired Comparisons Among Net Yield Indications

APPENDIX TABLE 1a -- Field level estimates of acreage and yield, Kansas, 1983 winter wheat validation study

Field Number	Acreages: Farmer-reported Pre harvest	Acreages: Farmer-reported Post harvest	Acreages: Digitized	Net yields: Actual weighed	Net yields: Postharvest farmer-reported	Net yields: Regular OY Mean	Net yields: Regular OY S.E.	Net yields: At-harvest Mean	Net yields: At-harvest S.E.
	acres	acres	acres	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a
4	75.7	75.7	75.7	53.2	52.7	51.7	3.7	51.7	3.7
7	30.0	30.0	28.6	29.8	32.0	38.7	3.3	30.6	3.1
16	18.0	18.0	19.0	44.1	46.4	50.6	2.6	50.6	2.6
39	58.0	58.0	65.3	50.1	55.0	55.7	2.5	55.7	2.5
45	27.8	27.8	27.8	44.7	44.0	41.0	6.3	41.0	6.3
48	80.0	78.5	78.5	58.2	61.0	55.2	2.6	55.2	2.6
71	62.5	62.5	64.1	46.9	50.0	43.2	3.5	43.2	3.5
74	50.1	50.1	50.1	43.4	43.0	48.2	3.7	48.2	3.7
78	154.4	154.4	154.4	27.6	27.0	31.6	2.1	31.6	2.1
100	188.5	188.5	178.9	36.2	35.0	33.3	3.8	33.3	3.8
104	82.0	82.0	84.4	32.9	33.0	37.4	3.4	37.4	3.4
117	75.0	75.0	70.6	59.4	55.7	64.1	2.9	64.1	2.9
125	43.6	43.6	43.5	32.1	30.6	35.6	3.7	35.6	3.7
137	71.3	71.3	71.3	44.5	31.5	46.3	3.4	46.3	3.4
143	158.0	158.0	155.5	30.2	38.0	31.4	1.8	31.4	1.8
149	16.0	15.0	16.0	40.2	45.0	46.2	4.3	46.2	4.3
154	148.2	144.0	148.2	29.3	30.0	37.8	2.3	36.7	3.9
171	53.2	53.2	53.2	47.9	48.0	48.1	4.1	48.1	4.1
176	78.1	78.1	78.6	41.1	41.3	42.3	3.6	42.3	3.6
202	29.0	29.0	29.0	32.0	31.1	37.5	3.5	37.5	3.5
207	38.0	35.3	35.3	32.6	22.2	37.4	4.6	36.0	5.5
224	50.5	50.5	47.4	19.1	19.1	20.5	3.2	20.5	3.2
228	40.2	40.2	40.2	28.9	28.8	25.7	2.7	25.7	2.7
230	56.0	56.0	53.7	37.6	35.2	37.4	2.0	37.4	2.0
255	62.0	62.0	64.1	36.3	40.0	37.6	2.3	37.6	2.3
269	210.1	210.0	206.4	44.8	44.0	51.1	3.9	51.1	3.9
273	30.0	30.0	32.9	41.9	45.9	44.4	2.8	44.4	2.8
281	158.6	158.6	157.3	33.5	35.0	37.8	3.1	37.8	3.1
287	8.5	8.5	8.5	35.0	35.2	41.4	4.8	41.4	4.8
294	28.7	28.7	28.7	34.3	34.3	45.4	3.5	45.4	3.5

APPENDIX TABLE 1b -- Field level estimates of acreage and yield, Washington, 1983 winter wheat validation study

Field Number	Acreages: Farmer-reported Pre harvest	Acreages: Farmer-reported Post harvest	Acreages: Digitized	Net yields: Actual weighed	Net yields: Postharvest farmer-reported	Net yields: Regular OY Mean	Net yields: Regular OY S.E.	Net yields: At-harvest Mean	Net yields: At-harvest S.E.
	acres	acres	acres	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a
3	150.0	150.0	150.0	43.1	42.3	41.0	3.1	38.3	3.9
7	237.0	237.0	237.0	53.8	53.5	61.0	4.9	61.0	4.9
9	188.0	188.0	188.2	43.4	43.0	50.4	2.9	57.7	4.4
10	78.2	78.2	78.2	77.0	73.6	77.5	2.4	75.9	3.4
16	162.0	162.0	162.0	43.4	42.5	40.9	2.9	40.9	2.9
18	250.6	250.6	250.6	55.5	55.6	60.8	2.7	60.8	2.7
19	262.0	226.7	225.1	42.2	40.3	67.5	5.7	67.5	5.7
31	105.0	105.0	106.0	87.6	82.0	88.5	5.7	88.5	5.7
33	50.0	50.0	50.0	21.5	29.8	24.7	3.7	23.0	1.3
37	190.0	190.0	182.8	64.9	64.0	53.2	6.4	62.4	5.0
39	200.0	200.0	242.7	103.8	103.0	88.1	7.8	97.7	7.0
46	166.0	166.0	166.0	113.1	61.0	64.0	7.2	64.0	7.2
48	72.0	72.0	72.0	111.2	108.0	64.8	5.7	64.8	5.7
49	172.2	172.2	172.2	50.9	50.2	46.8	10.4	46.8	10.4
52	101.0	101.1	106.0	46.9	49.0	49.0	6.7	49.0	6.7
54	166.0	166.0	120.6	113.9	74.0	100.6	11.4	88.2	8.6
56	45.0	45.0	45.0	73.2	89.0	103.5	3.6	103.5	3.6
63	20.0	20.0	20.0	151.4	148.0	171.2	9.8	171.2	9.8
68	20.0	20.0	19.3	161.2	152.0	148.6	5.9	131.1	7.1
72	85.0	85.0	85.0	102.9	101.2	104.6	6.3	104.6	6.3
78	79.0	79.0	79.0	91.4	90.0	100.5	9.0	100.5	9.0
80	115.0	115.0	115.0	78.3	89.0	102.8	8.8	102.8	8.8
82	288.4	288.4	288.4	37.2	40.0	41.7	2.7	41.7	2.7
84	50.0	50.0	51.0	56.8	58.0	43.0	7.6	43.0	7.6
87	192.6	192.6	217.6	44.7	49.3	57.6	10.6	57.6	10.6
91	68.0	65.0	65.0	161.8	158.0	141.0	10.7	141.0	10.7
102	310.0	310.0	310.0	27.6	27.6	35.9	4.4	35.9	4.4
109	202.0	202.0	201.8	65.7	64.7	72.2	4.2	72.2	4.2
116	210.0	210.0	.	.	50.4	44.5	2.1	59.7	2.4
177	100.0	94.0	94.0	80.8	77.0	77.7	4.0	77.7	4.0

APPENDIX TABLE 2 -- Paired comparisons among mean net yield (bu/acre) indications
1983 winter wheat validation study

Net Yield Indications	Kansas 30 fields	Washington 29 fields	Combined states 59 fields
Regular OY	41.8	75.2	58.2
At-harvest	41.5	74.8	57.8
Difference	0.4	0.3	0.4
S.E. of difference	0.3	0.9	0.5
Paired t-statistic	1.3	0.4	0.7
Regular OY	41.8	75.2	58.2
Actual weighed	38.9	76.0	57.2
Difference	2.9	-0.9	1.0
S.E. of difference	0.7	3.3	1.7
Paired t-statistic	4.0*	-0.3	0.6
Regular OY	41.8	75.2	58.2
Postharvest farmer-reported	39.0	73.0	55.7
Difference	2.8	2.2	2.5
S.E. of difference	1.0	2.6	1.4
Paired t-statistic	2.7*	0.8	1.8
At-harvest	41.5	74.8	57.8
Actual weighed	38.9	76.0	57.2
Difference	2.5	-1.2	0.7
S.E. of difference	0.7	3.5	1.8
Paired t-statistic	3.7*	-0.4	0.4
At-harvest	41.5	74.8	57.8
Postharvest farmer-reported	39.0	73.0	55.7
Difference	2.5	1.8	2.2
S.E. of difference	1.0	2.6	1.4
Paired t-statistic	2.4*	0.7	1.6
Actual weighed	38.9	76.0	57.2
Postharvest farmer-reported	39.0	73.0	55.7
Difference	-0.1	3.1	1.5
S.E. of difference	0.7	2.4	1.2
Paired t-statistic	-0.1	1.3	1.2

* Significant at the 0.05 level.
NOTE: Any inconsistencies are due to rounding.