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# 1981 Sorghum Objective Yield Study

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ABSTRACT

This study shows that objective procedures can be applied to estimate sorghum yield and that several plant characteristics can be observed early in the growing season and used to forecast gross yield. The 1981 results in Kansas were encouraging for gross yield and farmer reported yield. However, lodging in postharvest samples caused a very high harvest loss. The final number of heads per acre can be predicted with good accuracy using stalk and head counts. Forecasts of final grain weight per head can also be made but these models do not provide the same precision as the head count models.



ACKNOWLEDGMENTS

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## 1981 SORGHUM OBJECTIVE YIELD STUDY

**Dave Aune**

### INTRODUCTION

The Statistical Reporting Service (SRS) has conducted annual objective yield (OY) surveys for the major field crops since the late 1950's. Several different research studies were conducted between 1959 and 1972 to develop procedures for a grain sorghum objective yield. This research was revived in 1981 with the intent of beginning a regular operational objective yield survey in 1982. Subsequently, budgetary constraints have delayed the implementation of this program.

This study examined all aspects of an objective yield survey with much of the direction provided by the results of the earlier research. The objectives of this project were:

1. to examine the mean expanded net yield and sampling error from the survey data to determine if the procedure provides a reliable yield indication.

2. to derive the optimum plot size and the number of plots to be set out in each field.

3. to begin development of forecasting models and determine which data items should be retained and which can be eliminated.

4. to establish editing criteria for data collected for future surveys.

5. to collect data to assess the large area application of SORGF, a grain sorghum growth simulation model.

This paper focuses on the results of the traditional objective yield portion of the survey. However, some of the SORGF data provides some useful information for building forecasting models. The analysis of SORGF is presented in a separate report.

Sorghum Objective Yield research dates back to 1959 when Iowa State University began a series of projects lasting five years. In these studies, researchers looked at alternative ways of estimating number of kernels and dry kernel weight, examined several measurable plant characteristics for their value as predictor variables, and derived optimum number of plots and plot size. The 1959 study (Nieto de Pascual, 1960) used three methods of estimating the kernel count of a head. The methods were (1) counting the kernels on a randomly selected branch and expanding by the branch count, (2) counting the kernels on two branches in each of three strata and expanding to strata totals and summing these totals, and (3) weighing two samples of 200 kernels each and dividing this average weight into the total grain weight. The second approach proved to be the best, however this method is very tedious. An optimum plot of 3 rows by 80 feet was derived. The 1960 study (Nieto de Pascual, 1961) examined wet head weights, wet kernel weights, and head stem weights over time to learn about growth characteristics. The optimum plot was found to be two rows by four feet for estimating weight per head. The 1961 study (Cochran, 1962) computed correlations between dry kernel weight and 13 observable plant characteristics including culm diameter, head length, and head circumference for different fieldwork periods. Correlation coefficients were small for all variables in August but improved considerably in September. By mid-October, most correlations were greater than 0.8. Three methods of estimating kernel count were attempted: (1) visually comparing a head to a head with known number of kernels, (2) obtaining the weight of two samples of 100 kernels and dividing the average into the total kernel weight, and (3) counting the kernels in a three gram sample. The weight estimator was good in September and October, but none of the methods worked in August. The derived optimums were five plots, each one row by ten feet. The 1962 study (Cochran, 1963) focused on predicting dry kernel weight using plant counts and dry matter weight data collected in August and September. The 1963 study (Baker, 1964) continued the work done during the previous study.

SRS researchers first became directly involved in Sorghum OY studies in 1964. A project using only three subjectively chosen farms was inititated by the Oklahoma State Statistical Office. The findings of this study (Von Steen, 1966) indicated culm diameter and head length are the best characteristics to use for prediciting grain weight per head. The study also notes that head volume (water displacement) may be of value as a predictor variable. The optimum plot size based on August plant counts was found to be two rows by five feet. A 1969 project, conducted in Texas and Kansas, looked at detailed counts and measurements on heads clipped at immature growth stages. The report (Vogel, 1970) presents simple correlation coefficients between several plant measurements including culm diameter, head length, dry head weight, and head width at the midpoint. The field procedures were not designed to check optimum plot size. A 1971 study was performed in Texas and focused on developing forecast equations for grain weight per head and final head count. This study also introduces models by maturity category. The report (Wood, 1972) identifies head length, culm diameter, and dry head weight as the most useful predictor variables for grain weight per head. Head and stalk counts are used to forecast final head count at harvest. The optimum number of plots was found to be two with each plot three rows by five feet.

## SUMMARY

The 1981 Sorghum Objective Yield Research Study has shown that a practical operational survey to estimate grain sorghum yields at maturity is possible. By randomly locating two plots that are three rows by four feet, in an appropriate number of samples, a reliable estimate of mean gross yield can be made at the State level. Furthermore, various measurable plant characteristics can be observed at immature stages of plant development and used to predict final yields.

The 1981 Sorghum Objective Yield Research Study produced a mean gross yield of 70.4 bushels per acre (bpa) with an average harvest loss of 9.2 bpa from 97 usable samples. The mean net yield of 61.2 bpa is much lower than the Crop Reporting Board estimate of 67 bpa. This is a result of an unusually large mean harvest loss. The farmer reported average net yield is 68.2 bpa. The coefficients of variation for mean gross yield and mean farmer reported yield are less than 5 percent, but the coefficient of variation for mean harvest loss is nearly 19 percent.

The derived optimum number of units per sample is 1.93. The optimum unit size is 2.34 rows by 1.29 sections (each section is 3 feet). The recommended number of units and the unit size is two units of three rows by four feet. The number of fields to be selected is determined by available funding; however, 100 usable samples are adequate to produce a State level mean whose coefficient of variation is less than 5 percent.

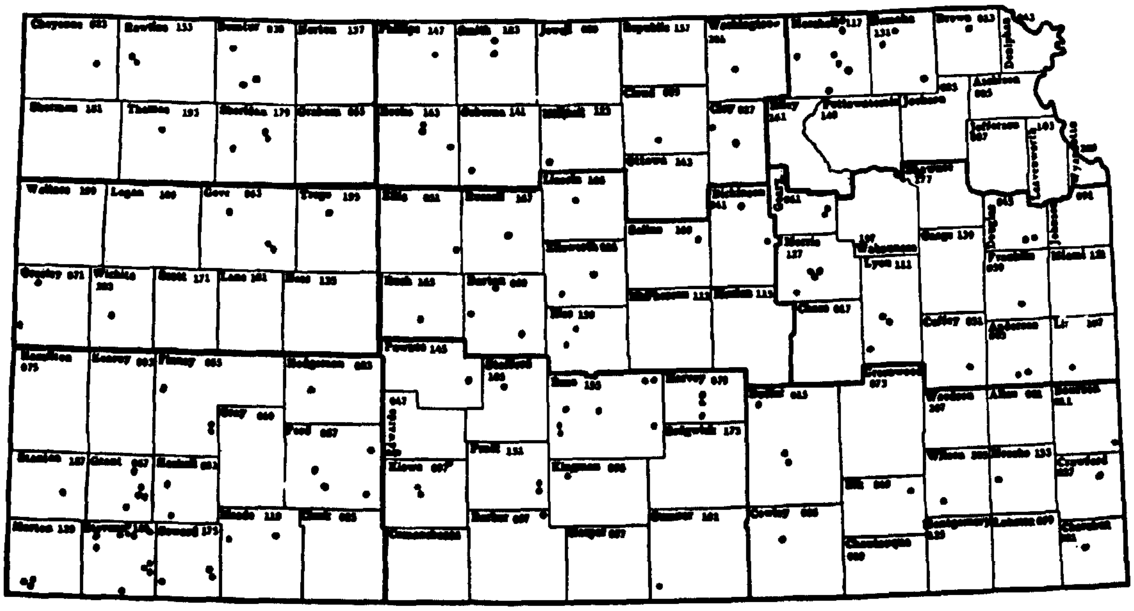
Multiple regression procedures were used to establish forecast equations, by maturity class, for predicting final head count per sample from monthly stalk and head counts. By the milk stage, all heads had emerged and stalk count was no longer used as a regressor variable. The value of r-square ranged from .795 to .998 with the mean square error falling from 46.711 in the prebloom stage to 0.612 by hard dough.

The forecast equations for grain weight per head in pounds use a variety of independent variables. The average culm diameter, average head length, and average head circumference figure prominently in the models. The dry matter fraction shows some marginal promise in two maturity classes but its overall usefulness is questionable. The average head volume is so highly collinear with head circumference that it was not considered. The range of the r-square is .361 to .634 and the range of the mean square error is 0.0010 to 0.0044.

## DATA COLLECTION PROCEDURES

A sample of 141 fields was selected using the procedures followed for the other field crop objective yield surveys. This procedure selected fields with probability proportional to size from the expanded June Enumerative Survey (JES) acres of sorghum planted or to be planted for grain. This allows a field to be chosen for more than one sample. In 1981, three fields contained two samples and one field selected was for three samples. Figure 1 shows the sample dispersion for 1981.

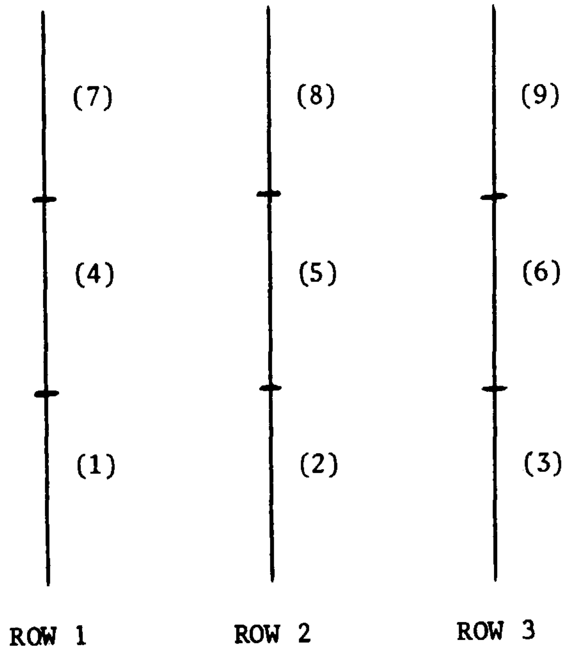
FIGURE 1 - Sample field locations



Field observations for all samples began in late June to accommodate the needs of the SORGF research. With the operator's permission, three plots (units), each 3 rows by 9 feet, were independently located by moving prescribed distances along the edge and into the field. These distances are independent random numbers of rows and paces assigned to each plot of each sample. Each plot was partitioned into nine 3-foot sections by dividing each 9-foot row length into three equal parts. Figure 2 is a diagram of the plot configuration showing the nine 3-foot sections.

Before physiological maturity, data were collected to be used to develop forecast models for heads per acre and grain weight per head. Due to the detailed nature of these measurements and the amount of time required to make them, these monthly measurements were made in a subplot within each unit. The subplot was defined to be the first section in rows 1 and 2 (sections numbered 1 and 2 in Figure 2). Also, during the monthly visits, five heads were clipped from plants lying outside Unit 1 and mailed to the State office for additional measurements.

FIGURE 2 - Plot configuration




At maturity, all heads in each unit were clipped and weighed section by section. Those heads located within the subplots used to obtain monthly data (sections 1 and 2) were mailed to the State office. The remaining heads were disposed of according to the farmer's wishes.

After harvest, three gleaning units, each 2 rows by 3 feet, were laid out in even-numbered samples. A unit was located 5 rows and 5 paces away from each pre-harvest plot. Heads, partial heads, and loose grain within each unit were picked up and mailed to the State office in order to estimate harvest loss.

Farm operators were interviewed before the first field visit and after harvest to obtain planting and harvesting data. The initial interview, conducted in June, was used to obtain field acreage, sorghum variety, planting date, planting depth and permission to perform fieldwork. The post-harvest interview was used to secure the farmer's realized final yield. Copies of the forms used to collect the data are displayed in Appendix 1. A more detailed explanation of the field procedures can be found in the <u>1981 Sorghum Objective Yield Research Study Enumerator's Manual.</u>

The Generalized Edit (GE) System was used to reformat and edit the data. The editing guidelines as well as instructions for pre-survey preparations and laboratory procedures are described in the Sorghum Objective Yield Supervising and Editing Manual. The data were summarized using the Statistical Analysis System (SAS). Information about program logic and record layout is available from Yield Research Branch.

## DATA COLLECTION PROBLEMS AND SOLUTIONS

Several problems were encountered while conducting this survey. Some of the problems were created by excessive rainfall during the growing season. However, the majority of the problems resulted from unanticipated field situations and insufficient instructions. Several adjustments were made to the data collection procedures which solved most of these problems. Possible solutions to the remaining problems were found and are recommended for future suveys.

The wet spring of 1981, caused excessive delays in field preparation and seeding. Consequently, intentions made up a larger proportion of the grain sorghum acres planted and to be planted reported on the JES. Since the objective yield sample is selected from JES reported acres, a large number of the fields selected had not been planted by June 1. Rain continued to be a frequent occurrence into June and July, causing several samples to be lost because they were never planted. Other sample fields were planted to soybeans or left idle for fall wheat seedings. Table 1 shows the distribution of samples by their status.

TABLE 1 - Frequency of final field work status

| Sample status | Frequency | Percent |
|---|---|---|
| Fieldwork complete | 97 | 68.8 |
| Selected field not planted to sorghum | 20 | 14.2 |
| Selected field not for harvest as grain | 1 | .7 |
| Farmer harvested before fieldwork was complete | 4 | 2.8 |
| Samples lost during season | 2 | 1.4 |
| Farmer refusal | 17 | 12.1 |
| TOTAL | 141 | 100.0 |

Stalk counts made during all early season and final preharvest visits proved to be difficult. The definitions provided in the Enumerator's Manual were based on anticipated field situations. It was assumed that each point of emergence would consist of one main stalk with a few tiller stalks possible. A tiller stalk was defined to be a stalk that emerges from the ground close to the main stalk, often at a slight slant. Tillers are smaller in size compared to a main stalk and lack the brace roots present in main stalks. It was further assumed that each main stalk would produce a maximum of one head and that tillers would produce no heads. As the plants developed, many stalks that had been categorized as tillers had grown to the same size as the main stalk. Nearly all of these stalks had formed a head and displayed brace roots. It became obvious that counting total stalks and stalks with heads using the original definitions was of no benefit to the survey. Therefore, enumerators were instructed to count heads instead of stalks with heads. Futhermore, it is recommended that the stalk question in future surveys be modified to enable a count of tillers in addition to main stalks and that definitions allow for several main stalks at a point of emergence.

Previous sorghum research suggested that the volume displacement of a sorghum head might be an effective predictor of a final weight per head. In order to compute the volume, enumerators obtained a head circumference measurement by wrapping a cloth tape measure around the widest part of the head. The tape was drawn in tightly around the branches without constricting the head. There were two problems with this measurement approach that made it extremely difficult for enumerators to be consistent. First, the tape measure was hard to handle and enumerators had trouble locating the widest point of the head. A new measuring device was developed by printing the scale on a sheet of transparent plastic enabling the enumerators to form a cylinder around the head. The other problem was one of how tight to pull the measuring device around the head. The original definition left far too much latitude to provide consistent results. No change was made to the 1981 definition. It is recommended that the circumference measurement be made by pulling the cylinder as tight as possible around the head without damaging it. This means that head circumference measurements cannot be done until the head has completed flowering to avoid damaging the head.

During their monthly visit, enumerators encountered numerous instances in which the head was partially emerged from the flag leaf. Many enumerators were not sure whether these heads should be included in their total head count. The enumerators were instructed to include partially emerged heads in their count. Also, the lowest branching on the head was covered making the culm diameter and head length impossible to accurately measure. For these cases, head measurements were forfeited since pulling back the flag leaf would alter the development of the plant. It is not necessary that head measurements be made on an all or nothing basis. In future surveys, enumerators should make any of the head measurements that can be made without damaging the plant.

Sorghum enumerators with experience in other field crop objective yield surveys commented that it seemed that an inordinate number of units fell near the edge of the field. It is unknown whether this was a chance occurrence or a bias in the table of random numbers used for unit location. A true bias is likely to cause lower gross yield expansions and higher harvest losses since field edges frequently have lighter plant stands and poorer development. The rows and paces used for sorghum were chosen from the table used for wheat objective yield. The wheat table was chosen for its availability and convenience. Although no firm statement can be made about this situation, unit location numbers from a row crop objective yield are recommended for future surveys.

## ANALYSIS ASSUMPTIONS

Participation in all objective yield surveys is voluntary. The inability to obtain data due to an unwillingness to cooperate or the unavailability of the sample field may introduce a bias. A summary by status of the final preharvest visit is shown in Table 1. The amount of the bias is affected by the number of samples with no information and the characteristic differences between the respondents and non-respondents. The analysis of this survey assumes that no difference in yield components exists between the two groups and the state level mean is imputed. An alternative method of imputation would be to use a yield estimate from comparable fields for missing samples. Since the objective yield sample is selected from JES segments which are stratified by cultivation intensity, this approach could be done. However, the distribution of the OY samples is heavily skewed toward the more intensely cultivated land use strata, leaving very few samples in the lower intensity strata on which to estimate yield.

Variances were computed by assuming simple random sampling. This assumption is made for all operational objective yield surveys. The application of this assumption has been questioned since it disregards the actual sampling design. The validity of the assumption is currently being investigated. A preliminary report indicates that the assumption of simple random sampling is acceptable.

## SURVEY ESTIMATES AND ESTIMATES

### Yield Expansions

The final mean net yield expansion is the most important product of the objective yield survey. This expansion provides an indication, based on a probability survey, of the yield actually realized by farmers. The net yield is computed by estimating gross yield (biological production) and deducting the quantity of grain lost because of the harvest process. All expansions are computed at the sample level and averaged to obtain the State mean. All yield expansions are expressed as bushels per acre. A bushel of grain sorghum is defined to be 56 pounds of grain at 15.5 percent moisture.

The formulae for computing the yield expansions are:

$$\text{gross yield} = \frac{(\text{heads per acre})\,(\text{net weight per head in pounds})}{(56)}$$

$$\text{harvest loss} = \left[(\text{grams of grain from heads and pieces}) + 2\,(\text{grams of loose grain})\right] \times \left[\frac{(43{,}560)\,(12)}{(12\ \text{row-width})(18)} \cdot \frac{1 - \text{moisture content}}{.845} \cdot \frac{1}{(453.6)}\right]$$

where,

$$\text{heads per acre} = (\text{total number of heads from 3 units}) \times \left[\frac{(43{,}560)\,(12)}{(81)\,(12\ \text{row-width})}\right]$$

$$\text{net weight per head} = \left[\begin{matrix}\text{field weight per}\\ \text{head in pounds}\end{matrix}\right] \times \left[\begin{matrix}\text{threshing}\\ \text{fraction}\end{matrix}\right] \times \left[\begin{matrix}\text{dry matter}\\ \text{fraction}\end{matrix}\right]$$

$$\text{threshing fraction} = \frac{\text{weight of threshed grain in grams}}{\text{weight of heads at threshing}}$$

$$\text{dry matter fraction} = \frac{(\text{field weight of lab heads in pounds})(453.6)}{\text{weight of heads at threshing in grams}} \cdot \frac{1\text{-moisture content}}{.845}$$

and

56 converts pounds to bushels
453.6 converts grams to pounds
43,560 converts square feet to acres
12 adjusts the row width to a one row basis
81 represents the total feet of row clipped
12 row-width is the sum of the three 4 row-space measurements
18 represents the total feet of row gleaned
.845 standardizes the moisture to 15.5 percent.

Table 2 presents the descriptive statistics for the survey estimates and the two main components of gross yield. Three estimates of net yield are shown. The correct survey estimate of the final mean net yield is 61.179 bpa with a standard error (SE) of 3.853 and a coefficient of variation (CV) of 6.3 percent. The mean net yield based only on samples that were gleaned is 64.38 (SE = 4.976, CV = 7.73). The farmer reported net yield is 68.231 (SE = 3.274, CV = 4.8). The official Crop Reporting Board (CRB) estimate of final yield is 67 bushels per acre.

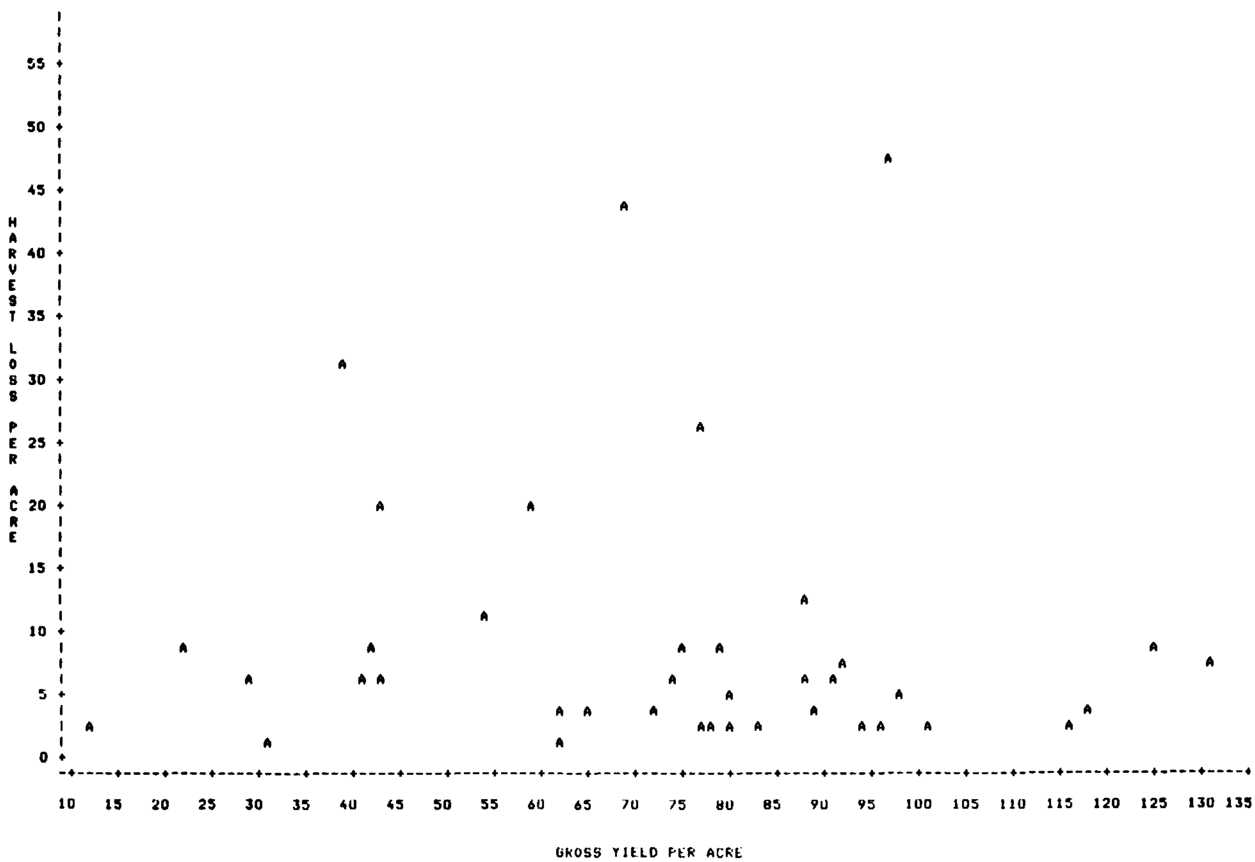
TABLE 2 - Summary of yield estimates

| Variable | n | Mean | Standard Error | Coefficient of Variation 1/ |
|---|---|---|---|---|
| Heads per acre | 97 | 36,054 | 1,522 | 4.22 |
| Weight per head (lb) | 97 | .112 | .005 | 4.46 |
| Gross yield | 97 | 70.373 | 3.438 | 4.89 |
| Harvest loss | 39 | 9.194 | 1.730 | 18.82 |
| Comparable net yield 2/ | 39 | 64.380 | 4.976 | 7.73 |
| Farmer reported net yield 3/ | 95 | 68.231 | 3.274 | 4.80 |
| Net yield 4/ | 97 | 61.179 | 3.853 | 6.30 |

1/ The coefficient of variation (CV) is the standard error divided by the mean expressed as a percent.
2/ Net yield computed using only those samples for which gleanings were made.
3/ Net yield reported on the Form D postharvest interview.
4/ Net yield computed as mean gross yield minus mean harvest loss.

The mean net yield is low compared with the CRB and farmer reported estimates. The mean gross yield is consistent with the other estimates; however, the mean harvest loss is very large. Figure 3 plots the expanded harvest loss versus gross yield for the samples that were gleaned. The plot vividly shows the presence of several extremely large harvest loss expansions. The farmers, whose fields produced the six largest harvest loss expansions, reported significant damage due to lodging in the selected field. The causes given were insects and wind. The mean of the ratios of harvest loss to gross yield to is 15.9 percent. State mean harvest loss ratios for other OY crops generally range from 4 to 10 percent of gross yield. The presence of large harvest loss expansions is common, however, the small number of gleanings (39) allows the outliers to greatly influence the State mean.

FIGURE 3
Expanded harvest loss vs expanded gross yield




Plot Comparison

Since the final preharvest data were recorded section by section, the mean gross yield can be computed for several plot sizes. Beginning with the first section in Row 1, rows and sections can be added to form units of up to three rows that are three, six, or nine feet in length. The mean, standard error, and coefficient of variation of gross yield for all possible plot sizes are shown in Table 3. The consistency of the data is demonstrated by the diminishing standard errors as the number of rows increases.

TABLE 3 - Mean, standard error, and coefficient of variation for gross yield for selected plot sizes

| Number of rows | | Length of Rows 3 feet | 6 feet | 9 feet |
|---|---|---|---|---|
| 1 | mean | 71.901 | 72.503 | 71.306 |
| | standard error | 3.773 | 3.719 | 3.579 |
| | C.V.1/ | 5.25 | 5.13 | 5.02 |
| 2 | mean | 71.712 | 72.111 | 70.920 |
| | standard error | 3.661 | 3.489 | 3.489 |
| | C.V. | 5.10 | 4.84 | 4.92 |
| 3 | mean | 71.149 | 71.062 | 70.373 |
| | standard error | 3.574 | 3.420 | 3.438 |
| | C.V. | 5.02 | 4.81 | 4.89 |

1/ Standard error divided by mean expressed as a percent.

Acreage Estimates

The estimate of planted acres of sorghum from the JES is adjusted to estimate the acres of sorghum for harvest as grain. The adjustments are based on data collected from the two farmer interviews conducted during the survey. For each sample, the ratio of the acres of sorghum for harvest as grain as reported during the initial interview (Form A) to the JES acres of sorghum planted and to be planted was computed. The mean ratio was used to adjust the State expanded JES acres to estimate the acres of sorghum for harvest as grain. In 1981, the mean ratio was 0.819 and the expanded JES acres planted and to be planted for grain in Kansas was 3,840,934. The estimate of acres of sorghum for harvest as grain is 3,145,725 with a standard error of approximately 286,044. The standard error is approximate because the covariance could not be calculated.

The second adjustment is based on the post-harvest interview (Form D) field level data. The ratio of the acres harvested in the sample field as reported on the Form D to acres in the sample field as reported on the Form A revises the acres for harvest estimate. The mean ratio is 0.997 and the revised estimate of acres for harvest as grain is 3,136,288 with a standard error of approximately 288,602. The final CRB estimate of acres of sorghum harvested for grain is 3,560,000.

## PLOT OPTIMIZATION

Previous sorghum objective yield research has produced several different optimum plot sizes. No concensus plot size has been established because of different cost functions and different analysis approaches. The 1981 survey was designed to recompute the optimums. The approach used for this project is to simultaneously derive the optimums for number of plots, rows within plots, and length of row using the variance components and cost for each level.

A nested analysis of variance was used to find the variance components. The sample plots were constructed such that sections are fully nested within rows, rows are nested within units and units within samples. The design is also completely balanced. That is, each row has the same number of sections (observations).

The general form of the linear model is:

$$Y_{ijkl} = \mu + A_i + B_{i(j)} + C_{ij(k)} + D_{ijk(l)}$$

where

$Y_{ijkl}$ = total head weight for section l in row k in unit j of sample i.
$\mu$ = overall mean.
$A_i$ = between sample effect (i = 1,2,...97).
$B_{i(j)}$ = between plots within samples effect (j = 1,2,3).
$C_{ij(k)}$ = between rows within plots effect (k = 1,2,3).
$D_{ijk(l)}$ = between sections within rows effect (l = 1,2,3).

Each level has mean 0 and variances $\sigma^2_a$, $\sigma^2_b$, $\sigma^2_c$, and $\sigma^2_d$, respectively. Rows and sections were selected using contiguous sampling. This means that rows and sections are not sampled randomly, but are chosen in groups. Wood (1972, p.5) notes that the use of variance components eliminates the problem of bias since the variance components are computed within the next highest level instead of over the entire population.

The degrees of freedom and expected mean squares for a three-way nested analysis of variance are shown in Table 4. By equating the mean squares with their respective expected values, estimates of the variance components can be found by solving the system of equations. The mean squares for the 1981 survey data are also shown in Table 4.

TABLE 4 - Degrees of freedom, mean squares, and expected mean squares for three-way nested analysis of variance

| Source | df | MS | E(MS) |
|---|---|---|---|
| Between Fields | 96 | 6.065 | $\sigma^2_d+3\ \sigma^2_c+9\ \sigma^2_b+27\ \sigma^2_a$ |
| Between Units | 194 | 0.942 | $\sigma^2_d+3\ \sigma^2_c+9\ \sigma^2_b$ |
| Between Rows | 582 | 0.411 | $\sigma^2_d+3\ \sigma^2_c$ |
| Within Rows | 1,746 | 0.216 | $\sigma^2_d$ |
| Corrected Total | 2,618 | | |

The costs in minutes primarily represent the average amount of time attributable to each level. For example, the cost between rows is the time spent gathering equipment and moving to the next row. The between sample cost is adjusted to include mileage and the between section costs includes the time required to perform the clipping and weighing. The cost estimates were based on times recorded on the survey forms, administrative records and field experience. The cost estimates are shown in Table 5. By letting 'C' represent cost and 'n' represent sample size, the following formulae were used to find the optimum sample sizes. A brief discussion of this approach can be found in Jessen (1978), Section 9.3.

$$n_b = \sqrt{\frac{C_a \hat{\sigma}^2_b}{C_b \hat{\sigma}^2_a}} \qquad n_c = \sqrt{\frac{C_b \hat{\sigma}^2_c}{C_c \hat{\sigma}^2_b}}$$

$$n_d = \sqrt{\frac{C_c \hat{\sigma}^2_d}{C_d \hat{\sigma}^2_c}}$$

The number of fields to be selected ($n_a$) is primarily determined by funding levels with consideration given to a target coefficient of variation. Table 5 presents the actual variance components, cost estimates, and optimum sample sizes derived from the survey data. While the optimum number of units and rows must be integers, the optimum row length (1.29 sections) can be expressed as 3.87 feet. Therefore, the recommended number of plots is two and recommended plot size is three rows by four feet.

TABLE 5 - Variance components, cost estimates and optimum sample size

| Level | Variance component | Cost estimate1/ | Optimum sample size |
|---|---|---|---|
| Between fields | .1898 | 120 | |
| Between units | .0590 | 10 | 1.93 |
| Between rows | .0648 | 2 | 2.34 |
| Between sections | .2145 | 4 | 1.29 |

1/ Expressed in minutes

## FORECAST MODELS

The 1981 data give evidence that reasonable forecast models can be developed for predicting final head count and final net weight of grain per head from early season counts and measurements. These predicted values, along with current year row space measurements, provide forecasts of gross yield per acre in advance of the harvest season. An estimate of historic harvest loss is deducted from the predicted gross yield to forecast net yield.

The forecast models are developed by maturity class since the worth of the predictor variables depends on the growth stage of the plants. The maturity class of each unit is determined by field enumerators according to the definitions in Appendix 2. The rounded average of the three unit maturity classes was used to determine the maturity class of the sample.

### Final Head Count

Two variables were collected monthly as regressor variables for forecasting the total number of heads in all units at harvest. These are total stalk count (excluding tiller stalks) and total head count. Originally, enumerators were instructed to count the number of stalks with heads instead of the number of heads. However, during the August 1 survey, enumerators had so much difficulty differentiating tillers and main stalks that the question was changed to count the number of heads. The change of measurement did not affect the forecast models because most samples had not developed heads by the August 1 survey period.

A known collinear relationship which becomes stronger as the plant develops exists between the two regressor variables . For this reason, no statistical check was made for collinearity. A stepwise regression procedure was used to identify which variables should be included in the model for each maturity class. The significance level for entry and the significance level to stay were 0.15.

With the form of the model established for each maturity class, the data sets were individually examined for influential data points. Six diagnostics were used to flag potential extreme data values. The diagnostics are the studentized residual, Cook's D, the covariance ratio, DFFITS, and two DFBETAS. A brief description of these is given in Appendix 4. Threshold values for each diagnostic were based on suggestions from Belsley, Kuh, and Welsch (1980) and values used by SRS (Methods Staff). Any observation that produced four or more diagnostics that were more extreme than the threshold value was deleted. Observations with three extreme diagnostics were deleted only if the more conservative diagnostics (studentized residuals and Cook's D) suggested their removal. Fewer than ten percent of the observations were deleted from any class. Plots of the final head count versus the regressor variables selected for each maturity class are shown in Appendix 3. The circled observations were deleted from the data set.

Table 6 presents the "best" regression equation for each maturity class and the associated statistics. The evolution of the models through successive maturity classes clearly show the survival characteristics of a sorghum head. Once a head emerges and begins to flower (bloom class), the likelihood of its survival to maturity is very high. Thus, all models which use monthly head count as a regressor variable have r-squared values of .900 or greater with diminishing mean square errors (MSE).

TABLE 6 - "Best" regression equations for final head count

| Maturity Class | n | $r^2$ | MSE | Equation |
|---|---|---|---|---|
| Prebloom (1) | 90 | 0.795 | 46.711 | 6.1203 + 0.9603 (stalks) |
| Bloom (2) | 36 | 0.945 | 9.523 | 3.2219+0.1474(stalks)+0.8555(heads) |
| Milk (3) | 38 | 0.900 | 22.631 | 4.8843 + 0.9225 (heads) |
| Soft Dough (4) | 42 | 0.977 | 3.871 | 0.6047 + 0.9878 (heads) |
| Hard Dough (5) | 22 | 0.998 | 0.612 | 0.5090 + 0.9748 (heads) |

Weight per Head

Forecast models for final net grain weight per head were more difficult to develop. The weight per head is defined as the average weight in pounds of threshed grain per head adjusted to 15.5 percent moisture. Five independent variables were collected during the monthly visits for use as regressor variables. The five variables are culm diameter, head length, head circumference, head volume, and dry matter fraction. These variables have shown some promise as forecast variables in previous sorghum research (Cochran (1961), Von Steen (1966), Vogel (1970), Wood (1972)).

The culm diameter was measured one-half inch below the lowest branching. Since a culm is not perfectly round, the widest diameter was recorded. The head length was measured from the lowest branching to the tip of the head. The head circumference was obtained by placing a sheet of plastic around the head as tightly as possible without constricting the head. The head volume variable is a value proportional to the true volume and was derived as the square of the circumference multiplied by the head length. The dry matter fraction was found by dividing the weight of five heads dried to zero moisture by the weight of these heads before drying. Enumerators clipped the five heads from stalks located just outside Unit 1. These heads were taken beyond Row 1 during one month and beyond Row 2 the next month. If a third monthly clipping was necessary, the heads were clipped from Row 1 beyond the first clipping area.

The matrix of pairwise correlations between all independent variables and the final grain weight is shown in Table 7. The culm and head measurement not only show good correlation between themselves but also with final grain weight. However, the extremely high correlation between the circumference and volume is an indication of the possible presence of collinearity. Since the volume variable represents the interaction between length and circumference, the presence of collinearity is not unlikely. The dry matter variable shows poor correlation with all other variables.

TABLE 7 - Correlation matrix for independent variables and final net grain weight per head with sample sizes

| Variable | Length | Circumference | Volume | Dry Matter | Grain Weight |
|---|---|---|---|---|---|
| Culm Diameter | 0.621<br>306 | 0.559<br>306 | 0.508<br>306 | -0.043<br>281 | 0.550<br>288 |
| Head Length | -- | 0.443<br>306 | 0.443<br>306 | -0.098<br>281 | 0.439<br>288 |
| Head Circumference | | -- | 0.938<br>306 | 0.015<br>281 | 0.424<br>288 |
| Head Volume | | | -- | -0.004<br>281 | 0.427<br>288 |
| Dry matter | | | | -- | 0.070<br>273 |

When the data were partitioned by maturity class for model development, only two observations remained in the prebloom class. The final mean net weight of grain is given as the forecast of final grain weight per head for this class. The data sets for the other four maturity classes were examined for collinearity using the Variance Inflation Factor (VIF). In each class, the average head volume displayed a strong dependency (high VIF) and was dropped from the general form of the model. The collinearity statistics were recomputed on the new model and no other dependencies were evident. Appendix 4 presents a brief description of the VIF.

Each data set was checked for influential data points using the four variable model. The same diagnostics used in the development of the head count models were used and the same decision criteria were applied. A total of eight diagnostics were examined (four of them were DFBETAS). Observations flagged as being extreme by five or more diagnostics were deleted. Decisions on observations with four extreme diagnostics were made on a case by case basis. The total number of observations deleted was eleven. All classes had fewer than ten percent of the observations deleted.

A stepwise procedure was used to select the most important variables in each maturity class. The r-square value of models produced by this procedure were reviewed with respect to the r-square values of all possible models. Table 8 presents the "best" regression model for each maturity class with the sample size, r-square and mean square error for each maturity class. The model shown is the model produced by the stepwise selection procedure for each class except the hard dough class.

In this class, a three variable model was chosen over the one variable (circumference) model established by the stepwise process. The selected model has a larger r-square (by 38 percent) and a smaller mean square error (by 9 percent) than the stepwise model. The stepwise procedure did not find other significant variables because of a lack of degrees of freedom.

All observations that had been previously deleted were reinstated and the influential data analysis was repeated. This analysis resulted in only one of the reinstated observations being retained and two additional observations being deleted. The parameter estimates shown in Table 8 were derived from the final data set.

TABLE 8 - "Best" regression equations for net grain weight per head

| Maturity class | n | $r^2$ | MSE | Equation |
|---|---|---|---|---|
| Pre-bloom (1) | | (1981 average) | | 0.11195 |
| Bloom (2) | 45 | 0.361 | 0.00091 | - 0.10672 + 0.01811 (diameter) + 0.00674 (length) - 0.00196 (circumference) |
| Milk (3) | 32 | 0.634 | 0.00066 | - 0.06762 + 0.01121 (length) + 0.00501 (circumference) - 0.08227 (dry matter) |
| Soft dough (4) | 36 | 0.550 | 0.00044 | - 0.03936 + 0.01738 (diameter) |
| Hard dough (5) | 16 | 0.501 | 0.00100 | - 0.06695 + 0.01023 (length) + 0.00840 (circumference) - 0.08870 (dry matter) |

Because of the difficulties in performing the measurement, the average head circumference was not expected to be a very useful variable. The data do not show evidence supporting this. When the head circumference measurement is redefined to be more consistent, it should be a more valuable regressor variable. The average dry matter fraction proved to be a marginally useful variable. Although dry matter appears in two of the final models, most of the models containing dry matter had the lowest r-square values. Since the dry matter fraction is an expensive data item, its value as a regressor variable should be closely monitored in a research mode before deciding to use it in an operational program.

EDIT LIMITS

Reasonable edit limits must be established to insure the quality of the data used in forecasting and estimating. This is especially true in an operational survey since the editing of data is decentralized. Recommended edit limits are presented in Appendix 5. These limits were established by reviewing the descriptive statistics and frequency counts. The frequency distribution of most of the data items is skewed toward the larger values and the suggested edit limits reflect this.

RECOMMENDATIONS

The following list of items outlines recommended changes to the Sorghum Objective Yield Survey procedures. The recommendations are based on actual field experience as well as the analysis of the data collected.

1. The optimum plot size and number of plots derived from the 1981 data is 2 units of 3 rows by 4 feet. However, while the program is in a research mode, a plot size of 3 rows by 2 sections is recommended for each of 2 units. This will enable the optimums to be reexamined.

2. Redefine the head circumference measurement. The original approach led to gross inconsistencies in how enumerators obtained the data. A new measuring device was introduced during the survey to improve the quality of the measurement. The new device, made from transparent plastic, made it easier for enumerators. However, two problems remain. The first is how tight should the device be drawn around the head and, second, is that the plastic was only 10 inches long and was frequently too short to encompass the entire head. Both problems can be solved by defining the actual measurement to be the circumference of the head with all branches drawn in snugly within the cylinder. This measurement cannot be made until all flowers have dried to avoid damaging the head.

3. Change stalk and head count questions on all Form B's. This will help determine how to deal with the problem of identifying tillers. During this study, several stalks that were identified as tillers in August developed into main stalks (individual root systems and heads) in later months. The new questions should be:

   3a. Number of main stalks
   b. Number of heads on main stalks

   4a. Number of tiller stalks
   b. Number of heads on tiller stalks

   Stalks placed in Item 4a in August will not be required to remain as tillers throughout the survey. If, as the plant develops, it becomes apparent that a "tiller" should have been classified as a main stalk, it can be moved into Item 3a. This approach will help evaluate, through month to month shifts, the difficulty of correctly identifying tillers and still provide a total count of heads. Item 4b should seldom be positive.

4. Clarify when a head becomes a head. A head should be counted if any part of the head has emerged from the leaf sheath and is clearly visible.

5. Determine rows and paces using the Corn Objective Yield table. The corn table is structured for 2 independent units and was not compatible for this year's survey with 3 units. The wheat table was used as a substitute but there were a couple of problems encountered. Wheat OY uses paces along and paces into the field. This permits zero paces along the edge of the field which is not acceptable when rows are substituted for paces. The other problem is that an inordinate number of units fell along the edge of the field, which is believed to be a contributing factor to the problems of excessive harvest losses. Hopefully, the corn tables will help solve some of these gleaning problems.

6. Although the volume measurement was dropped as a regressor variable in 1981, it should not yet be eliminated from the survey. Since the volume is an interactive term between circumference and length, it should continue to be considered until the problems of measuring circumference are resolved.

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## Appendix 1: Forms

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

### FORM A: SORGHUM YIELD SURVEY – 1981
### INITIAL INTERVIEW

| YEAR, CROP, FORM, MONTH | |
|---|---|
| **121 __** | |

About the first of June a representative from our office obtained some information about your farming operations. Now, as part of a research project, we are interested in estimating the production of grain sorghum and updating information about your sorghum fields. Your response to this survey is voluntary and not required by law. However, we need and appreciate your cooperation.

Date (________________) .................... 170

Starting Time .................... 171

JES PLANTED TRACT ACRES

1. Around June 1, you planted or intended to plant .................... 101 ___ . ___
acres of sorghum for all purposes in ________ fields in this tract. *(Do Not Change)*
*SHOW operator his tract and fields on PHOTO. VERIFY the fields and the acreages of sorghum planted in the tract and entered in the shaded areas of Table A. OUTLINE and label on the photo all acres reported in Column 5. MAKE necessary corrections and new entries in non-shaded areas of Table A.*

> *If no sorghum was planted in tract, correct Table A and return all forms.*

*RECORD the acreages of sorghum to be harvested for grain in Column 6 and ADD to total.*

**TABLE A**

| FIELD NUMBER *(Sample field number is circled.)* | TOTAL ACRES IN FIELD | ACRES PLANTED TO SORGHUM | Acres in USES or CROPS other than sorghum to be harvested for grain *(For example: fence rows, ditches, waterways, roads, other crops, etc.)* | | ACRES OF SORGHUM FOR GRAIN |
|---|---|---|---|---|---|
| | | | USE | ACRES | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| | . | . | | . | . |
| | . | . | | . | . |
| | . | . | | . | . |
| | . | . | | . | . |
| | . | . | | . | . |
| | . | . | | . | . |

2. The total sorghum acreage *(Column 6)* to be harvested for grain in this tract is .................... Acres 102 ___ . ___

IS THAT RIGHT?
- *NO – Review all fields. RE-ADD Column 6.*
- *YES – Continue.*

## FORM A: SORGHUM (Cont'd)

*All questions on this page apply to the SAMPLE FIELD ONLY.*

*If no sorghum is intended to be harvested for grain in the designated sample field, BUT a NEW field to be harvested for grain is listed in Table A, this new field then becomes the sample field to enter in Item 3.*

3. Copy acres of sorghum for grain in Sample Field Number ______ from Table A ............................ *Record acres or "0"* ................ Acres | 103 . |

If Item 3 is zero, go to Form H.

4. a. On what date was this field planted? ( ____________ ) ........................ | 106 |

   b. What variety of grain sorghum is planted in this field? ( ____________ ).............. | 104 |

   c. What was the planting depth? ............................................ Inches | 107 . |

NOW – COMPLETE FORM H BEFORE ASKING ITEM 5.

5. "With your permission I will go out to the field and mark off three small units to be used in making stalk and head counts. I will return to the units to record the date of half-bloom and each month until harvest to make counts and clip a few heads to determine their weight and size. After you have finished harvesting this field, I will return to ask you about production. It will be appreciated if you can keep a record of the total amount of sorghum harvested from this field. I will also go out to the field a few days after harvest and pick up any loose grain left in the sample plots.

   Would this be all right? Yes ☐
   No ☐ *If "no" conclude interview and return all forms.*

6. Where should I leave the heads clipped from the units? ____________

Thank you very much for your help.

| | |
|---|---|
| IMPORTANT: | Review this form for completeness. Record ending time and sign name.<br>Calculate the probable date of half-bloom as Planting Date + 2 months.<br>Calculate the probable harvest date as Planting Date + 3½ months.<br>Copy these probable dates to the kit envelope.<br>Copy net acres for harvest for sample field to Question 1 on Form D. |

Ending Time (Military Time) | 172 |

Status Code............ | 180 |

Enumerator ____________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

**FORM H: SORGHUM YIELD SURVEY – 1981**
**FERTILIZER INTERVIEW**

| YEAR, CROP, FORM, MONTH (1–4) |
|---|
| **1081** |

1. Copy acres of sorghum planted in Sample Field No. __________ from Form A, Table A, Col. 3 .............................................. [801 ____ . __]

*If Item 1 has* —
- *A zero entry – Go to Form A and enter ending time.*
- *An Acreage entry – Continue.*

2. Has this field been *(or will it be)* irrigated?

   YES ☐ = 1   NO ☐ = 2   Enter Code [802 ____]

3. Did you or will you apply ANY fertilizer on these (Item 1) __________ acres in Sample Field No. __________?   ENTER — 1 for Yes / 2 for No [803 ____]

*If Item 3 has* —
- *A Code 1 entry – Go to Item 4.*
- *A Code 2 entry – Go to Form A, Item 5.*

**FERTILIZER**

**EXAMPLES OF ANALYSIS BY KIND**

Analysis Means Percentage of N, $P_2O_5$ and $K_2O$.

| Kind | Analysis Examples |
|---|---|
| Ammonium Nitrate | 34 — 0 — 0 |
| Anhydrous Ammonia | 82 — 0 — 0 |
| N Solutions (Pressure) | 37 — 0 — 0; 40 — 0 — 0, ETC. |
| N Solutions (Non-Pressure) | 32 — 0 — 0, ETC. |
| Superphosphate | 0 — 46 — 0, ETC. |
| Mixed Fertilizers (Liquid or Dry) | 12 — 12 — 12; 6 — 20 — 20, ETC. |

*Turn Page to Record Fertilizer Applications*

FORM H: Fertilizer Interview (Cont'd)

4. On these (Item 1) ____________ acres, how much of each kind of fertilizer has been or will be applied per acre?
*(Include all amounts applied specifically for this sorghum crop since preparation of field began last fall or this spring.)*

TABLE A: Use this table to record any fertilizer applications that INCLUDED CARRIER MATERIALS. Record each application on a separate line.

| LINE | KIND | ANALYSIS: Nitrogen "N" (Percent) | ANALYSIS: Phosphate "$P_2O_5$" (Percent) | ANALYSIS: Potash "$K_2O$" (Percent) | POUNDS APPLIED PER ACRE | FORM 1 - Solid 2 - Liquid 3 - Gas (Enter Code) | Month When Applied? (Code) | WAS APPLICATION 1 - At seeding or before 2 - After seeding (Enter Code) |
|---|---|---|---|---|---|---|---|---|
| A. | | 806 | 807 | 808 | 809 | 810 | 811 | 812 |
| B. | | 813 | 814 | 815 | 816 | 817 | 818 | 819 |
| C. | | 820 | 821 | 822 | 823 | 824 | 825 | 826 |
| D. | | 827 | 828 | 829 | 830 | 831 | 832 | 833 |
| E. | | 834 | 835 | 836 | 837 | 838 | 839 | 840 |
| F. | | 841 | 842 | 843 | 844 | 845 | 846 | 847 |

TABLE B: Use this table to record any fertilizer applications reported in POUNDS of ACTUAL NUTRIENTS. EXCLUDE CARRIER MATERIALS. Record each application on a separate line.

| LINE | ACTUAL NUTRIENTS APPLIED: Nitrogen "N" (lbs. per acre) | ACTUAL NUTRIENTS APPLIED: Phosphate "$P_2O_5$" (lbs. per acre) | ACTUAL NUTRIENTS APPLIED: Potash "$K_2O$" (lbs. per acre) | FORM 1 - Solid 2 - Liquid 3 - Gas (Enter Code) | Month When Applied? (Enter Code) | WAS APPLICATION 1 - At seeding or before 2 - After seeding (Enter Code) |
|---|---|---|---|---|---|---|
| A. | 848 | 849 | 850 | 851 | 852 | 853 |
| B. | 854 | 855 | 856 | 857 | 858 | 859 |
| C. | 860 | 861 | 862 | 863 | 864 | 865 |
| D. | 866 | 867 | 868 | 869 | 870 | 871 |
| E. | 872 | 873 | 874 | 875 | 876 | 877 |
| F. | 878 | 879 | 880 | 881 | 882 | 883 |

Enumerator ______________________________ *Return to Form A, Item 5.*

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

**FORM B-1: SORGHUM FLOWERING COUNTS**
**1981**

| YEAR, CROP, FORM, MONTH (1–4) |
|---|
| **1031** |

Has operator applied pesticides with organophosphorous content since last field visit? YES ☐ NO ☐

*If YES, enter latest application date* ______ *and name of pesticide* ______

**UNIT LOCATION**

| | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| Number of rows along edge of field ............ | | | |
| Number of paces into field ..... ........... | | | |

| | |
|---|---|
| Date (________) ...... | 370 |
| Starting Time ................ | 371 |

**ROW SPACE MEASUREMENTS**

| | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| 1. Is this the same unit that was laid out last month? *Check NO if this is the first visit to lay out the unit or if unit is relocated. For unit(s) checked YES skip to Item 3. NO—complete Item 2.* | YES ☐ NO ☐ | YES ☐ NO ☐ | YES ☐ NO ☐ |
| 2. a. Measure distance from stalks in Row 1 to stalks in Row 2 ...... ............ *Feet & Tenths* | 301 . | 302 . | 303 . |
| b. Measure distance from stalks in Row 1 to stalks in Row 5... ............... *Feet & Tenths* | 304 . | 305 . | 306 . |

**OBSERVATIONS WITHIN 2-ROW BY 3-FOOT SECTION**

| | UNIT 1 | UNIT 2 | UNIT 3 | ALL UNITS |
|---|---|---|---|---|
| 3. Number of stalks in both rows ....... | 311 | 312 | 313 | 314 |
| 4. Number of Item 3 stalks with flowers.. | 321 | 322 | 323 | 324 |

5. Compute and record ½ of the total in cell 314 ............................... ______ .

6. Is the figure in cell 324 greater than or equal to the total in Item 5?

*NO — Determine the date of the next visit using the table on the back page.*

*YES — STOP, no more flowering visits are necessary, the sample has reached the flowering stage.*

FORM B–1: SORGHUM (Cont'd)

| | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| 7. Growth stage of each unit . . . . . . . | 327 | 328 | 329 |

| GROWTH STAGE | | CODE | TIME TO NEXT VISIT |
|---|---|---|---|
| Planting to emergence | | 1 | 8 weeks |
| First leaf visible | *3 or less leaves* | 2 | 6 weeks |
| | *4 or more leaves* | 3 | 4 weeks |
| First leaf dropped, no flag leaf | | 4 | 3 weeks |
| Flag leaf extended | | 5 | 10 days |
| Boot or head emerged | | 6 | 4 days |

Use the most advanced growth stage recorded for any of the 3 units to determine when the sample should be visited next. Record the date of the next visit on the kit envelope.

| | |
|---|---|
| Ending Time | 372 |
| Status Code | 380 |

Enumerator ____________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

Form Approved
O.M.B. Number 535-[illegible]
C. E. 12-00388-2

## FORM B – 2: SORGHUM YIELD COUNTS – 1981

| | |
|---|---|
| YEAR, CROP, FORM, MONTH (1–4) | |
| 103_ | |

**MONTH CODE**

- Aug. 1 ........ 2
- Sept. 1 ........ 3
- Oct. 1 ........ 4
- Nov. 1 ........ 5

Has operator applied pesticides with organophosphorous content since last field visit? YES ☐ NO ☐

*If YES, enter latest application date* ______________ *and name of pesticide* ______________

**UNIT LOCATION**

| | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| Number of rows along edge of field | | | |
| Number of paces into field | | | |

| | |
|---|---|
| Date (__________)... | 370 |
| Starting Time ....... | 371 |

Is the sample field mature?

☐ NO, Continue. ☐ YES - STOP, Complete Form B-3.

**ROW SPACE MEASUREMENTS**

| | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| 1. Is this same unit that was laid out last month? *Check NO if this is the first visit to lay out the unit or if unit is relocated. For unit(s) checked: YES — skip to Item 3. NO — complete Item 2.* | YES ☐ NO ☐ | YES ☐ NO ☐ | YES ☐ NO ☐ |
| 2. a. Measure distance from stalks in Row 1 to stalks in Row 2 ................ Feet & Tenths | 301 . | 302 . | 303 . |
| b. Measure distance from stalks in Row 1 to stalks in Row 5 ................ Feet & Tenths | 304 . | 305 . | 306 . |

**OBSERVATIONS WITHIN 2-ROW BY 3-FOOT SECTION**

| | | | |
|---|---|---|---|
| 3. Number of stalks in both rows .................. | 311 | 312 | 313 |
| 4. Number of stalks with heads .................... | 315 | 316 | 317 |
| 5. Stage of maturity ............................ | 318 | 319 | 320 |

Pre-flower ..... 1
Flower ..... 2
Milk ..... 3
Soft Dough ..... 4
Hard Dough ..... 5

**FORM B-2: SORGHUM (Cont'd)**

**6. For each head, measure the culm diameter, head length and head circumference.**

| | UNIT 1 | | | UNIT 2 | | | UNIT 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Culm Diameter (mm) | Head Length (in) | Head Circum. (cm) | Culm Diameter (mm) | Head Length (in) | Head Circum. (cm) | Culm Diameter (mm) | Head Length (in) | Head Circum. (cm) | |
| 1 | 330 . | 331 . | 332 . | 333 . | 334 . | 335 . | 336 . | 337 . | 338 . | 1 |
| 2 | 339 . | 340 . | 341 . | 342 . | 343 . | 344 . | 345 . | 346 . | 347 . | 2 |
| 3 | 348 . | 349 . | 350 . | 351 . | 352 . | 353 . | 354 . | 355 . | 356 . | 3 |
| 4 | 357 . | 358 . | 359 . | 360 . | 361 . | 362 . | 363 . | 364 . | 365 . | 4 |
| 5 | 410 . | 411 . | 412 . | 413 . | 414 . | 415 . | 416 . | 417 . | 418 . | 5 |
| 6 | 419 . | 420 . | 421 . | 422 . | 423 . | 424 . | 425 . | 426 . | 427 . | 6 |
| 7 | 428 . | 429 . | 430 . | 431 . | 432 . | 433 . | 434 . | 435 . | 436 . | 7 |
| 8 | 437 . | 438 . | 439 . | 440 . | 441 . | 442 . | 443 . | 444 . | 445 . | 8 |
| 9 | 446 . | 447 . | 448 . | 449 . | 450 . | 451 . | 452 . | 453 . | 454 . | 9 |
| 10 | 455 . | 456 . | 457 . | 458 . | 459 . | 460 . | 461 . | 462 . | 463 . | 10 |
| 11 | 540 . | 541 . | 542 . | 543 . | 544 . | 545 . | 546 . | 547 . | 548 . | 11 |
| 12 | 549 . | 550 . | 551 . | 552 . | 553 . | 554 . | 555 . | 556 . | 557 . | 12 |
| 13 | 558 . | 559 . | 560 . | 561 . | 562 . | 563 . | 564 . | 565 . | 566 . | 13 |
| 14 | 610 . | 611 . | 612 . | 613 . | 614 . | 615 . | 616 . | 617 . | 618 . | 14 |
| 15 | 619 . | 620 . | 621 . | 622 . | 623 . | 624 . | 625 . | 626 . | 627 . | 15 |
| 16 | 628 . | 629 . | 630 . | 631 . | 632 . | 633 . | 634 . | 635 . | 636 . | 16 |
| 17 | 637 . | 638 . | 639 . | 640 . | 641 . | 642 . | 643 . | 644 . | 645 . | 17 |
| 18 | 646 . | 647 . | 648 . | 649 . | 650 . | 651 . | 652 . | 653 . | 654 . | 18 |
| 19 | 655 . | 656 . | 657 . | 658 . | 659 . | 660 . | 661 . | 662 . | 663 . | 19 |
| 20 | 711 . | 712 . | 713 . | 714 . | 715 . | 716 . | 717 . | 718 . | 719 . | 20 |
| 21 | 720 . | 721 . | 722 . | 723 . | 724 . | 725 . | 726 . | 727 . | 728 . | 21 |
| 22 | 729 . | 730 . | 731 . | 732 . | 733 . | 734 . | 735 . | 736 . | 737 . | 22 |
| 23 | 738 . | 739 . | 740 . | 741 . | 742 . | 743 . | 744 . | 745 . | 746 . | 23 |
| | Complete Form B-2A for research and clip areas beyond Unit 1; Go to Unit 2. | | | Go to Unit 3. | | | Conclude | | | |
| Office | 747 | 748 | 749 | 750 | 751 | 752 | 753 | 754 | 755 | Office |
| Volume Factor | 756 | | | 757 | | | 758 | | | |

Ending Time .... 372

Enumerator ________________________

Status Code .... 380

Form Approved
O.M.B. Number 535-0088
C.E. 12-00368-2a

UNITED STATES DEPARTMENT OF AGRICULTURE
Economics and Statistics Service

# FORM B–2A: SORGHUM YIELD COUNTS – 1981

**MONTH CODE**

Aug. 1 . . . . . 2
Sept. 1 . . . . . 3
Oct. 1 . . . . . 4
Nov. 1 . . . . . 5

| YEAR, CROP, FORM, MONTH (1–4) |
|---|
| 102___ |

Starting Time . . . . . . . . . . . . . . . . . [298]

Locate the research plants beyond Unit 1, Row 3. Skip the first 5 plants, then label the next 5 plants with red flagging ribbon.

| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 |
|---|---|---|---|---|---|
| 1. Number of leaves . . . . . . . . . . . . . . . . . . . | 200 | 204 | 208 | 212 | 216 |
| 2. Culm diameter . . . . . . . . . . *(millimeters)* | 201 . | 205 . | 209 . | 213 . | 217 . |
| 3. Head length . . . . . . . . . *(inches & tenths)* | 202 . | 206 . | 210 . | 214 . | 218 . |
| 4. Head circumference . . . *(centimeters)* | 203 . | 207 . | 211 . | 215 . | 219 . |

5. Have leaf measurements on the 5 research plants been made previously?

☐ NO ↓      ☐ YES - Skip to item 9.

6. Is the collar of the flag leaf visible on all 5 plants?

☐ YES ↓      ☐ NO - Record ending time and return to Form B–2.

| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 |
|---|---|---|---|---|---|
| 7. Plant height . . . . . . . . . . . *(feet & tenths)* | 220 . | 221 . | 222 . | 223 . | 224 . |

8. Measure the length and width of all leaves on the 5 research plants in inches and tenths.

a. Plant 1

| | Length | Width | | Length | Width | | Length | Width |
|---|---|---|---|---|---|---|---|---|
| 1. | 225 . | 226 . | 2. | 227 . | 228 . | 3. | 229 . | 230 . |
| 4. | 231 . | 232 . | 5. | 233 . | 234 . | 6. | 235 . | 236 . |
| 7. | 237 . | 238 . | 8. | 239 . | 240 . | 9. | 241 . | 242 . |
| 10. | 243 . | 244 . | 11. | 245 . | 246 . | 12. | 247 . | 248 . |

## FORM B–2A: SORGHUM (Cont'd)

8b. Plant 2

| Unit | Length | Width |
|---|---|---|
| 1. | 900 . | 901 . |
| 2. | 902 . | 903 . |
| 3. | 904 . | 905 . |
| 4. | 906 . | 907 . |
| 5. | 908 . | 909 . |
| 6. | 910 . | 911 . |
| 7. | 912 . | 913 . |
| 8. | 914 . | 915 . |
| 9. | 916 . | 917 . |
| 10. | 918 . | 919 . |
| 11. | 920 . | 921 . |
| 12. | 922 . | 923 . |

c. Plant 3

| Unit | Length | Width |
|---|---|---|
| 1. | 924 . | 925 . |
| 2. | 926 . | 927 . |
| 3. | 928 . | 929 . |
| 4. | 930 . | 931 . |
| 5. | 932 . | 933 . |
| 6. | 934 . | 935 . |
| 7. | 936 . | 937 . |
| 8. | 938 . | 939 . |
| 9. | 940 . | 941 . |
| 10. | 942 . | 943 . |
| 11. | 944 . | 945 . |
| 12. | 946 . | 947 . |

d. Plant 4

| Unit | Length | Width |
|---|---|---|
| 1. | 948 . | 949 . |
| 2. | 950 . | 951 . |
| 3. | 952 . | 953 . |
| 4. | 954 . | 955 . |
| 5. | 956 . | 957 . |
| 6. | 958 . | 959 . |
| 7. | 960 . | 961 . |
| 8. | 962 . | 963 . |
| 9. | 964 . | 965 . |
| 10. | 966 . | 967 . |
| 11. | 968 . | 969 . |
| 12. | 970 . | 971 . |

e. Plant 5

| Unit | Length | Width |
|---|---|---|
| 1. | 972 . | 973 . |
| 2. | 974 . | 975 . |
| 3. | 976 . | 977 . |
| 4. | 978 . | 979 . |
| 5. | 980 . | 981 . |
| 6. | 982 . | 983 . |
| 7. | 984 . | 985 . |
| 8. | 986 . | 987 . |
| 9. | 988 . | 989 . |
| 10. | 990 . | 991 . |
| 11. | 992 . | 993 . |
| 12. | 994 . | 995 . |

9. Has this sample reached the flower stage or beyond?

☐ YES

☐ NO - Record ending time and return to Form B–2

Skip the first 5 heads beyond Unit 1 or beyond the previous clip area (if appropriate), then clip the next 5 heads according to the schedule below. Bag, tag and send heads to the lab. Label the last plant clipped with red flagging ribbon.

August 1 – Row 1    September 1 – Row 2    October 1 – Row 1    November 1 – Row 2

Do NOT clip any heads beyond Row 3.

Ending Time [299]

Return to Form B–2

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

**FORM B—3: SORGHUM YIELD COUNTS — 1981**

| YEAR, CROP, FORM, MONTH (1—4) | |
|---|---|
| **1035** | |

Has operator applied pesticides with organophosphorous content since last field visit? YES ☐ NO ☐

*If YES, enter latest application date* ____________ *and name of pesticide* ____________

| **UNIT LOCATION** | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| Number of rows along edge of field | | | |
| Number of paces into field | | | |

| | |
|---|---|
| Date (________) . . . | 370 |
| Starting Time . . . . . . . | 371 |

**ROW SPACE MEASUREMENTS**

| | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| 1. Is this same unit that was laid out last month? *Check NO if this is the first visit to lay out the unit or if unit is relocated. For unit(s) checked: YES — skip to Item 3. NO — complete Item 2.* | YES☐ NO☐ | YES☐ NO☐ | YES☐ NO☐ |
| 2. a. Measure distance from stalks in Row 1 to stalks in Row 2 . . . . . . . . . . . . . . . . Feet & Tenths | 301 . | 302 . | 303 . |
| b. Measure distance from stalks in Row 1 to stalks in Row 5 . . . . . . . . . . . . . . . . Feet & Tenths | 304 . | 305 . | 306 . |

**OBSERVATIONS WITHIN 2-ROW BY 3-FOOT SECTION**

| | | | |
|---|---|---|---|
| 3. Number of stalks in both rows . . . . . . . . . . . . . . . . . . . | 311 | 312 | 313 |
| 4. Number of stalks with heads . . . . . . . . . . . . . . . . . . . | 315 | 316 | 317 |
| 5. Stage of maturity . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 318 | 319 | 320 |

Hard Dough . . . . . 5

Mature . . . . . 6

**FORM B—3: SORGHUM (Cont'd)**

6.- Clip all heads within each row in the count sections. Record the number of heads and total weight. Bag a tag each row separately. These bags will be mailed to the State office.

| | UNIT 1 | | UNIT 2 | | UNIT 3 | |
|---|---|---|---|---|---|---|
| | Number of Heads | Total Weight (lbs.) | Number of Heads | Total Weight (lbs.) | Number of Heads | Total Weight (lbs.) |
| a. Row 1, Section 1 | 110 | 111 . | 112 | 113 . | 114 | 115 . |
| b. Row 2, Section 1 | 116 | 117 . | 118 | 119 . | 120 | 121 . |

7. Clip, count and weigh all heads in the seven remaining sections. Dispose of these heads when all work is done.

| | | | | | | |
|---|---|---|---|---|---|---|
| a. Row 1, Section 2 | 122 | 123 . | 124 | 125 . | 126 | 127 . |
| b. Row 1, Section 3 | 128 | 129 . | 130 | 131 . | 132 | 133 . |
| c. Row 2, Section 2 | 134 | 135 . | 136 | 137 . | 138 | 139 . |
| d. Row 2, Section 3 | 140 | 141 . | 142 | 143 . | 144 | 145 . |
| e. Row 3, Section 1 | 146 | 147 . | 148 | 149 . | 150 | 151 . |
| f. Row 3, Section 2 | 152 | 153 . | 154 | 155 . | 156 | 157 . |
| g. Row 3, Section 3 | 158 | 159 . | 160 | 161 . | 162 | 163 . |

8. Clip heads from all five research plants beyond Unit 1, Row 3. Bag, tag and mail these heads to the State office.

Ending time .... 372

Enumerator ______________________ Status code .... 380

UNITED STATES DEPARTMENT OF AGRICULTURE
Economics and Statistics Service

C.E. 12-0038C-1

## FORM C–1: STATE LABORATORY DETERMINATIONS – 1981 SORGHUM YIELD SURVEY – CLIPPING AREA

**MONTH CODES**

Aug. 1.......... 2
Sept. 1.......... 3
Oct. 1.......... 4
Nov. 1.......... 5

| YEAR, CROP, FORM, MONTH (1–4) |
|---|
| **104**__ |

Date ________________ 470
*(Sample Processed)*

1. Wet weight of all 5 heads and basket .............................. (grams) | 401 | . |

2. Dry all 5 heads and record the dry weight for each head individually ................................ (grams)

| | Code | |
|---|---|---|
| Head 1 | 403 | . |
| Head 2 | 404 | . |
| Head 3 | 405 | . |
| Head 4 | 406 | . |
| Head 5 | 407 | . |

Lab Technician ______________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

**FORM C—2: 1981 SORGHUM YIELD SURVEY**
**Pre-Harvest Lab Determinations**
C.E. 12-0038C-2

| YEAR, CROP, FORM, MONTH (1—4) | |
|---|---|
| **1055** | |

Date Analyzed (______________)     Code 570

### HEADS FROM THE COUNT UNITS

| | | Weight of Heads in bags *(grams)* | Weight of bags and fasteners *(grams)* | Number of Heads |
|---|---|---|---|---|
| 1. Unit 1 | Row 1 | 501 . | 502 . | 503 |
| | Row 2 | 504 . | 505 . | 506 |
| 2. Unit 2 | Row 1 | 507 . | 508 . | 509 |
| | Row 2 | 510 . | 511 . | 512 |
| 3. Unit 3 | Row 1 | 513 . | 514 . | 515 |
| | Row 2 | 516 . | 517 . | 518 |

### THRESH ALL ROW 1 HEADS FROM ALL UNITS

4. Weight of threshed grain ............................................. Grams [519 .]

5. Moisture of threshed grain ............................................. Percent [520 .]

Lab Technician ______________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

**FORM C—2A: 1981 SORGHUM YIELD SURVEY**
**Research Lab Determinations**
C.E. 12-0038C-2A

| YEAR, CROP, FORM, MONTH (1—4) |
|---|
| **1055** |

Date ______________________ 571
*(Sample Processed)*

**HEADS FROM THE 5 RESEARCH PLANTS**

| | Weight of Head *(grams)* | Weight of Threshed Grain *(grams)* | Number of Kernels |
|---|---|---|---|
| 1. First Head .................... | 522 . | 523 . | 524 |
| 2. Second Head .................. | 525 . | 526 . | 527 |
| 3. Third Head .................... | 528 . | 529 . | 530 |
| 4. Fourth Head ................... | 531 . | 532 . | 533 |
| 5. Fifth Head .................... | 534 . | 535 . | 536 |
| 6. Loose grain left in bag ................................ | | 537 . | 538 |

**Lab Technician** ______________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

# FORM D: SORGHUM YIELD SURVEY
## 1981 Post--Harvest Interview

MONTH CODE

Oct. 1 ........ 3
Nov. 1 ........ 4
Dec. 1 or later. 5

YEAR, CROP, FORM, MONTH (1–4)

**106 __**

Earlier this season, I (or a representative from our office) obtained some information on your sorghum acreage and made some plant and head counts in your sorghum field. I would like to know how the crop turned out in the sample field. This information will help us in evaluating the counts made this season.

Date ( __________ ) .... 670

Starting Time .............. 671

1. Enter acres of grain sorghum for grain *(Item 3, on the back of Form A).*

Sample Field No. __________ ........ Acres 600 [ . ]

2. How many acres of sorghum were or will be harvested for grain from this field? .................. Acres 601 [ . ]

*If Item 2 is different from Item 1, ask Item 3.*
*If not, skip to Item 4.*

*Do not change Item 1.*

3. Earlier in the crop year *(Item 1)* ________ acres was recorded as being intended for harvest for grain. Can you give me a reason for the difference?

______________________________

______________________________

4. How many bushels were or will be harvested from these *(Item 2)* acres? ..........................
   - Total Bushels ........................ 607
   - OR
   - Bushels Per Acre ...................... 608 [ . ]

5. Was there any significant damage in this field due to drought, flooding, insects, disease, lodging, hail or other causes? .................. Yes = 1 No = 2 ... Enter Code 609

*If "YES", give cause(s) below.*

______________________________

______________________________

______________________________

6. Has this sample field been plowed since harvest?

NO ☐ *Complete a Form E in the sample field.*

YES ☐ *Select an alternate grain sorghum field for gleaning if available in the tract.*

I would like to thank you for your cooperation this season and hope you will continue to have an interest in crop estimating and crop reporting work. Before I go, I would like to go out to the field and pick up any loose grain left in the sample plots to give us some measure of harvesting loss.

Ending Time 672

STATUS CODE 680

Enumerator ______________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

# FORM E: SORGHUM YIELD SURVEY — 1981
## POST-HARVEST GLEANINGS

| YEAR, CROP, FORM, MONTH (1—4) |
|---|
| **107_** |

MONTH CODE

| | |
|---|---|
| Oct. 1 | 4 |
| Nov. 1 | 5 |

The post-harvest field gleanings should be completed as soon after harvest as possible, preferably within three days after harvest. If the sample field has been plowed, disced or pastured since harvest, select an alternate field for gleaning if one is available in the tract.

Date ( ________________ ) 770

Starting Time . . . 771

Enumerator ______________________________

| FIELD OBSERVATION — Unit Location | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| Number of rows along edge of field | | | |
| Number of paces into field | | | |
| 1 a. Measure distance from stalks in Row 1 to stalks in Row 2 . . . Feet & Tenths | 701 . | 702 . | 703 . |
| b. Measure distance from stalks in Row 1 to stalks in Row 5 . . . Feet & Tenths | 704 . | 705 . | 706 . |

GLEANINGS IN 3—FOOT UNITS

*Check each box as completed*

| | UNIT 1 | UNIT 2 | UNIT 3 |
|---|---|---|---|
| 3 Pick up all heads attached to stalks and all heads and pieces of heads with kernels in each middle. Deposit all grain in bag. Identify bag as "heads and pieces" . . . | ( ) | ( ) | ( ) |
| 4. Pick up all loose grain in middle for first row of each unit. Deposit in a separate bag. Identify bag as "loose grain" . . . . . | ( ) | ( ) | ( ) |

5 Was an alternate field used for making post-harvest observations? YES NO

*If post-harvest observations cannot be made, give reason here*

______________________________________________ Ending Time 772

______________________________________________ Status Code 780

POST-HARVEST LAB DETERMINATIONS

6. Weight of grain from heads . . . . . . . . . . Grams 707

7 Weight of loose grain from ground . . . . . . . . . . Grams 708

8 Moisture Content . . . . . . . . . . Percent (One Decimal) 709

*If samples combined for moisture test, show sample numbers combined* ______________ Date Analyzed ( ________ ) . . . . . . Code 710

**DO NOT** *show combined sample weights in Item 6 or 7.*

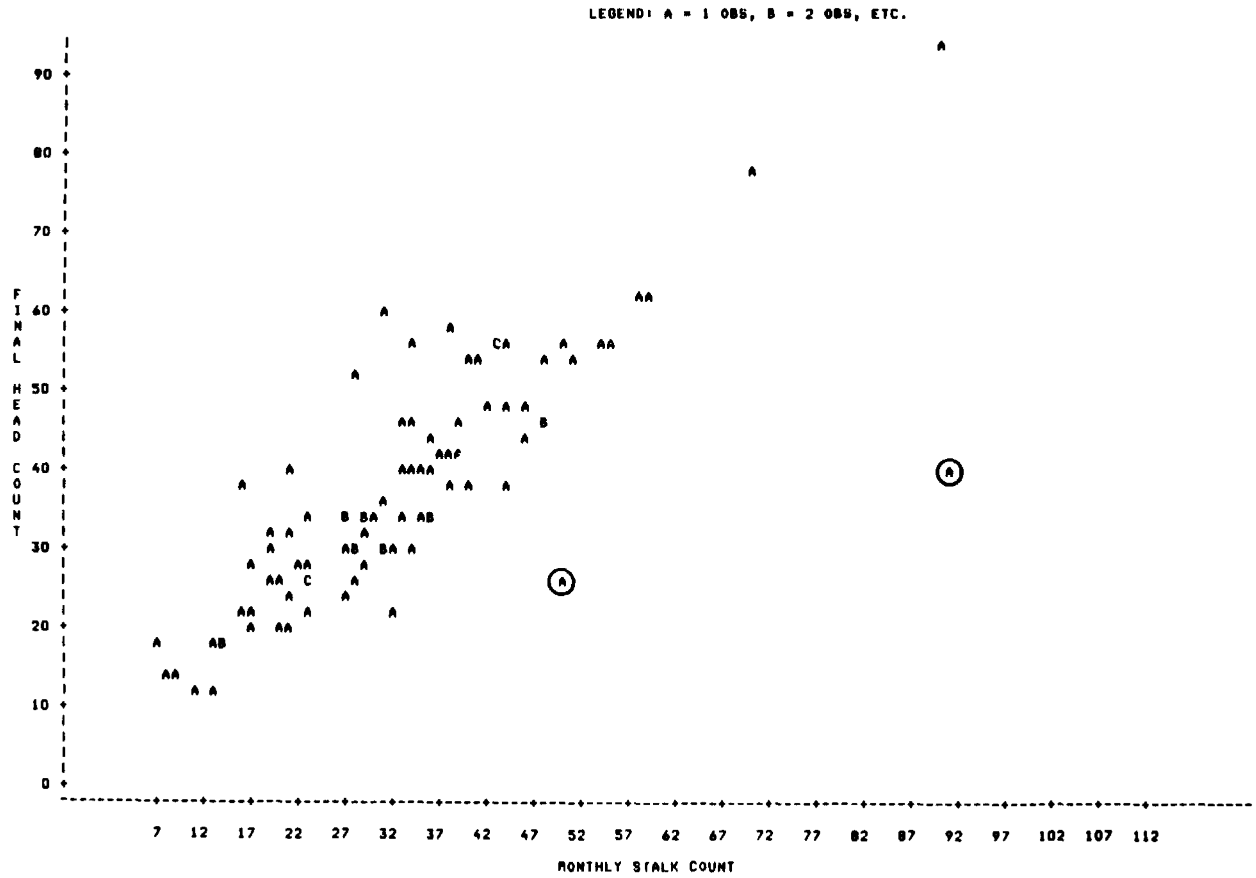
Lab Technician ______________________________

## APPENDIX 2: Maturity Code Descriptions

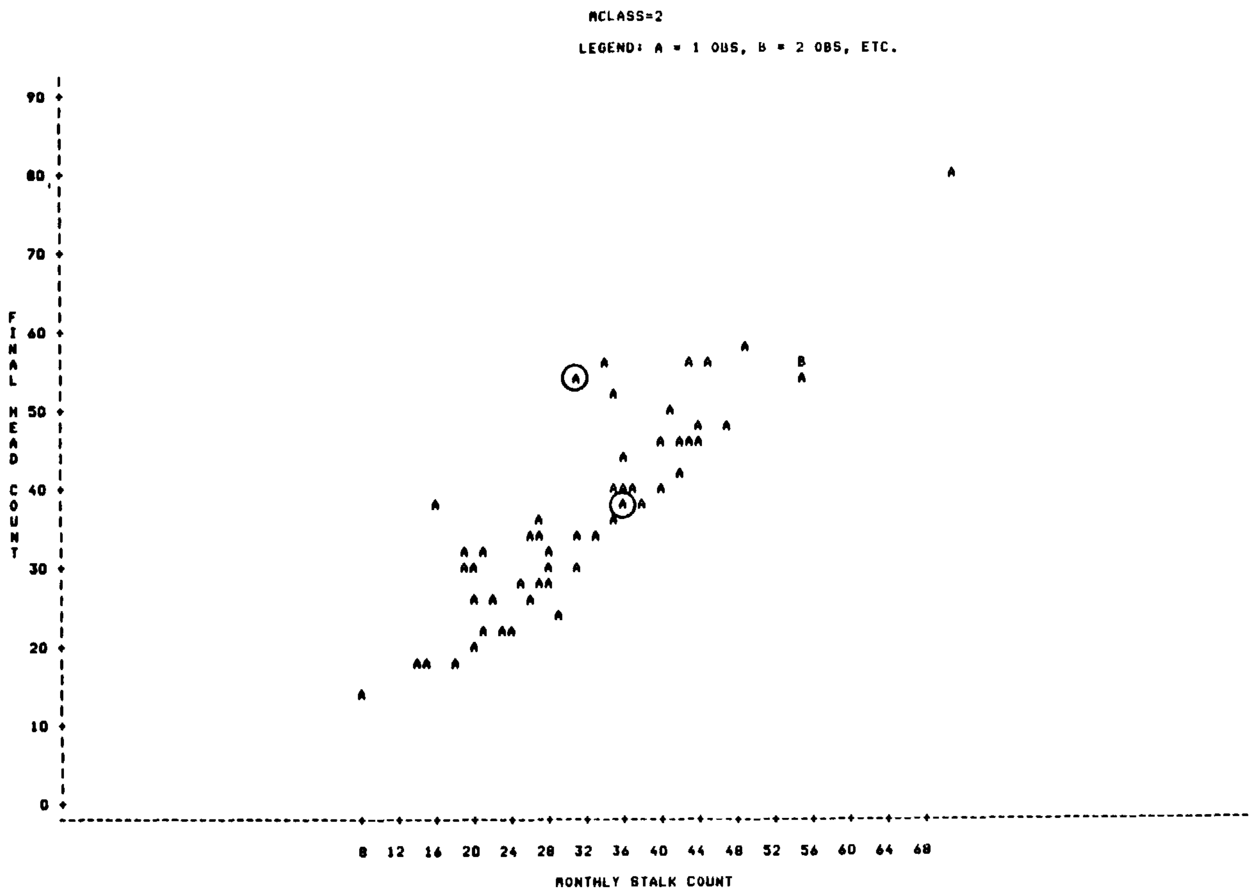
| | |
|---|---|
| 1. PREFLOWER (PREBLOOM) | All of the early growth stages of the sorghum plant before the flowers appear are considered preflower. This includes the plant emergence, leaf development, boot, and head emergence stages. |
| 2. FLOWER (BLOOM) | This stage is very short. During this time, the head may appear to have a yellowish hue when the flower parts are showing. |
| 3. MILK | Kernels are formed in heads. Kernels of grain are soft, moist and milky. When the grain is squeezed, a milky liquid can be observed. |
| 4. SOFT DOUGH | The grains can be easily crushed and the contents of the grains are soft and can be kneaded like dough with only a few grains containing milk. |
| 5. HARD DOUGH | The grains are fairly firm but not quite mature. The grains do not easily separate from the head. Nearly all of the final grain weight has accumulated. |
| 6. MATURE | The grains readily part from the head. The grain is tough and is not easily crushed by the thumbnail. |

APPENDIX 3: Plots of final head count vs
independent variables by maturity class

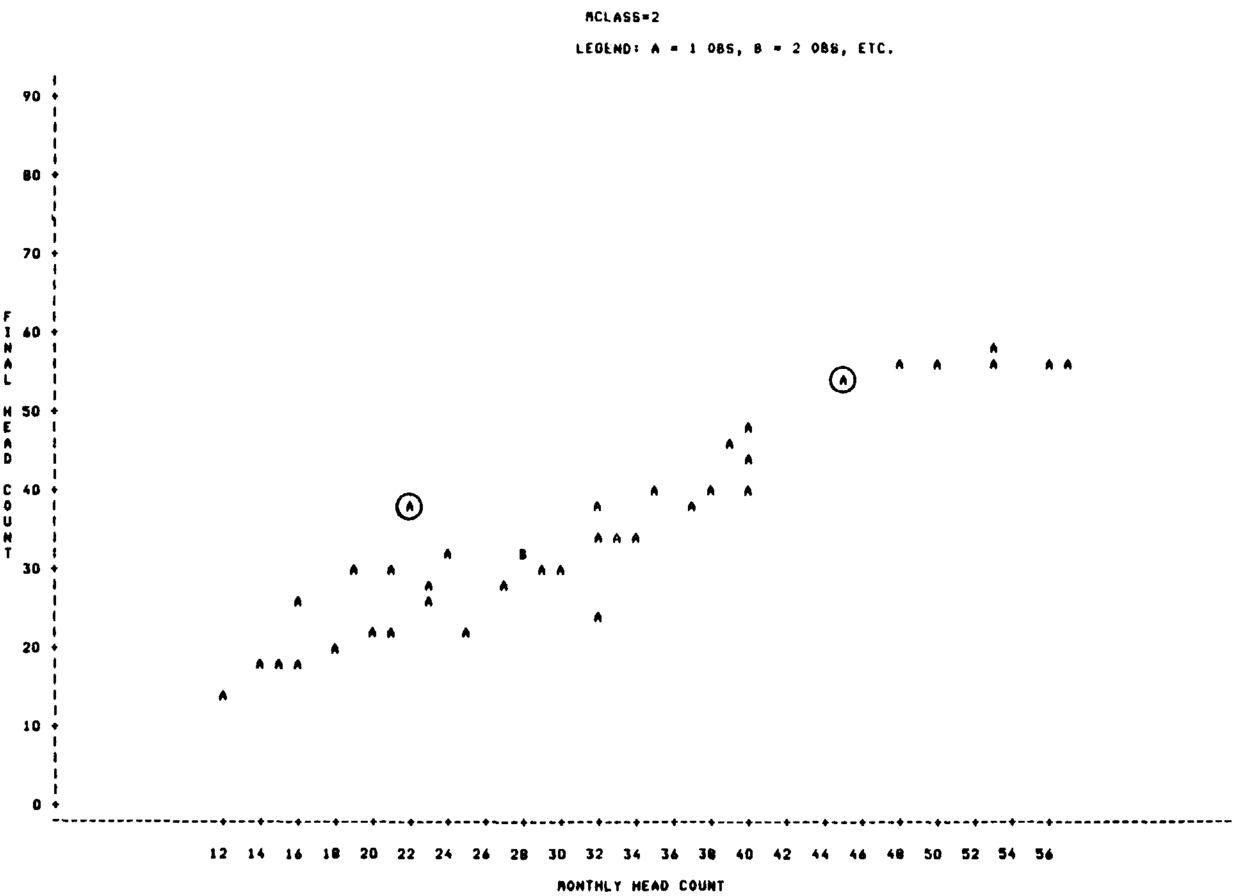
**PLOT A - Monthly stalk count vs. final head count,
prebloom stage**



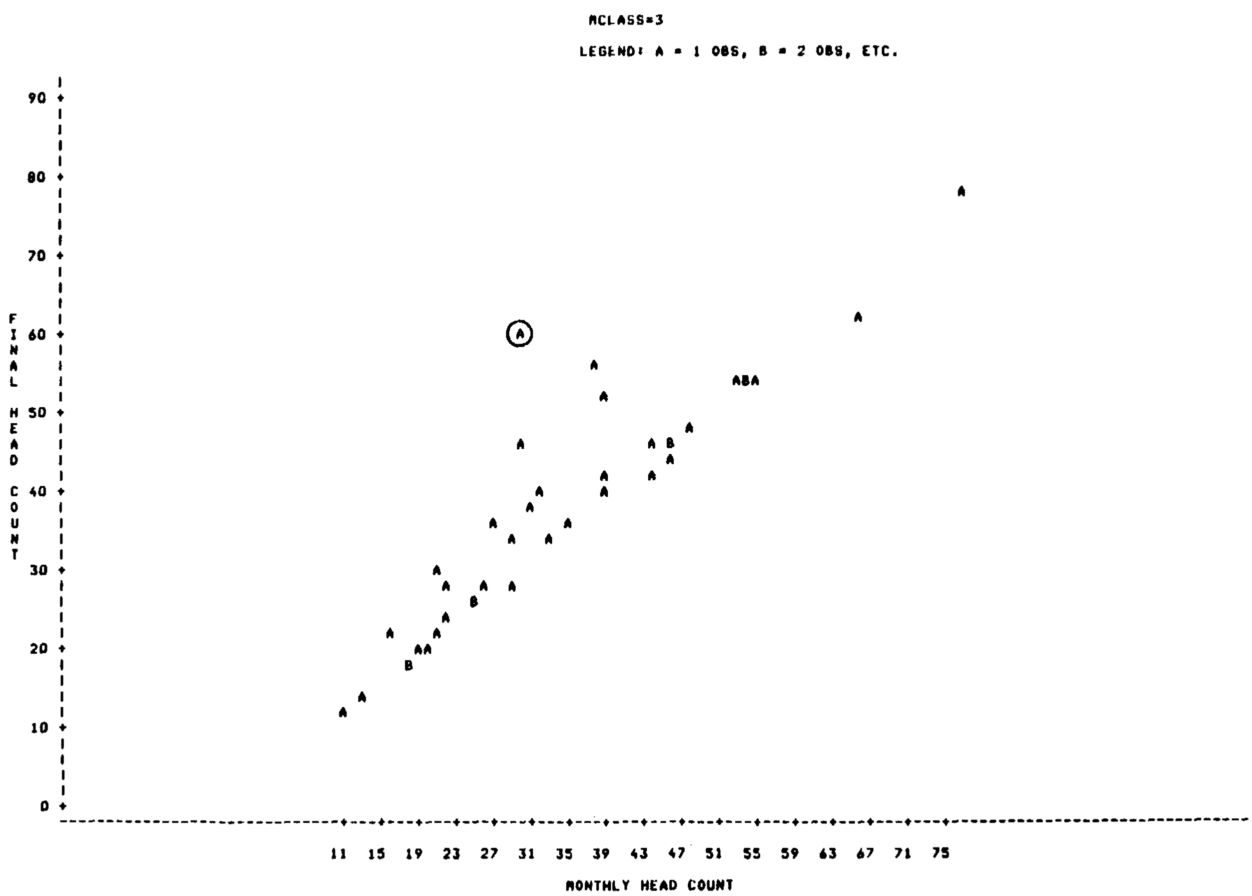
PLOT B - Monthly stalk count vs. final head count
bloom stage



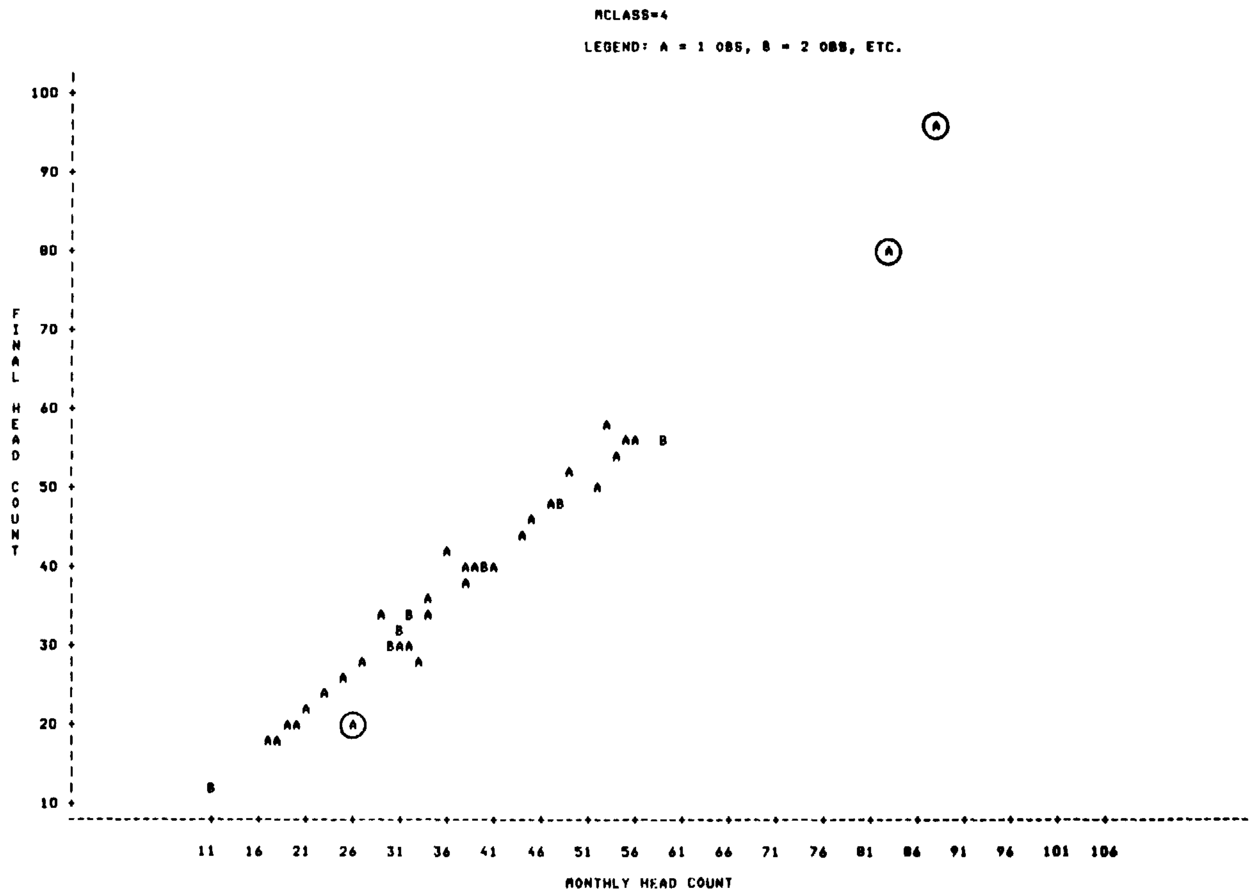
PLOT C - Monthly head count vs. final head count,
bloom stage



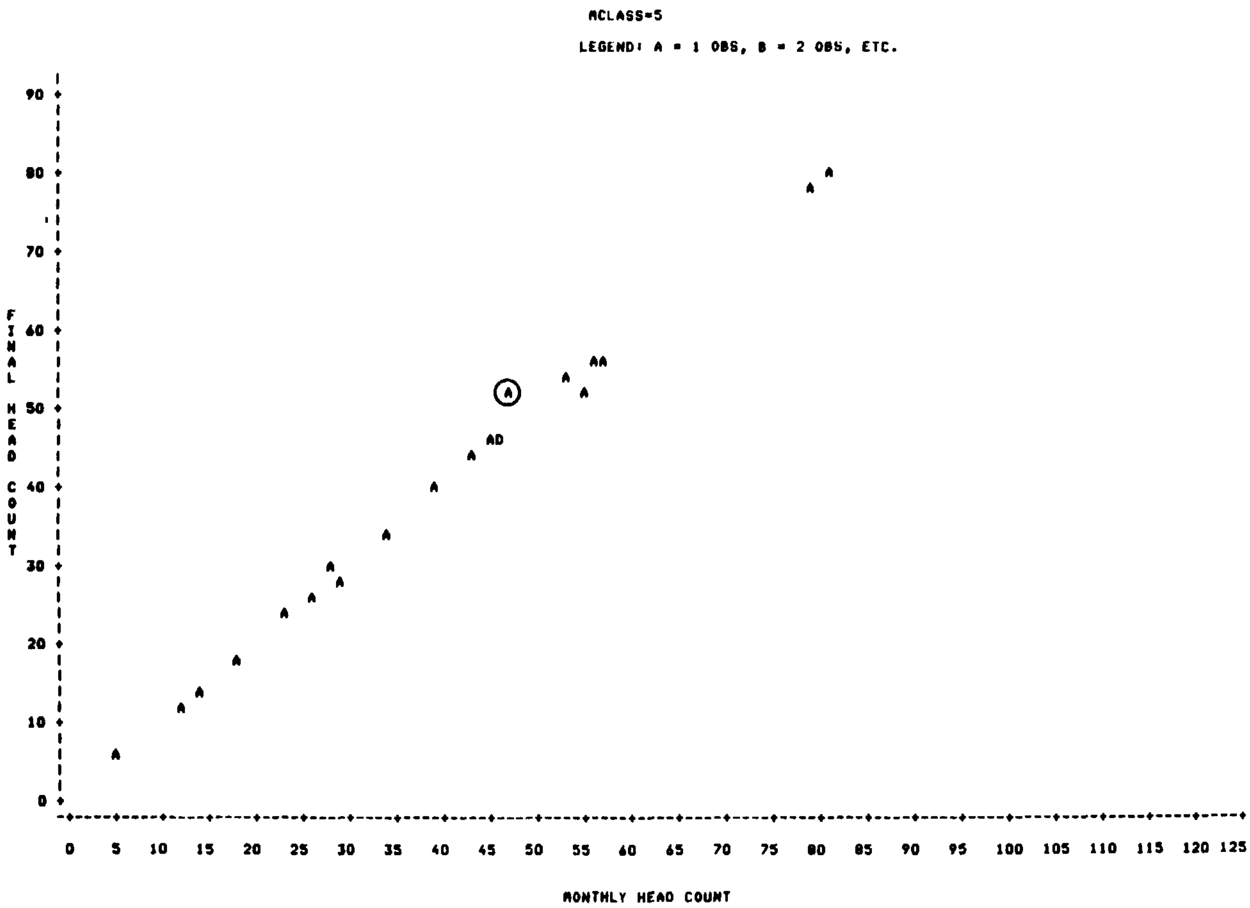
PLOT D - Monthly head count vs. final head count, milk stage



PLOT E - Monthly head count vs. final head count, soft dough stage



PLOT F - Monthly head count vs. final head count
hard dough stage



# APPENDIX 4

A brief description of the regression diagnostics is shown below. The formulae for the threshold values are also given, where p is the number of independent variables in the model and n is the number of observations.

1. Cook's Distance Measure (Cook's D) quantifies the effect an observation has on the least squares estimate of the parameter vector. The threshold values used were 0.105 (p=1), 0.195 (p=2), 0.266 (p=3), and 0.323 (p=4).

2. The covariance ratio for observation i, examines the determinant of the covariance matrix from the data set with no observations deleted and the determinant from the data set with the $i^{th}$ observation deleted. The threshold value were defined to be $1 \pm 3p/n$.

3. DFBETAS, for any observation i, measures the difference in a parameter estimate caused by deleting the $i^{th}$ observation, divided by standard error. A DFBETAS is computed for each independent variable in the model. The threshold values were defined as $2 / \sqrt{n}$.

4. DFFITS, for observation i, is the difference in the fitted values scaled by the standard error resulting from the deletion of the $i^{th}$ observation. The threshold value used was $2\sqrt{P/n}$.

5. The studentized residual measures the magnitude of the $i^{th}$ residual scaled by the standard error with the $i^{th}$ observation removed. Threshold values of -2 and 2 were used.

6. The Variance Inflation Factor is an indication of the dependency between the regressor variables. A VIF of 1 indicates orthogonality in the design matrix. A value between 1 and 5 implies a weak dependency and a value greater than 10 implies a strong dependency. Values between 5 and 10 are inconclusive. The 1981 sorghum data did not produce any inconclusive values.

APPENDIX 5: Edit Limits

| FORMS and VARIABLE | 1981 Statistics $\bar{X}$ | s | Min | Max | Recommendations Lower limit | Upper limit |
|---|---|---|---|---|---|---|
| Form A | | | | | | |
| JES acres | - | - | - | - | - | 500 |
| Length of interview (min) | 18 | 9.7 | 5 | 53 | 5 | 35 |
| Planting date | 160 | 16.6 | 114 | 202 | 130 | 190 |
| Planting depth (in) | 1.9 | .7 | .8 | 5 | 1.0 | 3.5 |
| Form B | | | | | | |
| Stalk count | 11.2 | 6.0 | 0 | 39 | 3 | 30 |
| Head count | 12.4 | 6.8 | 0 | 45 | 3 | 30 |
| Culm diameter (mm) | 9.4 | 2.6 | 2.0 | 18.9 | 4 | 14 |
| Head length (in) | 10.5 | 2.1 | 3.1 | 15.9 | 6 | 14 |
| Head circumference (cm) | 17.3 | 6.2 | 1.3 | 68.6 | 7 | 27 |
| Volume factor | 189.0 | 89.3 | 6.0 | 919.7 | 60 | 360 |
| Heads per section | 6.8 | 3.8 | 1 | 64 | 1 | 15 |
| Weight per head (lbs) | .19 | .095 | .009 | .733 | .04 | .4 |
| 4 - row spacing (ft) | 10.3 | 2.1 | 2.7 | 14.0 | 6.0 | 13.3 |
| Length of fieldwork (min) | 119.4 | 36.8 | 19 | 255 | 75 | 180 |
| Form C-1 | | | | | | |
| Dry matter fraction (Sept) | .39 | .110 | .25 | .74 | .28 | .85 |
| Dry matter fraction (Oct) | .55 | .149 | .28 | .89 | -- | -- |
| Dry head weight (Sept) | 23.5 | 16.5 | .6 | 79.4 | 4.0 | 115.0 |
| Dry head weight (Oct) | 48.3 | 33.7 | 2.1 | 153.9 | -- | -- |
| Wet weight (Sept and Oct) | 258.8 | 173.0 | 34.7 | 696.5 | 80.0 | 550.0 |
| Form H | | | | | | |
| % nitrogen (A) | 33.1 | 26.9 | 5 | 82 | - | - |
| % phosphate (A) | 34.0 | 15.1 | 10 | 60 | - | - |
| % potash (A) | 11.9 | 8.5 | 6 | 30 | - | - |
| Pounds per acre (A) | 97.3 | 64.9 | 4 | 300 | 40 | 200 |
| Nitrogen per acre (B) | 84.3 | 37.4 | 10 | 180 | 20 | 150 |
| Phosphate per acre (B) | 36.0 | 8.8 | 20 | 50 | 20 | 50 |
| Potash per acre (B) | 38.3 | 13.3 | 30 | 60 | 30 | 60 |
| Total percentage (A) | - | - | - | - | 28 | 82 |

| FORMS and VARIABLE | $\bar{X}$ | 1981 Statistics s | Min | Max | Recommendations Lower limit | Upper limit |
|---|---|---|---|---|---|---|
| Form C-2 | | | | | | |
| Weight in bags (gm) | 499.8 | 267.1 | 23.8 | 1302.0 | 80 | 1000 |
| Weight of heads (gm) | 478.3 | 267.5 | 3.4 | 1281.6 | - | - |
| Weight per head (gm) | 77.4 | 39.2 | 3.4 | 384.5 | 15 | 150 |
| Threshing fraction | .69 | .116 | .31 | .89 | .4 | .8 |
| Moisture (percent) | 13.4 | 9.2 | 2.5 | 96.6 | 6.0 | 18.0 |
| Form C-2A | | | | | | |
| Head weight (gm) | 62.5 | 37.7 | 1.3 | 245.5 | 12.0 | 130 |
| Threshing fraction | .75 | .15 | .017 | .97 | .4 | .85 |
| Kernel count | 2100.2 | 1201.1 | 2 | 7463 | 350 | 4000 |
| Loose grain weight (gm) | 3.7 | 4.0 | 0 | 20.7 | 0 | 8.0 |
| Loose kernel count (gm) | 157.4 | 173.9 | 0 | 865 | 0 | 300 |
| Form D | | | | | | |
| Interview length (min) | 11.7 | 12.5 | 2 | 60 | 5 | 30 |
| Yield (bushels per acre) | 68.2 | 31.9 | 4 | 148 | 30 | 110 |
| Form E | | | | | | |
| 4 - row space (ft) | 10.1 | 2.3 | 2.3 | 14.2 | 6.0 | 13.3 |
| Length of field work (min) | 92.7 | 37.4 | 35 | 165 | 30 | 150 |
| Weight of grain from heads (gm) | 188.7 | 245.6 | .8 | 1112.3 | 30.0 | 600.0 |
| Weight of loose grain (gm) | 15.9 | 18.3 | 1.4 | 90.3 | 2.0 | 50.0 |
| Moisture (percent) | 9.0 | 1.1 | 7.8 | 13.6 | 6.0 | 15.0 |



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