GRAIN SORGHUM

A PRELIMINARY FORECAST MODEL

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Table of Contents

	Page
Summary	ii
Introduction	1
Data Collection	2
General	2
Interview Forms	2
Field and Laboratory Work	2
Post Harvest Gleaning	4
Results	4
General	4
Within Plot Results	5
Weight of Grain Characteristics	5
Plant Population Characteristics	5
Outside of Plot Results	6
Grain Sorghum Model	12
Optimum Sample Design	16
Appendix A. Forms	19
Appendix B. Field and Laboratory Procedures	28

SUMMARY

Research results from the 1971 crop year indicate that the development of grain sorghum forecast model is highly possible. At early stages of development (pre-flower) plant population at harvest can be forecasted from number of stalks, but weight of grain per head would require the use of the historical average for weight of grain per head at harvest. Once maturity category three (flower) is reached there are three measured characteristics, (length of head, diameter of stalk, circumference of head), which could be used in estimating weight of grain per head. Number of stalks or number of emerged heads or both could be used at the flower stage for forecasting number of heads at harvest. Number of emerged heads could be used at stages beyond the flower stage of maturity to forecast number of heads at harvest.

The derived optimum plot size is five feet by three rows. This considerably reduces field work per unit from the level of the 1971 project.

INTRODUCTION

Over the past ten years Iowa State University and SRS have conducted several research projects dealing with the relationships of grain sorghum characteristics and yield. During 1971 an attempt was made to pool the key results of the ten years work into one project undertaken in south Texas between April and July. The goals of this project were to (1) study the relationship between final weight of threshed grain and (a) diameter of stalk one inch below the sorghum head, (b) circumference of the sorghum head and (c) length of the sorghum head; (2) study the relationship between number of stalks early in the season and total emerged heads at harvest; and (3) study the combinations of the parameters above into a grain sorghum forecast model.

DATA COLLECTION

General

The research project was set up along the lines of any regular objective yield survey conducted by the Statistical Reporting Service; that is, an interview of the operator to determine land use, lay out of sample plots in fields, measurements on selected characteristics of grain sorghum during growing season, laboratory work conducted on pre-harvest cuttings, clipping at harvest, harvest laboratory work, and post harvest gleaning and interview. Procedural sections where the research was concentrated will be explained in greater detail.

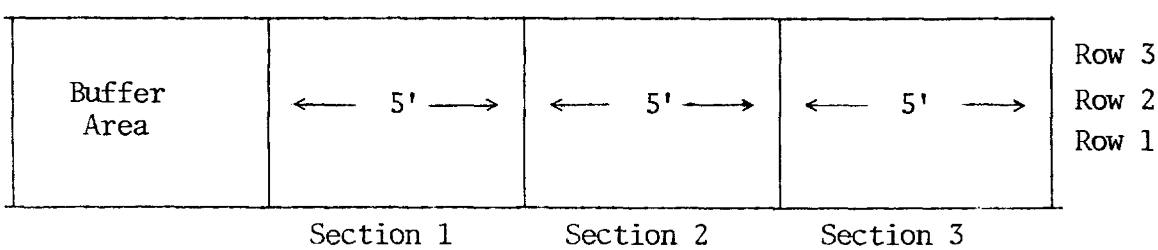
Interview Forms

Pre and post harvest interviews 1/ were conducted to determine amount of acreage intended for grain sorghum harvest and amount actually harvested. On the post harvest interview information on yield was collected. Further examples, and discussion of similar interviews can be found in corn, cotton, soybean and wheat objective yield survey manuals, USDA, SRS.

Field and Laboratory Work 2/

Twenty fields were selected from the 1970 June Enumerative Survey such that each field had a probability of selection proportional to its sorghum acreage. These fields were located within the triangle formed by San Antonio, Brownsville and Laredo. In each sample field, two units were selected, with each unit fifteen feet by three rows. Each unit was subdivided into five foot sections within each row. (figure 1)

Figure 1.--Sample unit layout design, Grain Sorghum, Texas, 1971



1/ All forms used in this project are in appendix A.
2/ Refer to appendix B for a detailed explanation of the procedures used for field and laboratory work.

Starting the last week in April each field was visited once a month until maturity. The different stages of maturity were defined as:

1. Head not emerged: At least 50 percent of the heads have not emerged inside of the unit or are not visible. A head is considered emerged if any spikelets can be seen through a split in the leaf sheaf or beyond the leaf.

2. Preflower: 50 percent or more of the heads have emerged, but no flowers have appeared yet on the head of the grain sorghum plant.

3. Flower: This stage will be very short. The head may appear to have a yellowish hue when the flower parts are showing.

4. 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.

5. Dough: The grains can be crushed between the thumb and fingernail, and contents of most of the grains are soft and can be kneaded like dough with only a few grains per head containing any milky liquid.

6. Mature: The grains readily part from the head and are likely to shake out of the glumes. The grain is firm and though it may be dented by pressure of the thumbnail, it is not easily crushed or if so breaks into fragments.

When the flower stage of maturity in a field was reached, observations were made on 2 sorghum plants in each 5 foot row section to measure length of head, circumference of head and diameter of stalk one inch below the head. The total number of stalks were counted in each section for maturity categories through the flower stage and the total number of emerged heads were counted from flower stage to maturity.

In addition a new clip section was designated each month for each unit adjacent to one of the two rows. Actual clipping of five sorghum heads began once the flower stage of maturity was reached and continued each month until harvest. The same measurements taken on the plants inside the unit were also taken on the five clipped heads. In addition, the weights of these five heads were obtained.

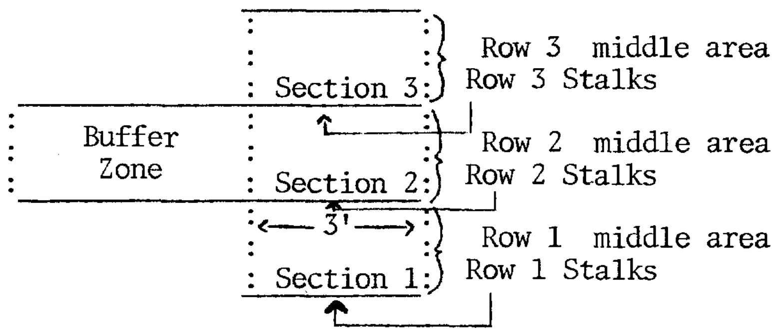
At maturity the 18 measurement heads in each unit were clipped and sent to the regional laboratory in Oklahoma City, Oklahoma. There the weight of head and weight of threshed grain were determined.

Post Harvest Gleaning

In order to estimate the amount of harvesting loss farm operators suffered, fields were revisited after harvesting was completed. For the most accurate results it was important that enumerators visit the harvested sample fields within one week after harvest.

The procedures for reaching the sample units were the same as for the regular survey. The only change in the layout was that the unit consisted of an area 3 feet by 3 rows (figure 2).

Figure 2.--Sample design for post harvest gleaning, Grain Sorghum, Texas, 1971



Within each section all heads, pieces of heads and loose grain within middle area were collected and placed in a bag to be weighed at the regional laboratory.

RESULTS

General

For this study data on five characteristics were collected for plants inside the plot and four characteristics for plants outside the plot prior to harvest. For plants inside the sample plot, three characteristics were studied in relation to weight of grain. These were: diameter of stalk one inch below sorghum head, length of sorghum head, and circumference of sorghum head. The other two characteristics: number of stalks and emerged heads, were studied for the purpose of estimating emerged heads at harvest. Immediately outside the unit the four characteristics studied were diameter of stalk one inch below sorghum head, length of sorghum head, circumference of sorghum head, and the weight of prematurely harvested heads in relation to weight of grain at harvest.

Within Plot Results

Weight of Grain Characteristics

The relationships between harvest weight of threshed grain and diameter of stalk one inch below the head, length of head, and circumference of head were all good (Table 1). The correlations for all maturity levels are significant at the .01 level ($\alpha = .01$). Looking at the three, circumference of head performs at a lower level then the other two, perhaps because of operational difficulties in wrapping the head with a cloth.

Table 1.--Coefficients of correlation of grain sorghum characteristics and threshed harvest weight per head by maturity category, Texas, 1971

Characteristics correlated to weight of threshed grain	Correlation Coefficient			
	MC 3 1/	MC 4	MC 5	MC 6
Diameter of stalk	.710	.741	.790	.747
Length of head	.743	.881	.746	.656
Circumference of head	.401	.855	.620	.530
Number of plants	162	36	378	360
$r_{.01}$	.205	.418	.132	.134

1/ MC defined as maturity category.

Plant Population Characteristics

Two characteristics were studied, the number of stalks in each unit and the number of emerged heads in each unit. The count of the number of stalks per unit was studied "through" the flower stage of maturity; the count of the number of emerged heads "started" at the flower stage and continued to maturity. The correlations between the number of stalks per unit and the number of emerged heads at harvest in the unit were significant at the .01 level for all months and maturity categories tested (Table 2). The number of emerged heads before harvest in the unit and the number of emerged heads at harvest in the unit were significantly correlated at the .01 level (Table 2). Neither number of stalks or emerged heads was significantly correlated with weight of grain at harvest.

Table 2.--Coefficients of correlation of grain sorghum characteristics and number of emerged heads at harvest, by month and maturity category, Texas, 1971

Number of emerged heads at harvest with	Correlation Coefficient			
	May	June		July
	MC 1 1/	MC 1	MC 3	MC 5
Number of stalks	.916	.834	.937	
Number of emerged heads prior to harvest			.891	.989
Number of units	35	10	8	14
$r_{.01}$	.449	.765	.834	.661

1/ MC defined as maturity category.

With such good results, it is possible to develop a model to forecast plant population from early season to harvest (MC 4 not computed due to insufficient data).

Outside of Plot Results

The concept here is to clip plants prior to maturity outside of the sample plot and use characteristic measurements from them to forecast yield average of sorghum heads within sample plot. All indications show that these estimates would prove unreliable unless the degree of measurement error can be determined. Measurement error means deviations from true values caused by using substitute plants. In this case weight measurements from plants adjacent to the sample plot were used as indicators of the situation within the plot.

The correlations between average characteristics measured prior to harvest from clippings outside the sample plot and average weight of grain per head inside the plot at harvest are shown in Table 3.

Table 3.--Correlations between characteristics outside of sample plot and average weight of grain per head inside plot at harvest

Outside measurement	Correlation coefficient	
	May	June
Average diameter	.29	.70 1/
Average length	.52 1/	.21
Average circumference	.23	.68 1/
Average preharvest weight	.52 1/	.60
Number of observations	22	9
$r_{.01}$ / $r_{.05}$	.53 / .42	.80 / .67

1/ Significant at α = .05.

Additional data from a 1970 survey shows that plants close together are better correlated than those more remote to each other. Plants next to each other at either end of a sample plot had correlations of .63 and .42 in two sets of data. Both are significant at α = .01. All correlations between plants at opposite ends of the 10 foot plots were not significantly correlated at α = .05.

The 1970 data supports the contention that distance is a prime factor in determining whether measurements on two plants are correlated significantly. The further apart the two plants the lower the correlation. This information prohibits the use of outside information effectively until more is determined about errors in measurement.

Sample plots in the 1971 survey can be broken into three 5 foot sections, representing different distances from the clippings outside of the sample plot (below). From data in the sub plots and clip area the degree of change in the correlations can be observed and an estimate of a correction factor (for measurement error) as a function of distance computed.

← 5' →	← 5' →	← 5' →	
Section One (1) $\hat{r}_{1c}$	Section Two (2) $\hat{r}_{2c}$	Section Three (3) $\hat{r}_{3c}$	Five Clipped Heads

Hypothesis: $\hat{r}_{ic} = f(d)$ where d is distance
i is section average length of head
c is clip area average length of head

Correlation results for June,

$\hat{r}_{1c}$ = .334

$\hat{r}_{2c}$ = .458

$\hat{r}_{3c}$ = .608

$\hat{r}_{c}$ = .520 (correlation using average of three sections)

These results cannot be taken as a proof of the hypothesis but are an indication that distance does play a role in similarity of plant characteristics. This similarity becomes more prominent the closer the plants are to each other. Also it seems highly probable that at some given distance the similarity between two sorghum heads is completely random, that is, $r \longrightarrow 0$ as $d \longrightarrow \infty$.

If measurement errors are found in the independent variable there is a method for correcting the regression coefficient 3/ (and the correlation coefficient).

3/ George W. Snedecor and William G. Cochran, Statistical Methods, Iowa St. Univ. Press, Ames, Sixth ed., 1967, p. 164.

$$\hat{b} = \frac{S_{xy}}{S^2_{\hat{x}}}$$ where $\hat{x}$ is average length of five clipped heads

y is average weight of grain in sub plot

$\hat{b}$ is regression coefficient with error

$$b = \frac{S_{xy}}{S^2_x}$$ where x is average length of heads in sub plots

let $S^2_x = S^2_{\hat{x}} - S^2_e$ and $\hat{x} = x + e$

where e is the measurement error with $N(0, \sigma^2_e)$

$$b - \hat{b} = \frac{S_{xy}}{S^2_x} - \frac{S_{xy}}{S^2_{\hat{x}}}$$

Substituting for S^2_x and combining terms gives

$$b - \hat{b} = \frac{S_{xy}}{S^2_{\hat{x}}} \left[\frac{(S^2_e)}{(S^2_{\hat{x}} - S^2_e)} \right]$$ let $$\frac{S^2_e}{S^2_{\hat{x}} - S^2_e} = \lambda$$

$$\therefore \quad b = \hat{b}\ (1 + \lambda)$$

Similarly for the true correlation coefficient, r, 4/

$$r = \hat{r}\ (1 + \lambda)^{1/2}$$

4/ Ronald A. Wood and Fred B. Warren, A Study of Sampling and Estimating Procedures for California Cling Peaches, U.S. Dept. of Agriculture, Statistical Reporting Service, January 1972.

An estimate for S_e^2 is found by breaking the variances down into their components. In this case, the component of variance to be found is the average between section variance (Tables 4-6).

Table 4.--Components of variance for average length of head within section one and the clipped heads outside of the unit, Texas Grain Sorghum, 1971

Source of Variation	Degrees of freedom	Mean Squares	Components of Variance
Between Fields	9	3.5377	0.4892
Between Units	10	1.5808	0.5690
Within Units (Section one and clip area)	20	0.4427	0.4427
Total	39	1.4487	

Table 5.--Components of variance for average length of head within section two and the clipped heads outside of the unit, Texas Grain Sorghum, 1971

Source of Variation	Degrees of freedom	Mean Squares	Components of Variance
Between Fields	10	4.2673	0.5518
Between Units	11	2.0601	0.8229
Within Units (Section two and clip area)	22	0.4144	0.4144
Total	43	1.7314	

Table 6.--Components of variance for average length of head within section three and the clipped heads outside of the unit, Texas Grain Sorghum, 1971

Source of Variation	Degrees of freedom	Mean Squares	Components of Variance
Between Fields	10	3.9160	0.3854
Between Units	11	2.3742	1.0278
Within Units (Section three and clip area)	22	0.3187	0.3187
Total	43	1.6811	

Using average length of heads from our survey data, the applicable variance components to be used for S_e^2 are:

$S_{e1}^2 = 0.4427$ for section 1 to clip section

$S_{e2}^2 = 0.4144$ for section 2 to clip section

$S_{e3}^2 = 0.3187$ for section 3 to clip section

where in a regression model the clip section is the independent variable, $S_{\hat{x}}^2 = 1.7933$

Section one --- $\lambda_1 = (.4427) / (1.7933 - 0.4427) = .3288$

Section two --- $\lambda_2 = (.4144) / (1.7933 - 0.4144) = .3005$

Section three --- $\lambda_3 = (.3187) / (1.7933 - 0.3187) = .2161$

Applying the lamda's to our unadjusted correlation coefficients on page 8 we can see the extent of the upward adjustment.

$r_{1c} = \hat{r}_{1c} (1 + \lambda_1)^{1/2} = .3846$ as compared to .3336

$r_{2c} = \hat{r}_{2c} (1 + \lambda_2)^{1/2} = .5232$ as compared to .4588

$r_{3c} = \hat{r}_{3c} (1 + \lambda_2)^{1/2} = .6710$ as compared to .6084

The number of observations for each of these was 22 (degrees of freedom = 20). To be significantly greater than zero at the .01 level (α = .01), r_{ic} must = .537; at α = .05, r_{ic} must = .423. Therefore, the subplot measurements closest to the clip sections were significantly correlated at α = .01 and the middle subplot to the clip sections at α = .05. The results are encouraging in that part of the measurement error is identified as being a function of distance. If care is used in selecting sample plants, the correction can be kept to a minimum or the measurement error determined and the estimates adjusted.

The next question is: "What variables should be used?" It would seem to increase the standard error unnecessarily if any characteristic measurements are taken outside the unit that could be taken inside the sample unit. That is, the only reason for moving outside the unit or to different plants would be because the characteristic measurement desired requires destructive sampling. This would be the case in weight of head prior to maturity.

In order to obtain a correction factor for weight of head a special survey would be necessary in which the subplots would also be destroyed prior to harvest to obtain average head weight for computation of the respective variance components (this year no measure of the head weight variance component was available).

GRAIN SORGHUM MODEL

The proposed model to follow makes use of the information in this report. Regression coefficients for each grain sorghum state would have to be computed independently; for this reason only a general model is discussed (parameters computed for Texas tables 7 and 8). The model developed here only carries forward to a point which would parallel other objective yield models; that is, to weight of grain per acre.

The model has two distinct parts: first, a plant population estimate for the sample plot; and second, an average weight of grain per plant estimate.

I. Plant Population Model for the Sample Plot

Maturity Category 1

$$Y_p = \alpha_o + \beta_1 x_1 + \beta_2 x_2$$

Y_p - forecast number of heads in plot at maturity

x_1 - number of stalks

x_2 - historical average of number of stalks obtained from crop reporting records kept by the Statistical Reporting Service. These records would come from previous years surveys once the objective yield program started.

Maturity Category 2

Same as mc 1

Maturity Category 3

Three Possibilities

a. $Y_p = \alpha_o + \beta_1 x_1$

b. $Y_p = \alpha_o + \beta_3 x_3$

c. $Y_p = \alpha_o + \beta_1 x_1 + \beta_3 x_3$

x_3 - the number of emerged heads

The choice of which of the three equations to use would depend upon previous survey correlation results.

Maturity Category 4

$Y_p = \alpha_o + \beta_3 x_3$

Maturity Category 5

Same as mc 4

II. Weight of Grain Per Head Model

Maturity Category 1 and 2

Y_w = historic average weight of grain per head

Maturity Category 3, 4, and 5

$Y_w = \alpha_o + \beta_1 x_1 + \beta_2 x_2 + \hat{\gamma}_1 z_1$

x_1 - average length of heads inside unit prior to harvest

x_2 - average diameter of stalk inside unit prior to harvest

z_1 - average weight of grain per plant from clip area prior to harvest

Some further explanation is necessary at this point. The computation of our regression coefficients entails errors in measurements. If we assume that the x_i variables inside the unit are independent of the z variable outside the unit then no effect upon the β's will occur. That is, $\hat{\gamma}_1$ will be the only coefficient corrected $\hat{\gamma}_1(1 + \lambda) = \gamma$.

This naive assumption should be put aside and it must be realized that some multicollinearity does exist; that is, the x's and z are not independent. The process of determining the β's and γ is now more complicated. A method to be used can be shown through the use of a 2 x 2 example 5/

$$Y = \beta_1 x_1 + \beta_2 \hat{z}_1$$

where $\hat{z}$ has measurement error.

In matrix notation

$$x = \begin{bmatrix} x_{11} & z_{11} \\ \vdots & \vdots \\ x_{1n} & z_{1n} \end{bmatrix} \qquad y = \begin{bmatrix} y_1 \\ \vdots \\ y_n \end{bmatrix}$$

$$\hat{\beta} = [x'x]^{-1} x'y$$

$$x'x = \begin{bmatrix} S_{x_1}^2 & S_{x_1 z_1} \\ S_{z_1 x_1} & S_{z_1}^2 - S_e^2 \end{bmatrix}$$

Let $A = S_{z_1}^2 - S_e^2$

$$B = S_{x_1}^2 (S_{z_1}^2 - S_e^2) - S_{x_1 z_1}^2$$

where S_e^2 is the appropriate component of variance

$$[x'x]^{-1} = \begin{bmatrix} \frac{A}{B} & -\frac{S_{x_1 z_1}}{B} \\ -\frac{S_{x_1 z_1}}{B} & \frac{S_{x_1}^2}{B} \end{bmatrix}$$

5/ This can be applied to a 3 x 3 model.

$$\begin{bmatrix} \hat{\beta}_1 \\ \hat{\beta}_2 \end{bmatrix} = \begin{bmatrix} \frac{A\, S_{x_1y}}{B} - \frac{S_{x_1z_1}\, S_{z_1y}}{B} \\ -\frac{S_{x_1z_1}\, S_{x_1y}}{B} + \frac{S^2_{x_1}\, S_{z_1y}}{B} \end{bmatrix}$$

The simple 2 x 2 shows that measurement error correction factor will filter through the entire system when the independent variables are not independent of one another.

From this point the plant population and weight of grain models are brought together to get a yield per acre which is where present objective yield models suffice to complete the grain sorghum model.

Table 7.--Regression analyses by maturity category, for weight of grain per head models, Texas Grain Sorghum, June 1, 1971

b	MC-3 1/		MC-5	
	Regression Coefficient	Standard Error	Regression Coefficient	Standard Error
Length of Head 2/	5.079	1.611	2.515	1.121
Diameter of Stalk 2/	-16.362	76.903	123.902	69.708
Weight of Clipped Head	- 0.359	0.605	0.174	0.211
Intercept	-15.744		- 27.701	
R	.819		.791	
Number of Observations	8		14	

1/ Maturity Category.
2/ Computed using average of six heads in section three. This is a rough estimate of the population parameter β.

Table 8.--Regression analyses by maturity category for plant population of plot models, Texas Grain Sorghum, June 1, 1971

b	MC-3		MC-5	
	Regression Coefficient	Standard Error	Regression Coefficient	Standard Error
Number of Stalks	0.510	0.174		
Number of Emerged Heads	0.402	0.232	1.122	0.048
Intercept	32.545		-19.326	
R	.955		.989	
Number of Observations	8		14	

OPTIMUM SAMPLE DESIGN

Three separate optimum within field sample designs were computed using three variables:

1. Number of stalks per row section.
2. Length of head per plant.
3. Diameter of stalk per plant.

The costs were computed in terms of time from the field forms used (table 7).

C_1 = time to travel between fields.

C_2 = time to travel between units and layout stakes at unit corners.

C_3 = time to travel between rows.

C_4 1/ = time to travel between sections.

C_5 = time to perform measurements on plants.

1/ For number of stalks this is the lowest level and represents the time to count all the stalks in each section.

Table 9.--Cost at each level of sampling in terms of time (minutes), Texas, 1971

Characteristics	Cost (minutes)				
	Field	Unit	Row	Section	Plant
Number of Stalks. . . .	60	10	.50	.64	
Diameter of Stalks. . .	60	10	.50	.50	.42
Length of Head.	60	10	.50	.50	.35

The variance components used in the optimum design are shown in Table 8.

Table 10.--Variance components for the respective levels of sampling, Texas, June 1971

Level of Sampling	Characteristic		
	Number of Stalks 1/	Diameter of Stalks	Length of Head
Between Fields (S_1^2)	62.55	.0002	.40
Between Units (S_2^2)	18.06	.0001	.62
Between Rows (S_3^2)	9.98	.0004	.33
Between Sections (S_4^2)	24.18	.0005	.22
Between Plants (S_5^2)		.0028	1.91

1/ Data used was May 1 for number of stalks per section.

The optimum allocation results for each of the three characteristics studied in algebraic terms are:

	Number of Stalks	Diameter of Stalk	Length of Head
$n_5 = \sqrt{\frac{C_4}{C_5} \frac{S_5^2}{S_4^2}}$		2.67	3.55
$n_4 = \sqrt{\frac{C_3}{C_4} \frac{S_4^2}{S_3^2}}$	1.37	1.04	.81
$n_3 = \sqrt{\frac{C_2}{C_3} \frac{S_3^2}{S_2^2}}$	3.32	8.32	3.27
$n_2 = \sqrt{\frac{C_1}{C_2} \frac{S_2^2}{S_1^2}}$	1.32	1.86	3.07

where: n_5 = number of plants per section

n_4 = number of sections per row

n_3 = number of rows per unit

n_2 = number of units per field

n_1 = number of fields (this value would be computed for a given variance or cost).

The optimum integer solution from these results is two units by three rows by one section. The number of plants per row section is three.

APPENDIX A

Forms

Forms used for 1971 Texas Grain Sorghum project:

1.	Form A	:	Interview Form
2.	Form B	:	Field Observations
3.	Form C-1	:	Immature Lab Samples
4.	Form C-2	:	Mature Lab Samples
5.	Form D	:	Post-Harvest Interview
6.	Form E	:	Post-Harvest Observations

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

O. M. B. Number 40-571019
Approval Expires 12/31/71

FORM A: INTERVIEW FORM

– Grain Sorghum –

Last year a representative from our office obtained some information about your farming operation. At that time, you stated that you had one or more fields planted to grain sorghum. Now, as part of a small research project, we are contacting a few operators who reported grain sorghum last year. Do you have grain sorghum planted this year inside these tract boundaries? Yes ☐ No ☐

We would like information about your crop and permission to lay out small plots and make monthly counts in one of your fields. Will this be all right? Yes ☐ No ☐

Crop Code	191
State	74
Segment No.	
Sample No.	
Date ( )	
Starting Time ( )	

1. Can you show me the location of your grain sorghum fields on this map?
   a. *Outline all fields on itek photo and number.*
   b. *List the acreage for each field below and accumulate.*

Field No. (a)	Acres in Field (b)	Acres Planted to Grain Sorghum (c)	Acres Plowed, Abandoned, etc. (d)	Acres Not Intended For Grain (e)	Net Acres To Be Harvested For Grain (f)	ACCUMULATED Net Acres To Be Harvested For Grain (g)
1	.	.	.	.	.	.
2	.	.	.	.	.	.
3	.	.	.	.	.	.
4	.	.	.	.	.	.
5	.	.	.	.	.	.
6	.	.	.	.	.	.
7	.	.	.	.	.	.
		.			.	

2. Then this makes a total of ________ acres planted to grain sorghum and ________ acres intended to be harvested for grain. Is that right? Yes ☐ No ☐

   a. *If no sorghum is to be harvested for grain,* **conclude the interview.**

   b. *If only one grain sorghum field is inside the tract boundary, it becomes the sample field.*

   c. *If* **more than one** *field is in the tract, select a random number between "1" and the total acres to be harvested. The field containing the selected acre becomes the sample field.*

   Selected Sample Acre(s) ________ ________

3. The following questions pertain only to the selected sample field.

   a. On what date was this field planted? ...... (________________) ☐

   b. What variety of grain sorghum is planted in this field? (________________) ☐

   c. Is or will this field be irrigated? Yes ☐ No ☐ ☐

   d. What is the probable date of harvest? ...... (________________) ☐

   Copy probable date of harvest to kit envelope. ☐

   Copy net acres for harvest for sample field to post-harvest form. ☐

Ending Time (________). ☐

Enumerator ________________________

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FORM B: FIELD OBSERVATIONS
– Grain Sorghum –

Crop Code..........	1 9 2 —
State	7 4
Segment No.	
Sample No.	
Unit No.	
Date (__________)	

Survey Period:

May 1 .... ☐

June 1......... ☐

July 1 .... ☐

Pre-Harv........ ☐

1. **Unit Location:** *(first visit only)* Acres in Sample Field ________

Number of rows along edge.... ☐

Number of paces into field.... ☐

Beginning Time: (At starting corner)... ☐

Arrival at Unit Time.. ☐

2. **Lay out the sample unit:** *(first visit only.)*

3. Measure the distance across four (4) row spaces (feet and tenths) *(first visit only)* .... ☐

Time Completed *(first visit only)*...... ☐

4. **Determine stage of maturity for unit:** *(Circle one)*

Head Not Emerged	Pre-Flower	Flower	Milk	Dough	Mature	
1	2	3	4	5	6	

If unit is in Maturity Codes 1 through 3, continue.
If Maturity Code is 4 through 6, skip to Item 6.

5. Count and record the number of stalks in each section.

	Number of Stalks		
	Section 1	Section 2	Section 3
Row 3			
Row 2			
Row 1			

Time Completed...... ☐

6. Count and record the number of emerged heads in each section.

	Number of Emerged Heads		
	Section 1	Section 2	Section 3
Row 3			
Row 2			
Row 1			

Time Completed...... ☐

Over

Form B (Continued)

If Maturity Codes 1 or 2, skip to Item 9.

7. **Tagged Plants INSIDE Count Sections:**

a. Randomly select 2 heads in each count section. Identify and record the selected head with the corresponding sample head number indicated below.

	Section 1		Section 2		Section 3	
Row 3	13	14	15	16	17	18
Row 2	7	8	9	10	11	12
Row 1	1	2	3	4	5	6

Time Completed...... [ ]

b. For the tagged plants, measure the diameter of stalks in each section.

	(Inches – nearest 1/16)					
	Section 1		Section 2		Section 3	
Row 3	13 .	14 .	15 .	16 .	17 .	18 .
Row 2	7 .	8 .	9 .	10 .	11 .	12 .
Row 1	1 .	2 .	3 .	4 .	5 .	6 .

Time Completed...... [ ]

c. For tagged plants, measure the length of the heads in all sections.

	(Inches – nearest 1/8)					
	Section 1		Section 2		Section 3	
Row 3	13 .	14 .	15 .	16 .	17 .	18 .
Row 2	7 .	8 .	9 .	10 .	11 .	12 .
Row 1	1 .	2 .	3 .	4 .	5 .	6 .

Time Completed...... [ ]

d. For tagged plants, measure circumference of heads in all sections.

	(Inches – nearest 1/8)					
	Section 1		Section 2		Section 3	
Row 3	13 .	14 .	15 .	16 .	17 .	18 .
Row 2	7 .	8 .	9 .	10 .	11 .	12 .
Row 1	1 .	2 .	3 .	4 .	5 .	6 .

Time Completed...... [ ]

If unit is in Code 3, 4, or 5, skip to Item 8.

e. If unit is mature (Code 6), clip each of the tagged heads and place each in a separate paper bag for shipment to laboratory at Oklahoma City. Time Completed...... [ ]

If unit is mature (Code 6), skip to Item 9.

8. **Counts Made OUTSIDE Count Section:**

a. Locate and tag the 6th through 10th heads **OUTSIDE** the unit in the pre-designated row.

	Heads OUTSIDE Count Section (Inches)				
	6th	7th	8th	9th	10th
b. Diameter of Stalk	.	.	.	.	.
c. Length of head	.	.	.	.	.
d. Circumference of head ..	.	.	.	.	.

e. Clip each head and place in a separate paper bag for shipment to laboratory in Austin Texas. Time Completed...... [ ]

9. *FIRST VISIT ONLY*. Measure the distance (in feet and tenths) from the unit (number of feet out of and along edge of field) to the starting corner.

	Feet
Distance into field..................	.
Distance along edge	.

Time arrived back at starting corner.... [ ]

Enumerator ______________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICIAL REPORTING SERVICE

O. M. B. NUMBER 40-S71019
APPROVAL EXPIRES 12/31/71

FORM C-1 SORGHUM
Immature Lab Samples

Survey Period

May 1 ( )
June 1 ( )
July 1 ( )

Crop Code	193_
State	74
Segment No.	
Sample No.	
Unit No.	
Date (_______)	

Starting Time [ ]

1. Diameter of Stalks (inches to nearest 1/16).

6th Head	7th Head	8th Head	9th Head	10th Head
.	.	.	.	.

Time Completed [ ]

2. Length of Heads (inches to nearest 1/8).

6th Head	7th Head	8th Head	9th Head	10th Head
.	.	.	.	.

Time Completed [ ]

3. Circumference of Heads (inches to nearest 1/8).

6th Head	7th Head	8th Head	9th Head	10th Head
.	.	.	.	.

Time Completed [ ]

4. Clip Stalks and weigh Heads (grams to nearest 1/10).

6th Head	7th Head	8th Head	9th Head	10th Head
.	.	.	.	.

Time Completed [ ]

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICIAL REPORTING SERVICE

O. M. B. NUMBER 40-S71019
APPROVAL EXPIRES 12/31/71

FORM C-2 SORGHUM
Mature Lab Sample

Crop Code	194_
State	74
Segment No.	
Unit Code	
Date (_______)	

Starting Time	

1. Measure Diameter of Stalks

(Inches - Nearest 1/16)

	Section 1		Section 2		Section 3	
Row 3	13 .	14 .	15 .	16 .	17 .	18 .
Row 2	7 .	8 .	9 .	10 .	11 .	12 .
Row 1	1 .	2 .	3 .	4 .	5 .	6 .

Time Completed	

2. Measure Length of Heads

(Inches - Nearest 1/8)

	Section 1		Section 2		Section 3	
Row 3	13 .	14 .	15 .	16 .	17 .	18 .
Row 2	7 .	8 .	9 .	10 .	11 .	12 .
Row 1	1 .	2 .	3 .	4 .	5 .	6 .

Time Completed	

Form C-2

3. Measure Circumference of Heads

(Inches - Nearest 1/8)

	Section 1		Section 2		Section 3	
Row 3	13 .	14 .	15 .	16 .	17 .	18 .
Row 2	7 .	8 .	9 .	10 .	11 .	12 .
Row 1	1 .	2 .	3 .	4 .	5 .	6 .

Time Completed [ ]

4. Clip Stalks and Weigh Individual Heads

(Grams - Nearest 1/10)

	Section 1		Section 2		Section 3	
Row 3	13 .	14 .	15 .	16 .	17 .	18 .
Row 2	7 .	8 .	9 .	10 .	11 .	12 .
Row 1	1 .	2 .	3 .	4 .	5 .	6 .

Time Completed [ ]

5. Weight of Threshed grain

(Grams - Nearest 1/10)

	Section 1		Section 2		Section 3	
Row 3	13 .	14 .	15 .	16 .	17 .	18 .
Row 2	7 .	8 .	9 .	10 .	11 .	12 .
Row 1	1 .	2 .	3 .	4 .	5 .	6 .

Time Completed [ ]

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

O. M. B. Number 40-S71019
Approval Expires 12/31/71

FORM D: POST-HARVEST INTERVIEW
– Grain Sorghum –

Earlier this year, I (or a representative from our office) contacted you and made some counts and head measurements on small units in one of your sorghum fields. I would like to know how **your crop** turned out in this field.

Crop Code.......	1 9 5 —
State	7 4
Segment No.	
Sample No.	
Date (________)	

1. **Enter from Form A:** **Interview Starting Time:** [ ]

   Sample field number (________) Acres for grain (________)

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

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

   DO NOT CHANGE ITEM 1.

3. The information I recorded earlier shows that (Item 1)________ acres probably would be harvested for grain. Could you tell me why there is a difference, so I can adjust my records?

   ____

   ____

4. How many **CWT.** were **harvested** from these (Item 2)________ acres?...**Total CWT.** [ ]

   If operator indicates yield per acre, multiply by acres in Item 2 to determine total CWT.

5. How many **CWT.** do you still **expect to harvest** from this field? .... **Total CWT.** [ ]

6. Then the **total CWT. harvested** (or expected) for this field is (4 + 5) .... **Total CWT.** (________)

7. On what **date,** was or will **harvest** be **completed** on this field? ____________ [ ]

8. Have any **livestock grazed** on this field since harvest or has it been **tilled** in any manner?

   NO ☐

   YES ☐ – *Select an alternate sorghum for grain field if available in the tract that has not been grazed or tilled.*

Time completed: [ ]

Enumerator ________________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

O. M. B. Number 40-S71019
Approval Expires 12/31/71

FORM E: POST-HARVEST OBSERVATIONS
– Grain Sorghum –

The post-harvest field gleanings should be completed as soon after harvest as possible, preferably within one week 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.

Crop Corn...	1 9 6 —
State	7 4
Segment No. .	
Sample No...	
Date (_____)	

Enumerator ________________________

	UNIT 1	UNIT 2
UNIT LOCATION Starting Time		
Number of rows along edge of field....		
Number of paces into field..............		
1. (a) Distance across 1 row space........ **Feet & Tenths**	.	.
(b) Distance across 3 row spaces....... **Feet & Tenths**	.	.

GLEANING 3 FOOT SECTIONS *Check each box as completed.* SECTION	1	2	3	4	1	2	3	4
2. Pick up all heads attached to stalks in each section and deposit in bag.....	( )	( )	( )	( )	( )	( )	( )	( )
3. Pick up all heads and pieces of heads in each middle and deposit in bag......	( )	( )	( )	( )	( )	( )	( )	( )
4. Pick up all loose grain in each middle and deposit in bag................	( )	( )	( )	( )	( )	( )	( )	( )
Ending Time								

5. Was an alternate field used for making post-harvest observation? YES ☐ NO ☐

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

____

____

POST-HARVEST LABORATORY DETERMINATIONS

Starting Time ☐

Thresh all grain from each bag **separately** and weigh. Enter weight in grams and tenths of grams.

Section	1	2	3	4
Unit 1	.	.	.	.
Unit 2	.	.	.	.

Ending Time ☐

APPENDIX B

Field and Laboratory Procedures

Unit Layout

The point of entry into the field was the first corner of the field reached when approaching the field. If the field had no definite corners, the field was entered from the point most accessible by car. If the field was selected for more than one sample, the second closest corner was used as the starting corner for the second sample number.

Total acres in the sample field were copied from Form A to Form B. A table of Unit Locations was supplied. The table was set up for four different field size as indicated at the top of the table. To determine which column was used reference was made to the acres in the sample field. The first unit locations to be used in each column were checked in red. Unit locations were shown for both unit 1 and unit 2. These numbers were entered on the B Form.

The beginning time was recorded when the enumerator left his car.

Unit 1 and Unit 2 were located independently of each other. The starting rows for Unit 1 and for Unit 2 were given on the line reading "Number of rows along edge of field". The line reading "Number of paces into field" gives the number of paces walked into the field before laying down the dowel stick to define the unit location. Unit 1 was always laid out before Unit 2, even though in many instances Unit 2 was closer to the point of entry into the field. The steps for locating sample plots were:

Step 1:

The starting corner was marked so it was clearly visible on later visits. A piece of plastic flagging ribbon was tied to a fence or some nearby object or a large stake was driven in the ground and ribbon attached.

Step 2:

The enumerator walked along the end of the crop rows. The number of crop rows indicated for Unit 1 were counted. This was Row 1 of Unit 1; the next row further away from the starting corner was Row 2 of Unit 1. A piece of flagging ribbon was tied onto the first stalk in Row 1. This helped define the same row on subsequent visits to the sample field.

Step 3:

The required number of paces were walked into the field along the middle between Row 1 and Row 2. The first pace was started about one and a half feet in front of the plowed end of Row 1. This starting point applied even if plants were not growing to the plowed end of Row 1.

Step 4:

After having taken the last of the required paces, the dowel stick was laid down so that it touched the toe of the enumerators shoe. The dowel stick was laid down across Row 1 and Row 2, and at right angles to the direction of the rows.

The time of arrival at unit was recorded. At the time of the first visit this time was after the enumerator reached the unit and laid the dowel down. On the other visits it was the time the enumerator reached the unit indicated.

The following steps indicate how each one of the units was to be laid out after reaching the location.

Step 1:

The zero end of the 50 ft. steel tapes was anchored just beyond the dowel stick and directly along side the plants in Row 1. The zero end of the tape was anchored firmly and close to the ground so it would not move when the measurements were being made. The sample number was marked on a florist stake and inserted at the anchor point.

Step 2:

A "starting" florist stake was inserted which identified "U1 S1" for Unit 1 and Section 1 exactly at the 5 foot mark. Next stakes were inserted exactly at the 10, 15 and 20 foot marks. These stakes were placed straight up and down with the flat side at right angles to the row direction and as close to the center of plants in Row 1 as possible. Stakes inserted at the 10 and 15 foot marks were labeled as "U1 S2" and "U1 S3".

Step 3:

The 50 foot tape was anchored just beyond the dowel stick and directly along side the plants in Row 2.

Step 4:

For Row 2 a "starting" florist stake was inserted at the 5 foot mark and stakes at the 10, 15 and 20 foot marks. The starting florist stake was marked as follows: "U1 S4" for Unit 1 and Section 4 identification. Also, stakes were identified at the 10 and 15 foot marks as "U1 S5" and "U1 S6".

Step 5:

For Row 3, the dowel stick was slid straight across so it laid across rows two and three. The 50 foot tape was just anchored beyond the dowel stick and directly along side the plants in Row 3. No florist stake was placed by anchor for Row 3.

Step 6:

For Row 3, a "starting" florist stake was inserted at the 5 foot mark and stakes at the 10, 15 and 20 foot marks. The starting florist stake were marked as follows "U1 - S7" for Unit 1 and Section 7 identification. Also stakes were labeled at the 10 and 15 foot marks as "U1 S8" and "U1 S9".

Step 7:

A 2 foot piece of flagging ribbon was tied near the top of the first plant included in the unit for each section. Rule 1 was used at the starting stake for each count section in each row.

Rule 1: If a plant emerges from the ground exactly at the starting stake, include that plant in the section. Include the entire hill if any plant in a hill is included at the starting stake.

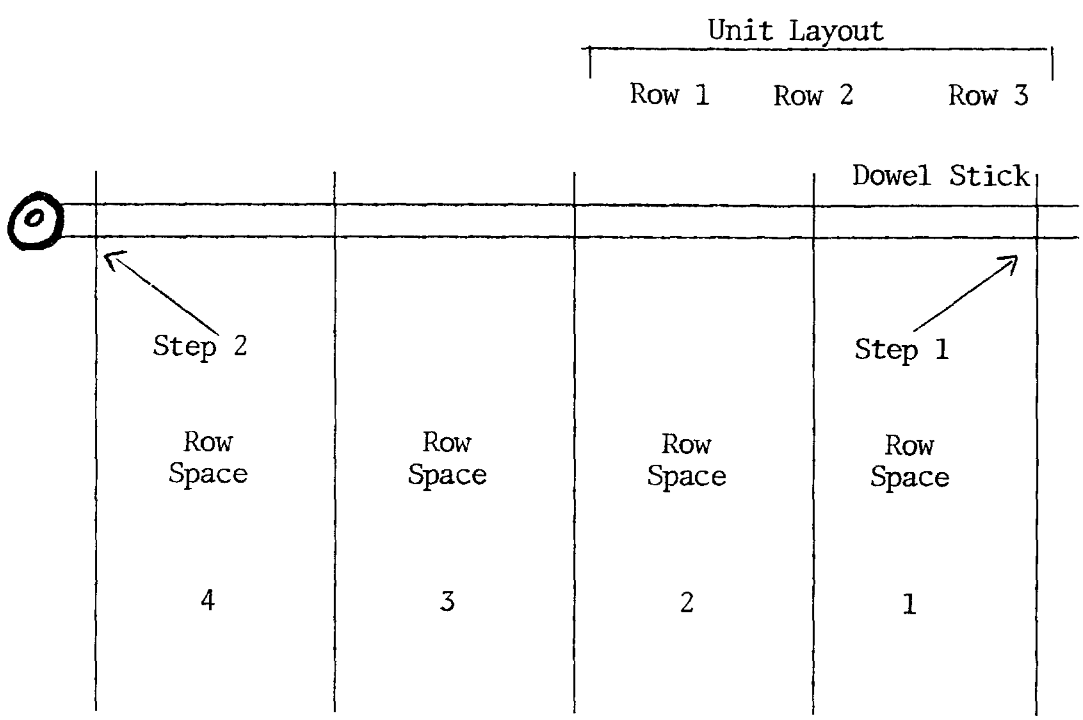
Step 8:

A 2 foot piece of flagging ribbon was tied near the top of the last plant inside the unit for each section. Rule 2 was used at the ending stake in each section.

Rule 2: If a plant emerges from the ground exactly at the ending stake, exclude that plant from the count section. Exclude the entire hill if any plant in a hill is excluded at the ending stake.

Field Observations

Each month measurements were made and counts taken in the sample plot and on the plants. What follows is the procedure for each of these observations. First the distance across four row spaces was measured at the point where the dowel stick crosses the rows. The 50 foot tape was anchored in the center of row 3 and stretched back across row 2 and row 1 plus two more rows which lie outside the unit.



The stage of maturity was recorded. The maturity levels are defined below.

1. Head not emerged: If at least 50 percent of the heads were not emerged inside of the unit or were not visible code 1. A head was considered emerged if any spikelets could be seen through a split in the leaf sheaf or beyond the leaf.

2. Preflower: At this time 50 percent or more of the heads have emerged but no flowers have appeared yet on head of the grain sorghum plant.

3. Flower: This stage will be very short. At the time it is in flower, the head may appear to have a yellowish hue when the flower parts are showing.

4. 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.

5. Dough: The grains can be crushed between the thumb and fingernail, the contents of most of the grains are soft and can be kneaded like dough with only a few grains per head containing any milky liquid.

6. Mature: The grains readily part from the head and are likely to shake out of the glumes. The grain is firm and though it may be dented by pressure of the thumbnail, it is not easily crushed or if so breaks into fragments.

At this point two roads could be taken, if maturity level 4 through 6 was attained the next item was skipped, if not, the number of stalks in each section was recorded.

The number of stalks in each 5-foot row section was counted. All stalks were counted inside the section, regardless of size or condition.

Any stalks growing in the row space between Row 1 and Row 2 were included in the count for Row 1. Likewise, stalks between Row 2 and Row 3 were included in the count for Row 2 and Row 3.

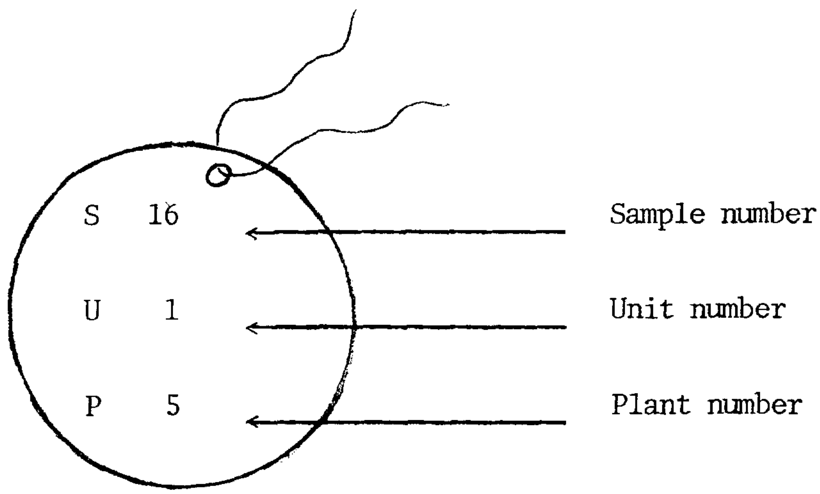
The number of emerged heads in each section were counted. These were to be counts of all heads attached to stalks which emerge within the count section. A head was counted as an emerged head if any spikelets could be seen through a split in the sheaf leaf or beyond the leaf.

The next two items were enumerated only if in maturity stages 3 through 6.

The five parts of item 7 refer only to the two tagged plants in each section. These plants were selected as follows.

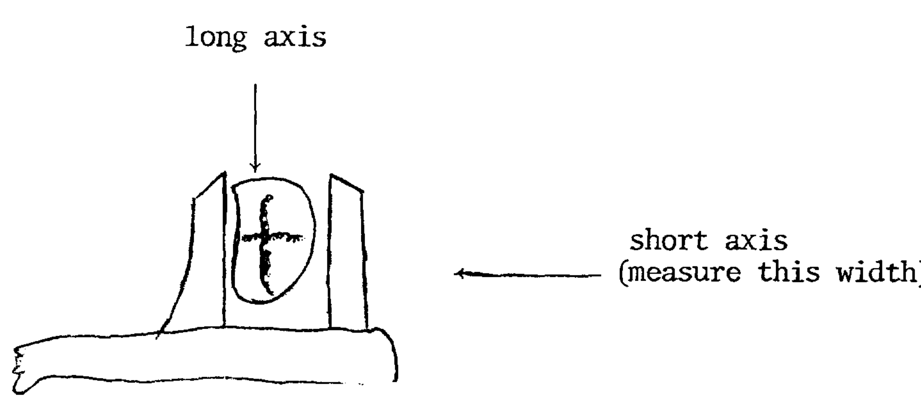
a. Using the item 6 count of emerged heads for each section, two heads were randomly selected.

   Each head in a section was assigned a number and two numbers were selected from a random table of numbers. Each of the selected heads was tagged with an ID tag so it could be easily found on later visits.



b. The first part was to measure the diameter of stalks for the tagged plants in each section.

   The diameter of the stalk was measured for each tagged plant at a point 1 inch below the head of the plant. The stalk usually was not round so the stalk was measured across the shortest axis as shown below.



c. Measurements of the length of heads on tagged plants in all sections were made.

The length of the head for each tagged plant was measured from the point of attachment of the lowest fruiting branch to the top of the tallest fruiting branch. Some of the lower branches on the head may have had no fruit on them or may have been missing entirely.

d. For tagged plants, the circumference of the heads were measured in all sections.

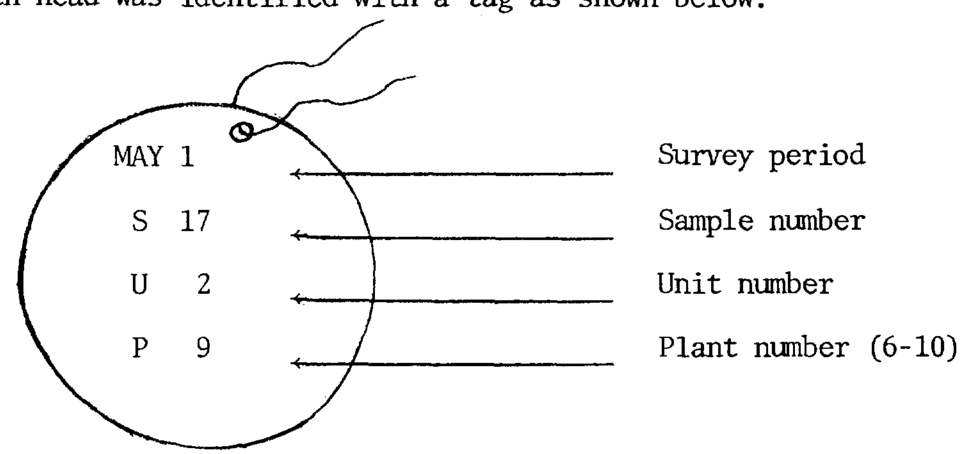
A wrap around cloth with a cloth measuring tape was used. The cloth was wrapped around the head of the plant so the tape would measure the head at the largest point. The cloth was wrapped tight enough so the branches were pulled up into a compact group. The circumference of the head was then read directly from the cloth tape wrapped around the outside.

e. If units were mature (code 6), each of the tagged heads was clipped.

If the maturity code was 3-5, counts were made outside of the sample plots.

The 6th through 10th heads outside the plot in a pre-designated row were located and tagged.

Each head was identified with a tag as shown below.



After the heads were properly tagged, measurements were made on each head. Measurements on the diameter of stalk, length of head and circumference of head were made the same as indicated above for the tagged plants inside the count unit.

When all the measurements were made and recorded, each head was clipped 4 inches below the head. These were placed in separate paper bags along with the ID tag and secured with a rubber band. These heads were sent to the State laboratory. The ending time was recorded after both plots were completed and the enumerator had returned to his car.

Laboratory Procedures

Form C-1

Each month of the survey prior to maturity, five heads were clipped outside each plot. These samples were sent to the SSO in Austin, Texas. In Austin four measurements were made on the heads.

1. Diameter of each stalk to the nearest 1/32" was measured.
2. Length of each head to the nearest 1/8" was measured.
3. The circumference of each head to the nearest 1/8" was measured.
4. The weight of each head (stalk clipped) to the nearest 1/10 of a gram was recorded. These values were used to compare the homogenity of the sample fields; i.e. does each stalk behave in the same way.

Form C-2

At harvest the sample plots are clipped and the heads (with a small portion of the stalk left attached) were sent to the regional laboratory in Oklahoma City, Oklahoma. At this point five measurements are made on the heads.

1. Diameter of each stalk to the nearest 1/32" was recorded.
2. Length of each head to the nearest 1/8" was recorded.
3. The circumference of each head to the nearest 1/8" was recorded.

4. The weight of each head (stalk clipped) to the nearest 1/10 of a gram was recorded.

5. Each head was threshed and the weight to the nearest 1/10 of a gram was recorded.

These figures then are used for correlations with early season figures.