United States Department of Agriculture

Statistical Reporting Service

Statistical Research Division

SRS Staff Report Number YRB-85-03

June 1985

1983 Sunflower Objective Yield Survey Research

Douglas C. Bond

1983 SUNFLOWER OBJECTIVE YIELD SURVEY RESEARCH. By Douglas C. Bond, Statistical Research Division, Statistical Reporting Service, Department of Agriculture, Washington, D.C. 20250. June 1985. Staff Report No. YRB-85-03.

ABSTRACT

The Statistical Reporting Service (SRS), U.S. Department of Agriculture, studied objective yield survey methods for forecasting and estimating North Dakota oilseed sunflower yield and acreage for a third year in 1983. The 1983 survey estimated at-harvest yield of 1,342 lb per acre, 29-percent above SRS's official Crop Reporting Board (CRB) figure of 1,040 lb per acre. Survey models for forecasting heads per acre had R^2 values of 0.91 to 0.97; however, models for forecasting weight of filled seeds per head had R^2 values of only 0.14 to 0.36. Harvested acreage estimates, based on early-season and end-of-season interviews of farmers, were 1.86 and 1.88 million acres, 15.3 and 14.6-percent lower than the CRB's 2.2 million acres. Research indicated that accurate at-harvest estimates of net yield may be attained if objective yield procedures are altered and carefully followed, and that combine-harvested yield may include substantial amounts of blank and broken seeds and trash. The CRB should precisely define "sunflower yield," including levels of blank and broken seeds and trash. This report recommends changes in survey methods and additional research.

ACKNOWLEDGMENTS

Dick Coulter and Larry Beard of the North Dakota State Statistical Office and the North Dakota enumerators collected and edited data for the 1983 survey and helped collect research data. Dr. A. A. Schneiter, Agronomy Department, North Dakota State University, made suggestions and ensured that the research project was correctly conducted. Bessie Johnson of SRS's Yield Research Branch, Washington, D.C., typed this report.

Washington, D.C. 20250 June 1985

CONTENTS

SUMMARY AND RECOMMENDATIONS

In 1983, for the third year, the Statistical Reporting Service (SRS), U.S. Department of Agriculture, conducted an objective yield (OY) survey for North Dakota oilseed sunflower. The purposes were to develop early-season yield forecasting models, estimate net yield at harvest, and estimate harvested acreage. Also, SRS's Yield Research Branch investigated whether net yield estimated by OY methods is comparable with combine-harvested yield. These efforts found:

(1) The OY survey estimated at-harvest net yield of 1,342 lb per acre, 29-percent more than the estimate published by SRS's Crop Reporting Board (CRB) of 1,040 lb per acre.

(2) Acceptable models (R^2 values of 0.91 to 0.97) were developed for forecasting one yield component - heads per acre.

(3) No good model was found for forecasting yield, because the models developed for forecasting weight of filled seeds per head (the other yield component besides heads per acre) had unacceptably low R^2 values (0.14 to 0.36).

(4) Some data collected for forecasting were not actually useful for forecasting.

(5) Estimates of harvested acreage, based on early-season and end-of-season interviews of farmers, were 1.86 and 1.88 million acres, respectively, 15.3 and 14.6-percent lower than the CRB's estimate of 2.2 million acres.

(6) OY methods may be able to accurately estimate net yield. In a controlled experiment in one field, net yield estimated by OY methods (with some procedural changes) was lower than combine-harvested yield (corrected for blank and broken seeds and trash); however, the difference was not statistically significant, so the OY net yield estimate was comparable with combine-harvested yield.

(7) Approximately 10-percent blank and broken seeds and trash was found in combine-harvested yield in the above experiment.

This report recommends:

(1) Change at-harvest sampling so that an area of the field is clipped, rather than a certain number of heads.

(2) Do not collect data, such as counts of stalks with fruit and seed counts, that contribute little to forecasting.

(3) Investigate changing lab procedures:

a. Obtain moisture by oven drying rather than by moisture meter.
b. Obtain weight of seeds in the early-season lab.

(4) Through a quality control program, ensure that survey procedures are carefully followed, including unit location, timing of final preharvest and postharvest visits, moisture meter use, and lab isolation of filled seeds.

(5) Begin a regular research program to study procedures, such as time lags allowed between final unit sampling and farmer harvest, and lab procedures, such as moisture meter use and isolation of filled seeds.

(6) The CRB should precisely define "sunflower yield" in its publications, including levels of blank and broken seeds and trash.

(7) Investigate the benefits of separate units for forecasting and at-harvest estimating.

(8) Study alternatives to locating units by pacing, such as using a measuring tape, wheel, or Topofil (a box of measuring string). (The controlled experiment which successfully estimated combine-harvested yield used a measuring tape.)

(9) Conduct re-interview studies or other research to study farmers' responses in personal interviews.

The 1984 survey adopted recommendation (1). In response to recommendation (5), SRS in 1984 studied the effects of making final survey visits too soon before harvest on yield estimates, the accuracy of moisture meters, and the lab method of isolating filled seeds. Seed weighing will be added to the early-season lab of the 1985 survey (recommendation (3b)), and stalks with fruit will not be counted in the 1985 survey (recommendation (2)).

1983 SUNFLOWER OBJECTIVE YIELD SURVEY RESEARCH

By Douglas C. Bond

INTRODUCTION

The Statistical Reporting Service (SRS), U.S. Department of Agriculture (USDA), studied objective yield (OY) survey methods for North Dakota oilseed sunflower in 1983. A sunflower OY survey has been conducted for North Dakota every year since 1981, to develop models to forecast net yield as early as several months before harvest, forecast harvested acreage before harvest, and estimate net yield and harvested acreage at harvest.

This survey is "objective" because the forecasts and at-harvest estimates of yield are based primarily on countable and measurable crop characteristics, such as head and stalk population, head diameter, and number of seeds per head. The survey is not entirely objective, because acreage data are obtained through personal interviews of farmers rather than by field measurement, and supplemental yield estimates are obtained in postharvest interviews of farmers.

SRS conducted this survey experimentally from 1981 to 1983 and operationally beginning in 1984. When SRS considers the survey forecasts and estimates reliable, SRS's Crop Reporting Board (CRB) will use them as additional indicators for official USDA acreage, production, and yield figures. The North Dakota Acreage and Production (A&P) Survey is currently the CRB's major indicator for North Dakota oilseed sunflower yield. This mail survey of farmers, with telephone follow-up, is conducted each fall for information on livestock and a number of crops, including sunflower.

Craig documented the performance of the sunflower OY survey in 1981-82 and found that the OY at-harvest estimate of yield exceeded the CRB's estimate by roughly 50 percent each year (1)[1/]. Craig and other SRS staff concluded that the OY estimate was erroneous. This conclusion is not necessarily valid, because the CRB's estimate was based almost entirely on A&P survey results, and the A&P survey has several ongoing problems, including a somewhat incomplete frame and a very high nonresponse rate. For example, in 1983, the North Dakota State Statistical Office (SSO) drew a systematic random sample of about 11,500 farmers from a list frame of

1/ Underscored numbers in parentheses refer to literature cited at the end of this report.

about 33,000 farmers. The SSO felt that this incomplete frame was more than 90 percent complete. About 1,900 farmers, or 14 percent of those surveyed, returned the questionnaires by mail. The SSO systematically chose and telephoned nonrespondents, and obtained about 3,000 more responses. Overall, about 43 percent (4,900 of 11,500) of the selected farmers responded. SRS did not study the bias due to these problems, but such problems can result in seriously biased estimates (3). Cochran commented on nonresponse of this magnitude: "Unfortunately, any sizable percentage of non-response makes the results open to question by anyone who cares to do so." (2)

There are other deficiencies in the A&P survey. It obtains yield through ambiguous questions which do not specify if production should be corrected for moisture, blank and broken seeds, and trash. It does not require enumerators to probe respondents for more accurate answers and it does not require farmers to consult their records. The SSO mails A&P questionnaires in early November before some sunflower fields have been harvested.

Comparing OY and CRB yield estimates to assess the validity of the OY estimate is inappropriate, because of the problems listed above. The OY estimate may have problems, but careful, controlled experiments are needed to identify and correct them. Craig attempted to identify problems; however, he did not conduct any controlled experiments, and in comparison studies, he used data from North Dakota State University (NDSU) that were not comparable with OY data (1). Therefore, his conclusions that seed weight per head was possibly overestimated and that there was possibly a tendency to select heads that were too large were not well supported.

SRS conducted an experiment in 1983 as a first step toward identifying whether there are problems with the OY at-harvest estimate. The purpose was to see whether the OY net yield estimate was comparable with yield harvested by a combine, or if there were inherent problems causing the OY estimate to be high, such as the combine producing unmeasurable harvest loss by crushing seeds.

This report presents the work performed in 1983 in two parts - the OY survey and the experiment mentioned in the previous paragraph. This report gives methods and detailed results for these areas, a discussion, and conclusions. Appendix 1 contains the data collection forms used in the 1983 survey.

THE 1983 OBJECTIVE YIELD SURVEY

Methods

This section briefly describes methods used in the 1983 survey. An enumerator's manual and a survey supervising and editing manual give more details (5,6). Craig's thorough documentation of 1982 methods provides good details, because methods changed little between 1982 and 1983 (1).

Survey Overview

As in 1982, SRS randomly selected 125 samples. Enumerators interviewed the farmers who operated the fields containing the samples to find out if their fields were for harvest as oilseed sunflower, determine the acreage of the fields, and obtain permission to enter the fields. Enumerators visited usable samples monthly, starting in late July, 1983, until just before harvest or early December, whichever came first. They observed and measured characteristics including row spacing, head diameter, plant population, head population, and stage of maturity in small randomly selected units (plots) during these visits. They sent samples of heads to the SRS lab in Fargo, where technicians measured properties including number of seeds, diameter, and weight of filled seeds per head just before harvest. Enumerators visited the samples a last time soon after harvest, and sent gleanings to the lab in Fargo for weighing. They also conducted postharvest interviews with the farmers for their harvested acreage and production.

Yield Estimation

State-level net yield (in lb per acre at 10-percent moisture) was estimated using Craig's "first method," so that state-level estimated harvest loss was subtracted from state-level estimated gross yield (1). Harvest loss was estimated from data collected during the postharvest sample visits. Gross yield was estimated from data collected during the final preharvest sample visits (see the method described in Appendix IV of Craig's report). That is, seed weight per head was calculated from the weight of filled seeds threshed in the lab from heads collected in sample plots.

"Farmer-reported" state-level net yield was estimated by averaging yields reported in postharvest interviews. These yields were converted to a 10-percent moisture basis before averaging, based on moisture levels reported by the farmers.

Yield Forecasting

Regression models, which forecast the two components of at-harvest gross yield (heads per acre and weight of filled seeds per head), were developed from the data collected during the preharvest field visits of the 1982 and 1983 surveys. Data collected during the final preharvest field visits gave the dependent variables. Data collected during the earlier survey visits gave the independent (forecasting) variables. The data were grouped according to the Maturity Stages (1 through 6) of the sample plots at the time the forecasting data were collected. Models were not developed for Maturity Stages 1 and 6 because of scarcity of data.

Table 1 presents the independent variables considered for inclusion in the regression models. Some variables were excluded from consideration in certain cases. For example, PS (stalks per acre in prebud stage) was excluded in Maturity Stages 3-5 for forecasting heads per acre and weight of filled seeds per head because few, if any, stalks would be in the prebud stage if the sample Maturity Stage was 3 (open flower or seed filling) or greater. BDM (Form B average head diameter) was excluded in Maturity Stages 2 and 3 for forecasting weight of filled seeds per head because diameters were not measured until the sample Maturity Stage was 4 or greater.

Correlation coefficients were computed, by maturity stage, between the candidate independent variables and the dependent variables, heads per

TABLE 1 - Independent variables considered at each maturity stage for the forecasting models, 1983 North Dakota Sunflower OY Survey

Variable	Definition	Candidate for forecasting							
		Heads per acre				Weight of filled seeds per head			
		--- Maturity Stage ---							
		2	3	4	5	2	3	4	5
TS	Total stalks per acre	X	X	X	X	X	X	X	X
PS	Stalks per acre in prebud stage	X				X			
SB	Stalks per acre with buds, flowers, or heads	X	X	X	X	X	X	X	X
TBFH	Total buds, flowers, and heads per acre	X	X	X	X	X	X	X	X
BD	Buds per acre	X	X			X	X		
FL	Heads per acre with open flower or seed fill	X	X	X		X	X	X	
HD	Heads per acre with flower wilt or beyond		X	X	X		X	X	X
BDFL	BD + FL	X	X	X		X	X	X	
FLHD	FL + HD		X	X	X		X	X	X
BDM	Form B average head diameter, cm							X	X
BDM-SQ	BDM^2							X	X
CDM	Form C-1 average head diameter, cm							X	X
CDM-SQ	CDM^2							X	X
CSD	Seeds per head							X	X

NOTE: "X" denotes that the variable was a candidate in the maturity stage shown.

acre and weight of filled seeds per head. Independent variables were evaluated for inclusion in the models with the stepwise and maximum R^2 improvement options of the SAS STEPWISE procedure (4). Results of the maximum R^2 improvement option were examined more closely, to find simple, logical models. If adding a variable produced little increase in R^2 and little decrease in mean squared error (MSE), or if this variable was highly correlated with a variable already in the model, the model selected by the maximum R^2 improvement option without the added variable was chosen.

The adequacy of the chosen models was checked in the following way. The dependent variables were plotted against the chosen independent variables, to visually examine relationships. The residuals were plotted against the predicted values and against the independent variables. Histograms of studentized residuals were also examined. No attempt was made to remove outliers or influential observations.

Harvested Acreage Estimation

Information gathered in the farmer interviews gave forecasts and estimates of harvested acreage for oilseed. Craig described computations in detail (1). Acres of sunflower planted for all purposes, from SRS's June Enumerative Survey (JES), was multiplied by a ratio derived from the early-season interviews (recorded on Form A). The resulting Form A estimate (actually a forecast) was multiplied by a ratio derived from the postharvest interviews (recorded on Form D). The product was the Form D estimate of harvested acreage.

Results

Usable Samples

There was a low refusal rate of 2.4-percent of the samples in the initial farmer interviews (Table 2). After samples were eliminated because they were not oilseed or because there was no sunflower in the tract, 116 samples (92.8-percent of 125) remained that were suitable for this survey.

TABLE 2 - Samples for the 1983 North Dakota Sunflower OY Survey

Category	Number of samples	Percent of total samples
Farmer refusal	3	2.4
No sunflower in tract	2	1.6
Sunflower not for oilseed	4	3.2
Sunflower for oilseed, row-planted	115	92.0
Sunflower for oilseed, broadcast	1	0.8
TOTAL	125	100.0

Estimated Yield

The OY estimate of net yield was 1,342 lb per acre, 29-percent higher than the CRB's 1,040 lb per acre (Table 3). Gross yield was also estimated, from the method described in Craig's Appendix III, at 1,710 lb per acre, for comparability with his report. Estimated net yield based on this figure (1,710-207 = 1,503 lb per acre) was 44-percent above the CRB's figure. Regardless of which OY method was used, the estimate and the CRB's figure were related as they were in previous years: the OY estimate was much larger. The farmer-reported net yield estimate was 969 lb per acre. As in 1981 and 1982, this estimate was much closer to the CRB's yield than was the OY estimate.

TABLE 3 - Yield estimates, 1983 North Dakota Sunflower OY Survey

Type of estimate	Number of samples	Estimate lb per acre	Standard error lb per acre	Percent CV
Objective yield:				
Gross yield	112	1,549	66	4.3
Harvest loss	104	207	22	10.6
Net yield[1/]	112 & 104	1,342	69	5.1
Farmer-reported	113	969	31	3.2
Crop Reporting Board	NA	1,040	NA	NA

1/ Gross yield minus harvest loss.
NOTE: NA = Not applicable - not directly based on survey results.

Forecasting Models

Many candidate variables were highly correlated with heads per acre in each maturity stage, but correlations of candidate variables with weight of filled seeds per head were generally low (Table 4). Head diameter variables and seed counts were more highly correlated with weight of filled seeds per head than were stalk and fruit counts. Variables based on data collected in the lab (CDM, CDM-SQ, and CSD) were not as correlated with weight of filled seeds per head as were BDM and BDM-SQ, head diameter variables based on data collected in the field.

TABLE 4 - Correlation coefficients at each maturity stage between independent variables and heads per acre and weight of filled seeds per head, 1982-83 data, North Dakota Sunflower OY Survey

Variable	Correlation with heads per acre --- Maturity Stage --- 2 n = 85	3 n = 88	4 n = 88	5 n = 62	Correlation with weight of filled seeds per head --- Maturity Stage --- 2 n = 85	3 n = 86	4 n = 86	5 n = 62
TS	0.96	0.97	0.95	0.97	-0.40	-0.37	-0.32	-0.25
PS	0.40	NA	NA	NA	-0.07	NA	NA	NA
SB	0.89	0.97	0.95	0.97	-0.40	-0.36	-0.34	-0.25
TBFII	0.80	0.78	0.82	0.88	-0.33	-0.35	-0.26	-0.19
BD	0.83	0.03	NA	NA	-0.40	-0.17	NA	NA
FL	0.33	0.89	0.15	NA	-0.10	-0.25	-0.15	NA
HD	NA	-0.09	0.94	0.99	NA	-0.12	-0.31	-0.21
BDFL	0.86	0.93	0.14	NA	-0.40	-0.32	-0.18	NA
FLHD	NA	0.87	0.95	0.97	NA	-0.29	-0.33	-0.25
BDM	NA	NA	NA	NA	NA	NA	0.52	0.58
BDM-SQ	NA	NA	NA	NA	NA	NA	0.52	0.57
CDM	NA	NA	NA	NA	NA	NA	0.45	0.43
CDM-SQ	NA	NA	NA	NA	NA	NA	0.46	0.43
CSD	NA	NA	NA	NA	NA	NA	0.47	0.34

NOTES: n = Number of samples.
NA = Not applicable - there was no interest in this correlation.

For forecasting heads per acre, one-variable models were chosen from the PROC STEPWISE procedure described previously (Table 5). Two-variable models, selected by the maximum R^2 improvement option, were never chosen because there was little, if any, improvement in R^2 and MSE, and because the variables in the two-variable models were highly correlated (correlation coefficients were 0.84-0.98). The one-variable models had high R^2 values (0.91-0.97) and low coefficient of variation (CV) values (5.4-13.3-percent). (CV in regression models is the root MSE, divided by the mean of the dependent variable, expressed as a percent.) Stalk counts were selected as predictors for heads per acre in Maturity Stages 2 and 3; fruit counts were selected in Maturity Stages 4 and 5. All the plots of dependent variables against independent variables gave the impression of a linear relationship over a wide range of values of the independent variables (Appendix 2). The plots of residuals against predicted values and against independent variables did not show serious departures from the appearance of horizontal bands of points, which indicated there was no reason to believe that the assumption of constant variance was violated, that additional terms were needed in the models, or that transformations of variables were needed. Visual examination of the histograms of studentized residuals did not indicate serious departures from normal distributions. Also, over the maturity stages, 81 to 85-percent of the studentized residuals were between -1 and +1, and 91 to 94-percent were between -2 and +2. If the studentized residuals had been exactly normally distributed, approximately 67-percent would have been between -1 and +1, and approximately 95-percent would have been between -2 and +2. Thus, there were no appreciable violations of the assumption of normality of residuals.

TABLE 5 - Models selected to forecast heads per acre, 1982-83 data, North Dakota Sunflower OY Survey

Maturity stage	Number of samples	Variables selected	R^2	MSE (thousands)	Percent CV
2	85	TS	0.92	4,813	13.3
3	88	SB	0.95	2,946	10.3
4	88	FLHD	0.91	3,642	11.7
5	62	HD	0.97	691	5.4

How valuable were the counts of fruit and stalks with fruit for forecasting heads per acre? Was the simpler count of total number of stalks adequate? Models were constructed using only TS (total stalks per acre) as the independent variable, to answer these questions. In Maturity Stage 3, the model using TS had virtually the same R^2 and CV as the model in Table 5, which used SB (stalks per acre with fruit) (Table 6). In Maturity Stage 4,

the model using TS had a slightly larger CV than the model in Table 5. In Maturity Stage 5, the CV of the model with TS was over 50-percent greater than the CV of the model in Table 5, which used fruit counts. Therefore, counting fruit was useful, especially in Maturity Stage 5, but it was not helpful to break the total stalk count into stalks with and without fruit.

TABLE 6 - Heads per acre forecasting models using only total stalks per acre as the predictor, 1982-83 data, North Dakota Sunflower OY Survey

Maturity stage	Number of samples	R^2	MSE (thousands)	Percent CV
2	85	0.92	4,813	13.3
3	88	0.95	2,955	10.4
4	88	0.90	3,939	12.1
5	62	0.93	1,729	8.5

In all but Maturity Stage 4, one-variable models were chosen to forecast weight of filled seeds per head (Table 7). Models with more variables, selected by the SAS maximum R^2 improvement option, were not chosen because there was little, if any, improvement in R^2 and MSE. Also, in Maturity Stages 2 and 3, the variables in two-variable models were highly correlated (correlation coefficients were 0.90 and 0.92). The models shown in Table 7 had low R^2 values (0.14-0.36) and high CV's (33.0-40.3-percent). Head diameter measurements, when available (Maturity Stages 4 and 5), were selected. Seed count (CSD) was selected only in Maturity Stage 4. The plots of dependent variables against independent variables did not indicate nonlinear relationships (Appendix 2). The impression of the residual plots was not strikingly different from horizontal bands of points. Visual examination of the histograms of studentized residuals did not show inconsistencies with the assumption of normality. Also, in the four models, 67 to 73-percent of the studentized residuals were between -1 and +1, and 93 to 95-percent were between -2 and +2.

TABLE 7 - Models selected to forecast weight of filled seeds per head (grams), 1982-83 data, North Dakota Sunflower OY Survey

Maturity stage	Number of samples	Variables	R^2	MSE	Percent CV
2	85	BD	0.16	398	40.3
3	86	TS	0.14	343	37.1
4	86	BDM,CSD	0.36	355	36.0
5	62	BDM	0.34	271	33.0

Harvested Acreage

The Form A and Form D estimates of harvested acreage for oilseed were 15.3 and 14.6-percent, respectively, lower than the CRB's 2.2 million acres (Table 8). The CRB's estimate (which had no calculated standard error because it was not directly based on survey results) was within two standard errors of both estimates.

TABLE 8 - Estimated sunflower acreages, 1983 North Dakota Sunflower OY Survey

Type of estimate	Estimate (thousand acres)	Standard error (thousand acres)	Percent CV
JES sunflower for all purposes	2,019	176	8.7
Oilseed sunflower:			
Form A	1,863	168	9.0
Form D	1,878	173	9.2
Crop Reporting Board	2,200	NA	NA

NOTE: NA = not applicable - not directly based on survey results.

Errors in Timing of Visits

Enumerators were supposed to have visited samples for the last time before harvest no more than seven days before harvest, and they were to have re-visited samples no later than three days after harvest. However, they last visited approximately 80-percent of the samples more than seven

days before farmer-reported harvest (Table 9). They re-visited approximately 36-percent of the samples more than three days after farmer-reported harvest (Table 10).

TABLE 9 - Number of days between final preharvest visit and farmer-reported harvest date, 1983 North Dakota Sunflower OY Survey

Number of days	Number of samples	Percent of total samples
0 to 7	21	19.4
8 to 14	46	42.6
15 to 21	13	12.0
22 to 28	14	13.0
29 to 35	8	7.4
Over 35	6	5.6
TOTAL	108	100.0

TABLE 10 - Number of days between farmer-reported harvest date and postharvest visit, 1983 North Dakota Sunflower OY Survey

Number of days	Number of samples	Percent of total samples
0 to 3	54	64.3
4 to 7	24	28.6
Over 7	6	7.1
TOTAL	84	100.0

COMPARABILITY OF OBJECTIVE YIELD AND COMBINE-HARVESTED YIELD

Methods

Field Collection

To study the comparability of net yield estimated by OY methods with combine-harvested yield, NDSU planted "Hybrid 894" at the rate of approximately 50,000 seeds per acre in one field near Fargo. They later hand-thinned the field to a uniform density of approximately 20,000 plants per acre. On October 14, 1983, NDSU trimmed the edges of the field with an International Harvester model 1440, eight-row, axial-flow combine. The combine then cut a swath through the middle of the field, perpendicular to the row direction. NDSU and SRS staff marked off ten plots, each approximately 65 feet of four adjacent rows, in each half. After obtaining plot dimensions, they randomly located one OY preharvest unit, 15 feet of two adjacent rows, within each plot. They located units with a tape measure, and measured row widths for each unit.

The following day, NDSU and SRS hand harvested preharvest units, the combine individually harvested plots, and NDSU and SRS collected gleanings from a postharvest unit within each plot. Descriptions of these operations follow.

Hand harvesting - Heads with one or more seeds were counted in both rows of each OY preharvest unit. All these heads were clipped from one row and sent to an NDSU lab, where technicians threshed them, separated out broken seeds and trash, and removed blank seeds with an aspirator. They weighed the remaining filled seeds and took two samples of approximately 20 grams each to determine moisture content. The loss in weight, after drying samples for approximately 36 hours at 105°C in an air oven, was used to calculate the moisture content. For example, if a sample weighed 21.03 grams before drying and 18.99 grams after drying, its moisture was ((21.03 -18.99)/21.03) (100) = 9.7-percent.

Combine harvesting - After the preharvest units were hand harvested, the combine individually harvested plots containing them. Seeds from each plot were collected in a bucket as they came from the combine auger. Technicians weighed the seeds in the NDSU lab, and analyzed two samples of approximately 50 grams each for moisture content, as described above. After these samples were dried, technicians separated them into filled, blank, and broken seeds and trash, and weighed each part.

Collection of gleanings - Before the combine harvested the plots, one one-foot by five-row postharvest unit was randomly located in each plot and swept clean with a broom. After the combine harvested the plots, gleanings were collected from the postharvest units. All seeds within the units were collected and sent to the NDSU lab, where technicians isolated filled seeds. The filled seeds were weighed, and their moisture content was determined by drying in an air oven.

Yield Computations

Net yield in each unit, hand harvested by OY methods, in lb per acre at 10-percent moisture, was estimated as follows.

OY Net yield = Gross yield - Harvest loss

where:

Gross yield =

$$\frac{\text{(Weight of filled seeds from preharvest unit) (Conversion factor)}}{\text{(0.9) (Area of preharvest unit)}} \text{ (1-(Percent moisture/100))}$$

Harvest Loss =

$$\frac{\text{(Weight of filled seeds from postharvest unit) (Conversion factor)}}{\text{(0.9) (Area of postharvest unit)}} \text{ (1-(Percent moisture/100))}$$

Conversion factor = $\frac{43{,}560}{453.6}$ (converts grams per ft^2 to lb per acre)

Area of preharvest unit, ft^2 = (15) (1 Row width)

Area of postharvest unit, ft^2 = (1) (4 Row widths)

Yield in each plot harvested by the combine, in lb per acre at 10-percent moisture, was estimated in the following way (corrected for blank and broken seeds and trash).

Combine-harvested yield =

$$\frac{\text{(Weight of all seeds and trash from plot)(Percent filled seeds/100)(43,560)}}{\text{(0.9) ((Area of plot) - (Area of preharvest unit))}} \text{ (1-(Percent moisture/100))}$$

where:

Area of plot, ft^2 = (1 row width) (4) (Length of plot)

Area of preharvest unit is given above

Percent filled seeds =

$$\frac{\text{(Sample Weight of filled seeds)}}{\text{(Sample weight of filled, blank, and broken seeds and trash)}} \text{ (100)}$$

43,560 is the conversion factor (converts lb per ft^2 to lb per acre)

Note that the area of the hand-harvested unit was subtracted from the plot area, to account for seeds harvested before combining.

The OY net yield estimate and combine-harvested yield were compared with a two-tailed paired t-test with a sample size of 20.

Results

The OY net yield estimate of 1,054 lb per acre was 11.6-percent lower than the combine-harvested yield of 1,193 lb per acre, which was corrected for

blank and broken seeds and trash (Table 11). The difference was not statistically significant. Had the combine-harvested yield not been corrected for trash and so forth, it would have been 1,322 lb per acre, significantly higher than the OY estimate.

TABLE 11 - Comparison of net yield
estimated by OY methods and combine harvesting, 1983 sunflower research

Method	Estimate[1/]
Combine harvesting:	
Uncorrected for blank and broken seeds and trash	1,322
Corrected	1,193
OY Methods:	
Gross yield	1,202
Harvest loss	147
Net yield (Gross minus loss)	1,054
Difference[2/]:	139
Standard error of diffference	85
Paired t-statistic	1.63
Significance level	0.12

NOTE: 20 units in this experiment.
1/ Yield estimates are in lb per acre.
2/ Corrected combine-harvested yield minus OY net yield.

Combine-harvested yield contained 90.2-percent filled seeds (Table 12). The remainder was blank seeds (3.7-percent), broken seeds (1.3-percent), and trash (4.8-percent).

TABLE 12 - Components of combine-harvested sunflower yield, 1983 sunflower research

Component	Mean lb per acre	Percent of total yield
Filled seeds	1,193	90.2
Blank seeds	49	3.7
Broken seeds	17	1.3
Trash	63	4.8
TOTAL	1,322	100.0

NOTE: 20 units in this experiment.

DISCUSSION AND CONCLUSIONS

Yield Estimates

The 1983 Sunflower OY Survey estimate of net yield was much higher than the CRB's figure. In the NSDU field experiment, OY estimated net yield was lower than combine-harvested yield (corrected for blank and broken seeds and trash), but not by a statistically significant margin. Thus, in this experiment, OY estimated net yield was comparable with combine-harvested yield. There apparently were no factors, such as unmeasurable harvest loss, forcing the OY estimate to be high. Two different conclusions are suggested: OY methods inherently overestimate net yield, or OY methods may be able to correctly estimate net yield. Because of the possible problems with the CRB's estimate, the author believes there is little justification for the first conclusion and feels that the second conclusion is true, if some OY methods are changed and procedures are carefully followed.

Some changes and careful following of procedures are suggested because, in the research project, some OY procedures were changed and other procedures were very carefully followed. For example, preharvest and postharvest research units were located with a tape measure, rather than by pacing, which was the OY method. There were no visits to the preharvest research units before they were hand harvested, other than to thin plants and apply pesticides. In the OY survey, enumerators made several monthly visits before harvest to count plants and heads and possibly measure heads. In the research study, all heads (with seeds) in one row of each preharvest unit were clipped. Thus, instead of clipping three heads,

as in the OY survey, an area of the field was sampled. Technicians oven dried seeds to determine moisture content of research samples, but a moisture meter was used in the OY survey. Preharvest and postharvest research data were collected the same day as harvest. Recall that final preharvest and postharvest visits were often made long before or after harvest in the 1983 OY survey. There was greater attention to correctly following procedures in the research study than is possible in an OY survey, because only one field was involved, and because researchers were closely involved in data collection and supervision.

This research did not show that OY methods would always accurately estimate net yield, if procedures were changed and the survey were carefully conducted, because only one field, one variety, one set of conditions, and one type of combine were used. OY procedures could correctly estimate net yield.

Changes in OY survey procedures should be considered, because of the apparent success of the research project (the OY estimate was not significantly different from combine-harvested yield). Proposed changes include: clip an area, rather than a certain number of heads, during the final preharvest visit; determine moisture content by oven drying; use separate units for forecasting and at-harvest estimation; and randomly locate units with a measuring tape, wheel, or Topofil (a box of measuring string). Procedures such as sampling units within seven days of harvest must be more carefully followed. Research should be continued to examine sunflower OY procedures, such as the effect of sampling units more than seven days before harvest. Lab procedures should be studied, such as the use of moisture meters and isolation of filled seeds.

Several of the above recommendations have been adopted already. Beginning with the 1984 survey, an area was clipped during the final preharvest visit. Research in 1984 examined the effects of sampling units too soon before harvest on yield estimates, and studied the accuracy of moisture meters and the method of isolating filled seeds in the lab.

Research concluded that combine-harvested yield contained nearly 10-percent blank and broken seeds and trash. If this is typical of a farmer's harvest, then the OY method will not estimate farmer-harvested yield, because OY procedures isolate clean, filled seed. The amount of blank and broken seeds and trash usually included and reported in sunflower marketing should be determined, and the CRB should precisely define "sunflower yield" in its publications, including levels of blank and broken seeds and trash.

Forecasting Models

Simple, logical models with high R^2 values and low MSE's were developed to forecast heads per acre, but acceptable models were not found to forecast weight of filled seeds per head. Therefore, good yield forecasting models were not found, because forecasted yield is the product of forecasted heads per acre and forecasted weight of filled seeds per head. Other SRS OY surveys, such as that for soybeans, share this problem. SRS attempts to solve this problem by using historical average weight instead of a forecasted weight. This approach would not be useful for sunflower, because the average weight of filled seeds per head at the final preharvest

visit has not been constant from year to year. From 1981 to 1983, this weight was 54.9, 52.8, and 47.1 grams, respectively.

Breaking the total stalk count into stalks with and without fruit was not useful for forecasting heads per acre. Therefore, counts of stalks with fruit could be dropped. SRS has planned to drop these counts from the 1985 survey.

The gains from using seed count (CSD) in forecasting models may not have been great enough to justify obtaining it. CSD was selected as a forecasting variable for weight of filled seeds per head only in Maturity Stage 4. When CSD was deleted from the model, the R^2 was reduced from 0.36 to 0.27 and the MSE increased from 355 to 398. It is time-consuming to count seeds, and the counter costs over $2,000. Therefore, consideration should be given to eliminating seed counts from the C-1 form. Seeds should instead be weighed, and the usefulness of these weights for forecasting weight of filled seeds per head should be studied. Plans have been made to weigh seeds in the early-season lab of the 1985 survey.

Harvested Acreage

The 1983 OY harvested acreage estimates were lower than the CRB's estimate, and CV's were around 9-percent. As with yield estimates, a difference between OY indications and the CRB's figures does not necessarily mean that OY estimates were wrong. Possible errors in OY acreage estimation were not studied, but they should be investigated. SRS derives OY acreage estimates from figures that farmers report in personal interviews, so respondent errors and errors caused by interviewers are possible. One way of investigating errors is to re-interview farmers after the survey to check their responses.

REFERENCES

1. Craig, M.E. (1984), 1981-82 Sunflower Objective Yield Research. Washington, D.C., Statistical Reporting Service, USDA.

2. Dalenius, T. (1984), Review of "An Assessment of Research-Doctorate Programs in the United States: Mathematical and Physical Sciences," Journal of the American Statistical Association, Vol. 79, No. 387, p. 725.

3. Kish, L. (1965), Survey Sampling. New York, John Wiley & Sons, Inc.

4. SAS Institute, Inc. (1982), SAS User's Guide: Statistics, 1982 Edition. Cary, N.C.

5. U.S. Department of Agriculture, Statistical Reporting Service (1983), 1983 Sunflower Objective Yield Research Study - Enumerator's Manual. Washington, D.C.

6. U.S. Department of Agriculture, Statistical Reporting Service (1983), Sunflower Objective Yield Survey - Supervising and Editing Manual. Washington, D.C.

APPENDIX 1 Data Collection Forms Used in the 1983 Sunflower Objective Yield Survey

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088
C.E. 12-0035A

FORM A: SUNFLOWER YIELD SURVEY - 1983
INITIAL INTERVIEW

MONTH CODE
Aug. 1 1
Sept. 1 3
Oct. 1 5
Nov. 1 6

YEAR, CROP, FORM, MONTH (1-4)
351 ___

About the first of June a representative from our office obtained information about your farming operations. We are now interested in estimating the production of sunflowers and updating information about your sunflower fields. Your response to this survey is voluntary and not required by law. However, we need and appreciate your cooperation.

Date (_____) 170
Starting Time *(Military Time)* ... 171

JES PLANTED TRACT ACRES

1. Around June 1, you planted or intended to plant 101
acres of sunflower in _____ fields in this tract. *(Do not change)*
SHOW operator his tract and fields on PHOTO. VERIFY the fields and the acreages of sunflowers 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 sunflowers planted in tract, correct Table A and return all forms.

RECORD the acreages of sunflowers to be harvested for oil in Column 6 and ADD to total.

TABLE A

FIELD NUMBER *(Sample field number is circled.)*	TOTAL ACRES IN FIELD	ACRES PLANTED TO SUNFLOWERS	Acres in USES or CROPS other than sunflowers to be harvested for oilseed (For example: waterways, confectionery, other crops, etc.)		ACRES OF SUNFLOWERS FOR OILSEED
			USE	ACRES	
1	2	3	4	5	6
	•	•		•	
	•	•		•	•
	•	•		•	
	•	•		•	•
	•	•		•	
	•	•		•	•
	•	•		•	
	•	•		•	•
	•	•		•	
	•	•		•	•
	•	•		•	
	•	•		•	•

2. The total sunflower acreage *(Col. 6)* **to be harvested for oilseed in this tract is** .....**Acres** 102 •

IS THAT RIGHT? <
NO - - Review all fields, RE-ADD Col. 6.
YES - - Continue

IF ITEM 2 HAS <
A ZERO entry -- Return all forms.
An ACREAGE entry -- TURN PAGE.

FORM A: SUNFLOWER (Cont'd)

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

If no sunflowers were planted in the designated sample field, BUT a NEW field to be harvested for oilseed is listed in Table A, this new field then becomes the sample field to enter in Item 3. If there are two or more new fields, select the one nearest the originally selected field.

3. **Copy acres of sunflower for oilseed in Sample Field Number _____ from Table A** .....*Record acres or "O"* .....**Acres** 103 •

4. **What variety of sunflower did you seed in this field?** _____ 106
(Name and Number)

5. **On what date was this sunflower field planted?** _____ _____ 104
(Month and Day)

6. **Was this field sown by: Air ☐ = 1 Drill ☐ = 2** .....**ENTER CODE** 107

7a. **Even Numbered Samples**

"With your permission I will now go out to the field and mark off two small units to be used in making stalk and head counts."

"I will return to the units each month until harvest to make counts and clip a few heads to determine their weight and size. Would that be all right?".

YES ☐*Go to Item 8* **NO☐***-Conclude interview and return all forms.*

b. Odd Numbered Samples

"With your permission I will return shortly before harvest and mark off two small units. I will make counts and clip a few heads to determine their weight and size. Would that be all right?

YES☐ NO☐*-Conclude interview and return all forms.*

8. **Where should I leave the heads picked from the units?** _____
(Copy onto the sample kit envelope the location where the operator wishes you to leave the heads.)

9. **"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 oilseed harvested from this field".**

IMPORTANT:	*Review this form for completeness. Record ending time and sign name. Transfer necessary data from Table A to Form D, Item 1.*

Ending Time *(Military Time)* 172

STATUS CODE..... 180

ENUMERATOR: _____ **ENUMERATOR CODE** 190

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088
C.E. 12-0035B

FORM B—SUNFLOWER YIELD SURVEY—1983
COUNTS

MONTH CODE

August 1 1
September 1 3
October 1 5
November 1 6
December 1 7

YEAR, CROP, FORM, MONTH (1-4)
353 ___

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

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

Date (_____)	370
Starting Time *(Military Time)* ...	371

UNIT LOCATION

	UNIT 1	UNIT 2
Number of rows along edge of field		
Number of paces into field		

ROW SPACE MEASUREMENTS

For broadcast fields, do not complete question 2. Write a comment at the bottom of this page and skip to question 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.*

Enter 1 for YES / 2 for NO

UNIT 1	UNIT 2
301	307

2. a. Measure distance from stalks in Row 1 to stalks in Row 2 ..... **Feet and Tenths**

b. Measure distance from stalks in Row 1 to stalks in Row 5 ..... **Feet and Tenths**

UNIT 1	UNIT 2
303 .	304 .
305 .	306 .

COUNTS WITHIN 15-FOOT UNITS

	UNIT 1		UNIT 2	
	Row 1	Row 2	Row 1	Row 2
3. a. Number of stalks (Total)	321	322	323	324
b. Number of stalks in prebud stage	325	326	327	328
c. Number of stalks with buds, flowers, or heads ..... (Note: 3a should equal 3b + 3c).	329	330	331	332

	UNIT 1		UNIT 2	
	Row 1	Row 2	Row 1	Row 2
4. a. Total number of buds, flowers and heads	341	342	343	344
b. Number of buds	345	346	347	348
c. Number of heads with open flower or seedfill	349	350	351	352
d. Number of heads with flower wilt or beyond ..... (Note: 4a should equal 4b + 4c + 4d)	353	354	355	356

GENERAL COMMENTS: _____

(Continued on back)

FORM B—SUNFLOWER YIELD COUNTS (Cont'd)

Counts Within 15 Foot Units (Cont'd)

5. STAGE OF MATURITY *(Circle one stage code per unit)*

	Prebud or Earlier	Budding Visible	Open Flower and Seed Fill	Flower Wilting	Mature, Wet	Harvest Mature	Blank
UNIT 1	300 1	300 2	300 3	300 4	300 5	300 6	300 7
UNIT 2	302 1	302 2	302 3	302 4	302 5	302 6	302 7
	If lowest code for either unit is 1, 2, or 3, skip to bottom of page and enter name and time.			If lowest code for either unit is 4, 5, or 6, continue.			

MEASUREMENTS WITHIN UNIT 2, ROW 1

6. Measure diameter of all heads counted in Question 4d, Unit 2, Row 1. (Box #355-maturity code 4, 5, or 6)

Do **NOT** *remove head. Record widest and perpendicular measurements to nearest 1/10 centimeter using cloth tapes. If more than 30 heads, use blank space on right.*

	Widest	Perpendicular		Widest	Perpendicular		Widest	Perpendicular
1.	•	•	11.	•	•	21.	•	•
2.	•	•	12.	•	•	22.	•	•
3.	•	•	13.	•	•	23.	•	•
4.	•	•	14.	•	•	24.	•	•
5.	•	•	15.	•	•	25.	•	•
6.	•	•	16.	•	•	26.	•	•
7.	•	•	17.	•	•	27.	•	•
8.	•	•	18.	•	•	28.	•	•
9.	•	•	19.	•	•	29.	•	•
10.	•	•	20.	•	•	30.	•	•

Is Harvest planned within 7 days?

☐ YES→Complete questions 8 and 9 only (skip 7)
☐ NO→Complete question 7 only (skip 8 and 9)

Total Diameter 308 •
Total Number of Heads 309

7. Clip first 3 heads beyond Row 1 of Unit 2 which are maturity code 4, 5, or 6. Mail these heads to State Office.

HEAD	1	2	3
Maturity Code			

- **If harvest not within 7 days, then skip to bottom of page and enter name and time.**

CLIPPING OF HEADS WITHIN BOTH UNITS

8. Clip and tag 3rd, 4th and 5th heads that are maturity code 4, 5, or 6 *(approximately 2 inches below head)* **from Row 1 of both units. Then clip remaining heads that are maturity code 4, 5, or 6. Number of heads clipped** *(Include tagged heads)* .....

UNIT 1 Row 1	UNIT 2 Row 1	
		310

9. Weight of heads that are maturity code 4, 5, or 6 from Row 1 of both units. Both units weighed together *(Include tagged heads)* ..... **Pounds & Tenths** 311 •

NOTE: This is final preharvest visit if questions 8 and 9 are completed. Place 3rd, 4th and 5th heads of row 1 in separate bags for each unit and mail to office.

Ending Time 372
Status Code 380
Enumerator Code 390

Enumerator _____

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088

C.E. 12-0035C1

FORM C—1: SUNFLOWER YIELD SURVEY—1983
STATE LABORATORY DETERMINATIONS

MONTH CL
Sept. 1 ..... ,
Oct. 1 5
Nov. 1 6

YEAR, CROP, FORM, MONTH (1-4)
354 ___

Date Processed .....(Julian Date) 401

		HEAD 1	HEAD 2	HEAD 3
1. From ID Tag		402	403	404
Maturity Code				
2. Diameter in centimeters....(Tenths)	Widest	•	•	•
	Perpendicular	•	•	•
Record widest and perpendicular measurements and enter averages in boxes 405, 406 or 407.	Average	405 •	406 •	407 •
3. Number of fertile seeds		408	409	410

Lab Technician _____

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088

C.E. 12-0035-C-2

FORM C—2: SUNFLOWER YIELD SURVEY—1983
PRE—HARVEST LAB DETERMINATIONS

MONTH CODE
Sept. 1 3
Oct. 1 5
Nov. 1 6
Dec. 1 7

YEAR, CROP, FORM, MONTH (1-4)

355 ___

1. Date sample taken .....(Julian Date) [571]

Date Analyzed (Julian Date) [570]

HEADWEIGHT (BOTH UNITS COMBINED)

2. Weight of heads in sealed bags-include weight of bags and rubber bands .(Tenths) Grams [501] •

3. Weight of same number of new bags and rubber bands .....(Tenths) Grams [502] •

You may now remove the heads from the poly bags, but be sure to keep tagged and separated. If heads are too wet to thresh easily, heads can be dried for a short period.

4. Weight of heads just before threshing .....(Tenths) Grams [505] •

SEED COUNTS AND HEAD DIAMETER

		UNIT 1			UNIT 2		
5. HEAD DIAMETER IN CENTIMETERS . . .(Tenths) *Record widest and perpendicular measurements and enter averages in boxes 512-517.*	Widest	•	•	•	•	•	•
	Perpendicular	•	•	•	•	•	•
	Average	512 •	513 •	514 •	515 •	516 •	517 •
6. NUMBER OF FERTILE SEEDS.....		522	523	524	525	526	527

(Continued on back)

C—2: SUNFLOWER (Cont'd)

SEED WEIGHT AND MOISTURE DETERMINATIONS

7. Weight of fertile seed threshed from Unit 1 heads .....Grams (Tenths) 506 •

8. Weight of fertile seed threshed from Unit 2 heads .....Grams (Tenths) 511 •

9. Weight of fertile seed from both units at time of moisture test .....Grams (Tenths) 507 •

10. Moisture Content of fertile seed from both units 1/ .....Percent (One Decimal) 508 •

1/ If sample weight is too small for moisture test, check here ☐. Sufficient seed of known moisture content will be added so that a moisture test can be made. The moisture content of the small sample can be derived using the following formula:

$$E = \frac{(A + B)\,D - (B \cdot C)}{A}$$

Where:

A = Weight (in grams) of small sunflower sample (item 9 above) _____•_____ grams

B = Weight (in grams) of additional seed for moisture test _____•_____ grams

C = Known percent moisture content of B seed. _____•_____ percent

D = Percent moisture content of A and B combined. _____•_____ percent

and then

E = Percent moisture content of small sample (enter in item 10). _____•_____ percent

Weights and percents must be to one decimal (_____•_____).

If sample is too wet to do a moisture test, check here ☐. Combine all seeds for both units and set aside overnight to dry. Then repeat questions 9 and 10.

Lab Technician: _____

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088
C.E. 12-0035D

FORM D: SUNFLOWER YIELD SURVEY — 1983
POST—HARVEST INTERVIEW

MONTH CODE
Oct. 1 5
Nov. 1 6
Dec. 1 or later . . . 7

YEAR, CROP, FORM, MONTH (1-4)
356 ___

"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 sunflower fields. I would like to know how your crop turned out in this field."

Date (_____) 670
Starting Time *(Military Time)* . . . 671

1. *Enter from Form A, Table A.*

   Sample Field Number (_____) Acres for Oilseed (_____)

2. **How many acres of sunflower were** *(or will be)* **harvested for oilseed from this field? . Acres** 606 .

   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 as oilseed. Can you give me a reason for the difference?**

   _____

   _____

4. **How many pounds were harvested from these** *(Item 2)* _____ **acres?**
   Include seed harvested when opening the field and hand gleaning if any **. . . . Total Pounds** 607

   If operator indicated yield per acre, multiply by acres in Item 2 to determine total pounds. Show your work. YIELD PER ACRE (_____)

5. **How many pounds do you still expect to harvest from this field?**
   Include hand gleaning **. . . . . Total Pounds** 608

6. **Then the total pounds harvested** *(or expected from this field is Items 4 + 5)* **. . . . . Total Pounds** 612

7. **How was this production determined?**

   Pounds Held by Combine Bins . . . . . 1 ☐
   Number of Wagons or Truckloads . . . . 2 ☐
   Weight at Elevator . . . . . 3 ☐
   Capacity of Storage Bins . . . . . 4 ☐
   Field Not Harvested - Estimated . . . . . 5 ☐
   Other _____ . . . . . 6 ☐

   Enter Code 610

8. **On what date was or will harvest be completed in this field?** _____ **. . . . OFFICE USE** 604
   (Month and Day)

(Continued on Back)

FORM D: SUNFLOWER YIELD SURVEY

POST—HARVEST INTERVIEW (Cont'd)

9. **What was the moisture content of these seeds when they were harvested?** ..... **Percent** 611 .

How was the moisture content determined? _____
(For example: moisture meter, best estimate, etc.)

10. **Was there any significant damage (at least 10 percent crop loss) in this field due to birds, drought, flooding, insects, disease, lodging, hail, frost or other causes? If yes, what was the major cause of damage (check box and enter code)?**

NO (less than 10% loss).... ☐ = 1
YES, Bird ..... ☐ = 2
YES, Drought ..... ☐ = 3
YES, Flooding ..... ☐ = 4
YES, Insects ..... ☐ = 5
YES, Hail ..... ☐ = 6
YES, Frost ..... ☐ = 7
YES, Other - Specify ..... ☐ = 8

_____

Enter Code 609

"I would like to thank you for your cooperation this season. Before I go, I would like to go into the field in which we made out counts to check on harvest losses."

ENDING TIME 672

STATUS CODE 680

ENUMERATOR CODE 690

ENUMERATOR _____

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088

C.E. 12-0035E

FORM E: SUNFLOWER YIELD SURVEY—1983
POST—HARVEST GLEANINGS

MONTH CODE
Sept. 1 3
Oct. 1 5
Nov. 1 6
Dec. 1 or later . . . 7

YEAR, CROP, FORM, MONTH (1-4)
357 ___

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 or disced since harvest, select an alternate field for gleaning if one is available in the tract.

Date (_____) 770
Starting Time 771

Enumerator _____

Enumerator Code 790

UNIT LOCATION	UNIT 1	UNIT 2
Number of rows along edge of field	+5	+5
Number of paces into field	+5	+5

For broadcast field, skip to question 3. Comment below question 5 that this is a broadcast field.

	UNIT 1	UNIT 2
1. *Measure distance from stalks in Row 1 to stalks in Row 2* . . . . . Feet & Tenths	703 .	704 .
2. *Measure distance from stalks in Row 1 to stalks in Row 6* . . . . . Feet & Tenths	705 .	706 .

GLEANING—1 FOOT BY 6—ROW UNITS

Check each box as completed.

	UNIT 1	UNIT 2
3. Pick up all heads attached to stalks in rows 1 through 5 (not row 6) and all heads and pieces of heads with seeds in 5 row middles. Thresh and deposit all seeds in bags. Identify bag as "Threshed seed" 1/	( )	( )
4. Pick up all loose and broken seeds in middle for each unit. Deposit in a separate bag. Identify bag as "loose seeds"	( )	( )

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

If post-harvest observations cannot be made, give reason below and mail this form to the State office.

_____ Ending Time 772

_____ Status Code 780

1/ Try threshing seeds from the heads in the field. If this is a problem, place the entire head in the bag to be sent to the lab for threshing.

FORM E: SUNFLOWER (Cont'd)

Post-Harvest Lab Determinations

6. Weight of filled seeds from heads .....(Tenths) Grams | 707 | • |

7. Weight of loose filled seed from ground .....(Tenths) Grams | 708 | • |

8. Moisture Content of seeds from 6 and 7 above 2/.....Percent (One Decimal) | 709 | • |

Date Analyzed (_____) . . Code | 710 |

2/ If sample weight is too small for moisture test, check here ☐. Sufficient seed of known moisture content will be added so that a moisture test can be made. The moisture content of the small sample can be derived using the following formula:

$$E = \frac{(A + B)\,D - (B \cdot C)}{A}$$

Where:

A = Weight (in grams) of small sunflower sample (items 6 + 7 above) _____•_____ grams

B = Weight (in grams) of additional seed for moisture test _____•_____ grams

C = Known percent moisture content of B seed. _____•_____ percent

D = Percent moisture content of A and B combined. _____•_____ percent

E = Percent moisture content of small sample (enter in item 8). _____•_____ percent

Weights and percents must be to one decimal (•).

If sample is too wet to do a moisture test, check here ☐. Combine all seeds for both units and set aside overnight to dry. Then repeat questions 6, 7, and 8.

Lab Technician _____

1983
SUNFLOWER SAMPLE
ID TAG

STATE _____

SEGMENT NO. _____

SAMPLE NO. _____

DATE _____

ENUMERATOR _____

IF PRE-HARVEST SAMPLE
CHECK ONE

UNIT 1 ( )

UNIT 2 ( )

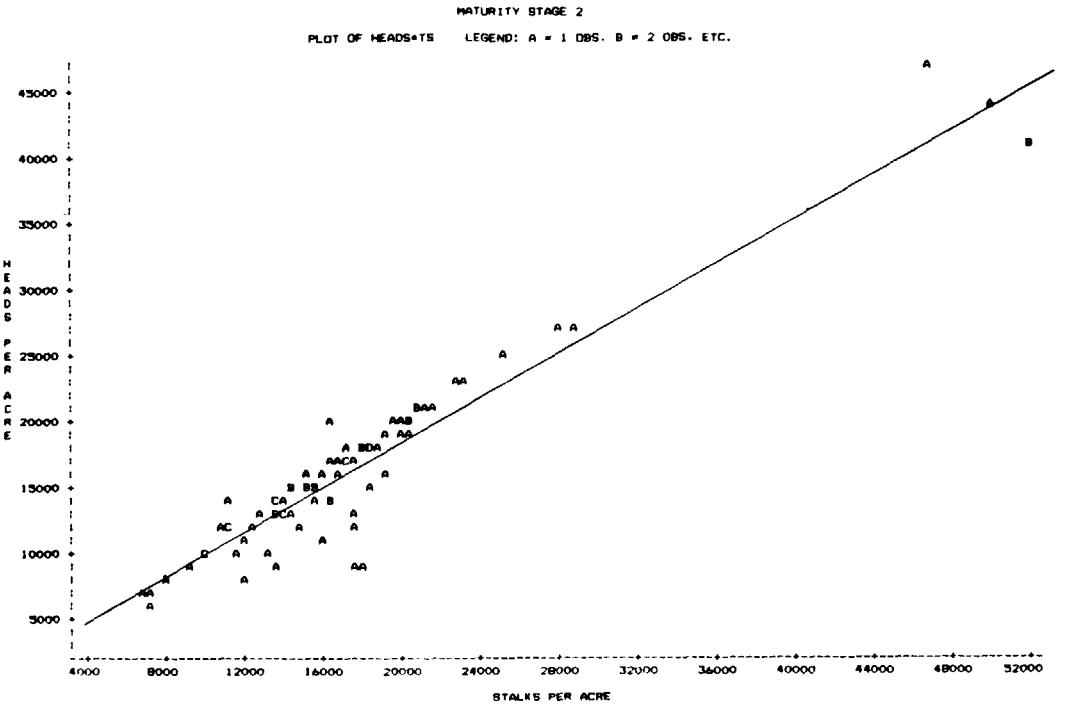
IF POST-HARVEST GLEANINGS
CHECK ONE

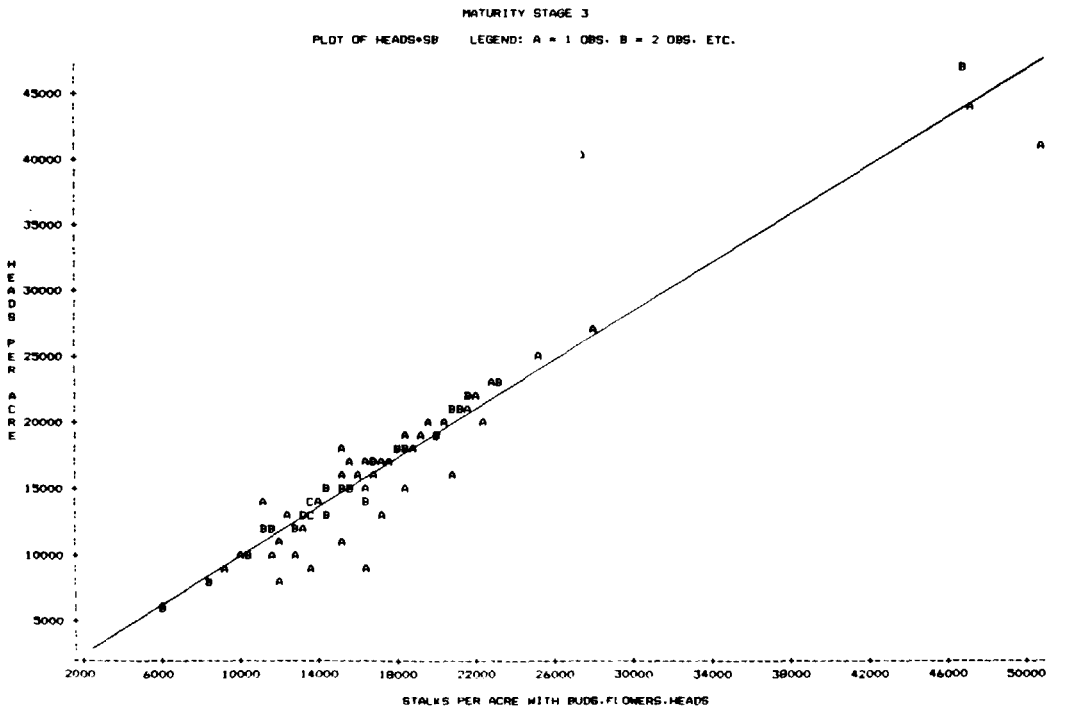
THRESHED SEED FROM HEADS ( )

LOOSE SEED FROM GROUND ( )

MAIL SAMPLE TO STATE LAB

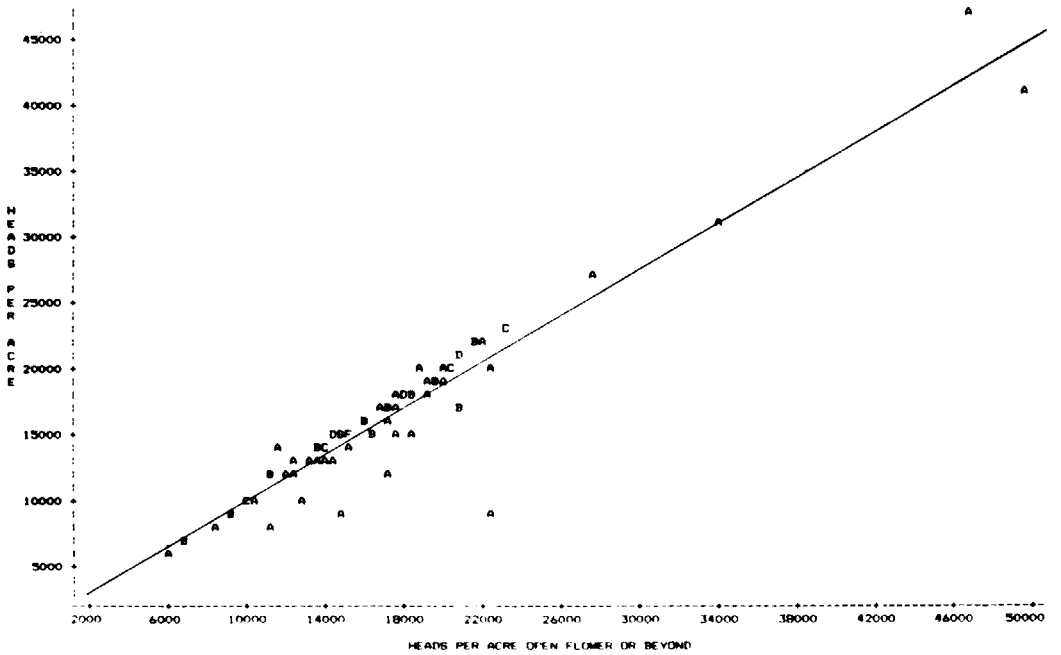
APPENDIX 2 Plots of Dependent Variables Against Independent Variables for Selected Forecasting Models





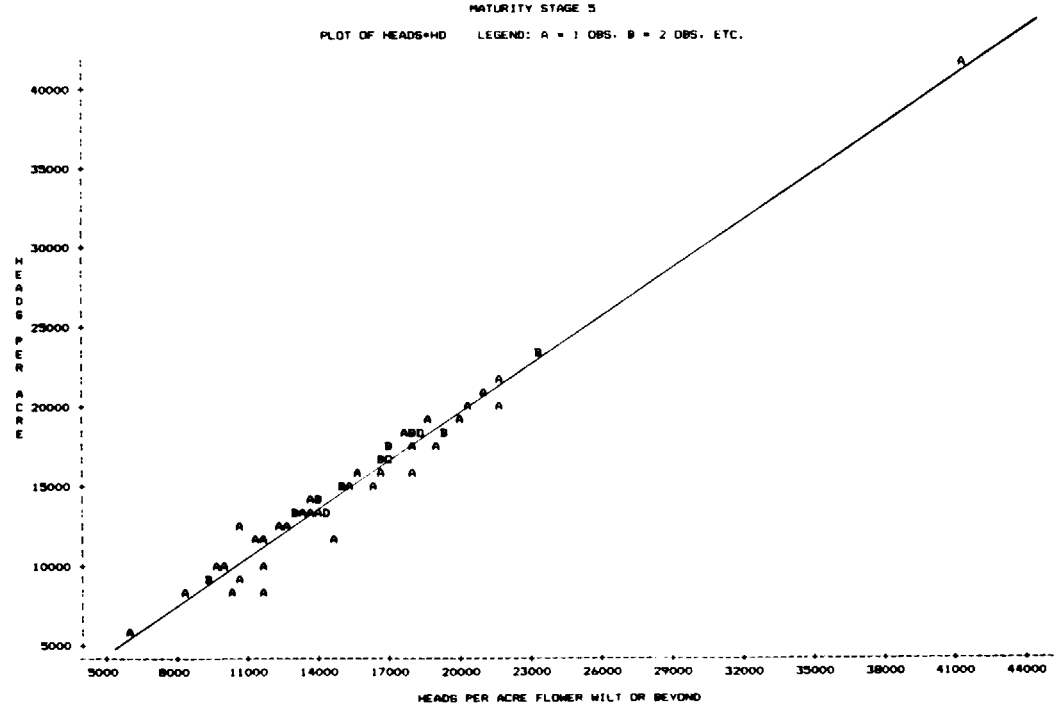
MATURITY STAGE 4

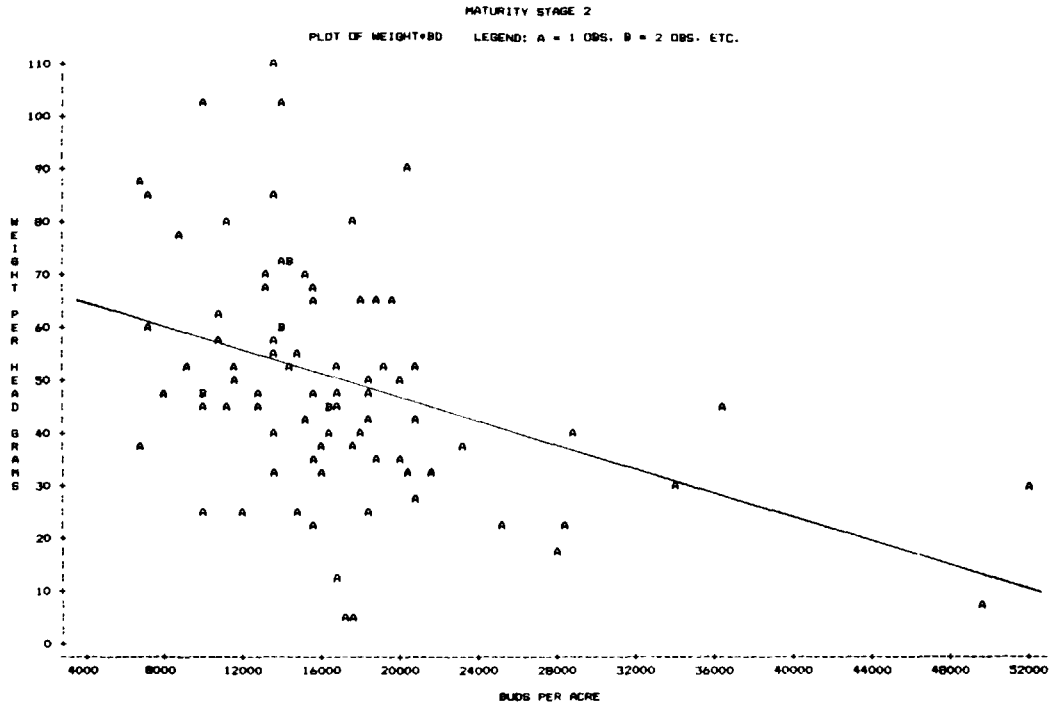
PLOT OF HEADS*FLHD LEGEND: A = 1 OBS, B = 2 OBS, ETC.

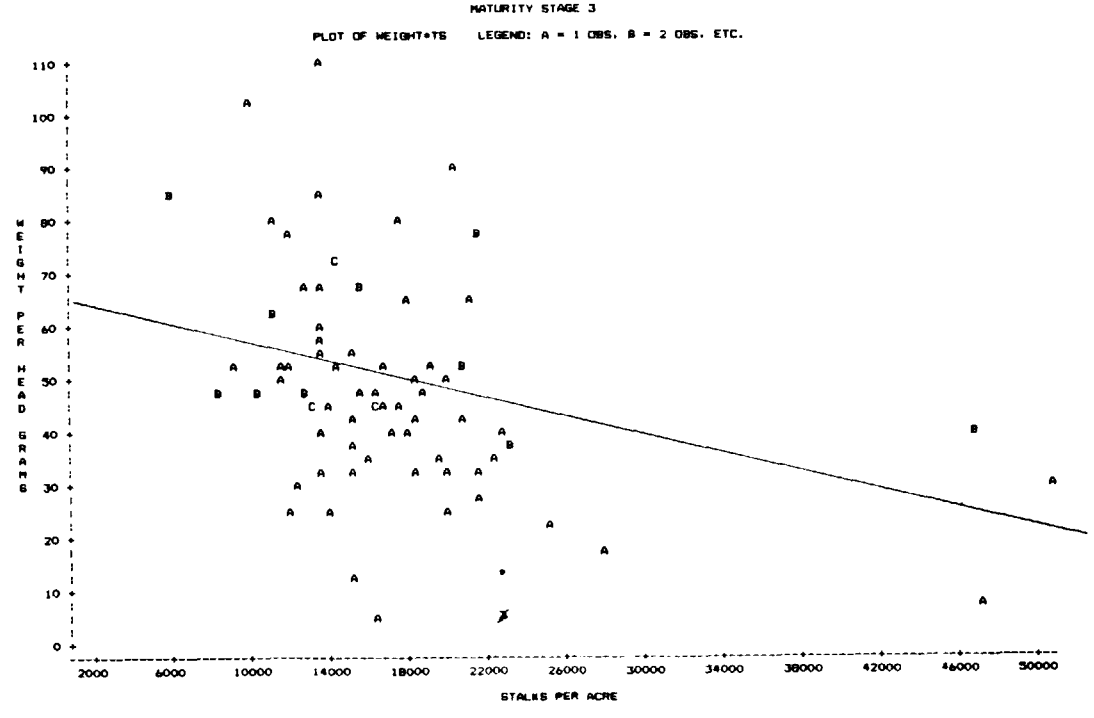


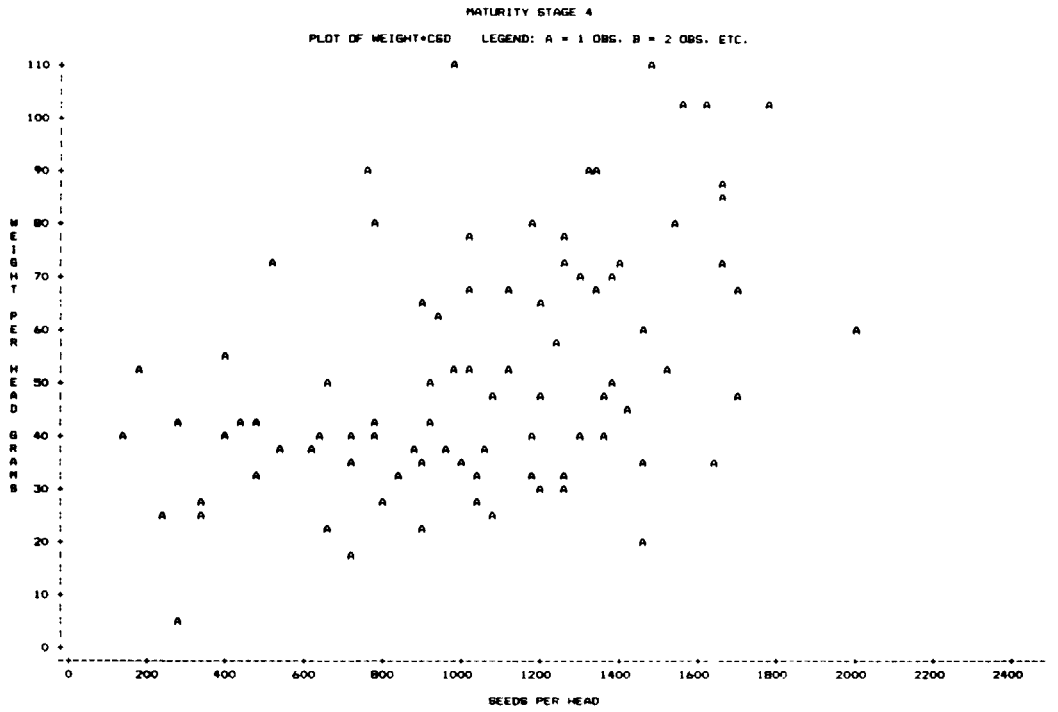
MATURITY STAGE 5

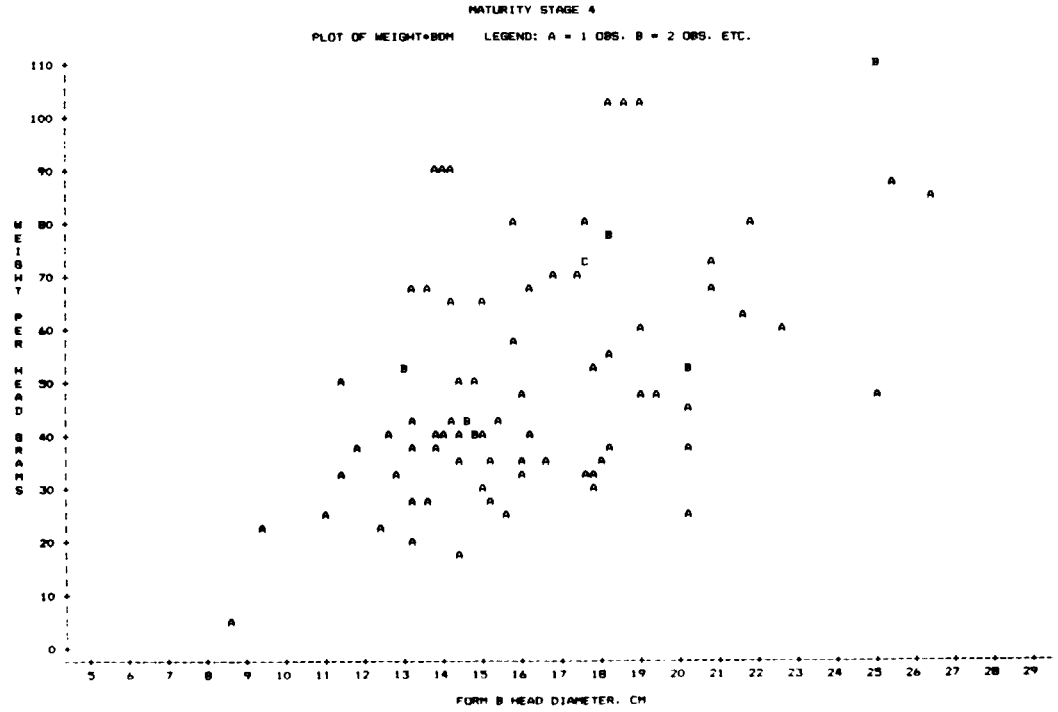
PLOT OF HEADS*HD LEGEND: A = 1 OBS, B = 2 OBS, ETC.

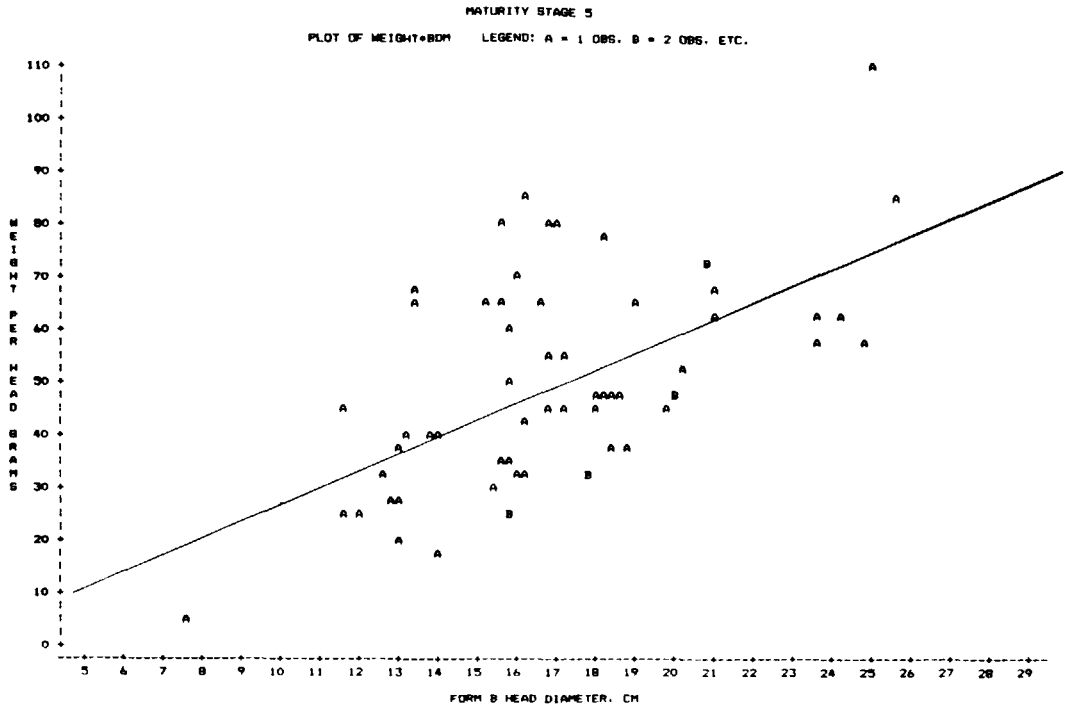



MATURITY STAGE 2
PLOT OF WEIGHT*BD LEGEND: A = 1 OBS, B = 2 OBS, ETC.
WEIGHT PER HEAD GRAMS
BUDS PER ACRE


MATURITY STAGE 3
PLOT OF WEIGHT*TS LEGEND: A = 1 OBS, B = 2 OBS, ETC.
WEIGHT PER HEAD GRAMS
STALKS PER ACRE


MATURITY STAGE 4
PLOT OF WEIGHT*CSD LEGEND: A = 1 OBS. B = 2 OBS. ETC.
WEIGHT PER HEAD GRAMS
SEEDS PER HEAD


MATURITY STAGE 4
PLOT OF WEIGHT*BDM LEGEND: A = 1 OBS. B = 2 OBS. ETC.
WEIGHT PER HEAD GRAMS
FORM B HEAD DIAMETER, CM


MATURITY STAGE 5
PLOT OF WEIGHT*BDM LEGEND: A = 1 OBS. B = 2 OBS. ETC.
WEIGHT PER HEAD GRAMS
110
100
90
80
70
60
50
40
30
20
10
0
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
FORM B HEAD DIAMETER, CM