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1981 Rice Objective Yield Study

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ABSTRACT

The purposes of this study were to develop objective procedures to estimate rice yield and to investigate procedures which use multiple regression models to forecast yield early in the season. Based on the results from 1981 in Arkansas, it is possible to estimate yield at harvest, although some potential data collection biases have not been resolved. It is possible to forecast heads per acre at maturity using early-season counts of stalks or heads. Early-season forecasts of weight of grain per head at maturity can also be made but not with a great deal of precision. Comments concerning data collection procedures are also presented.

ACKNOWLEDGMENTS

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INTRODUCTION

The Statistical Reporting Service has decided to develop an objective yield program for rice. This involves developing objective procedures to estimate yield at harvest as well as procedures to forecast yield prior to harvest. Originally at-harvest estimation procedures were to be operational in 1982, while early-season forecasts were to begin with the 1983 crop season. This timetable has been extended however, due to budgetary constraints.

A feasibility study, involving nine nonrandomly selected fields in Arkansas, was done in 1980 to evaluate the practicality of the data collection procedures. This study concluded that data collection problems prior to harvest could be overcome with proper equipment. However, post-harvest data collection problems due to muddy conditions and deep tire tracks could not be resolved. There was also much concern over field damage, not only because the damage could impair relations with the farmer, but also because damage early in the season may bias field observations at harvest.

In 1981 a more extensive study was conducted. This study involved 130 randomly selected fields throughout Arkansas. The objectives were to:

1) investigate procedures to estimate rice yield at harvest. This includes the effect of repeated visits to the field (handling effect), biases in the estimation of harvest loss due to harvesting equipment, and the effect of grain length (short, medium or long) on head weight.

2) develop regression models to forecast yield per acre. This involves building models for two components of yield -- number of heads per acre, and weight of threshed grain per head at maturity.

3) elicit comments and suggestions for improvements from enumerators and state office personnel concerning data collection procedures.

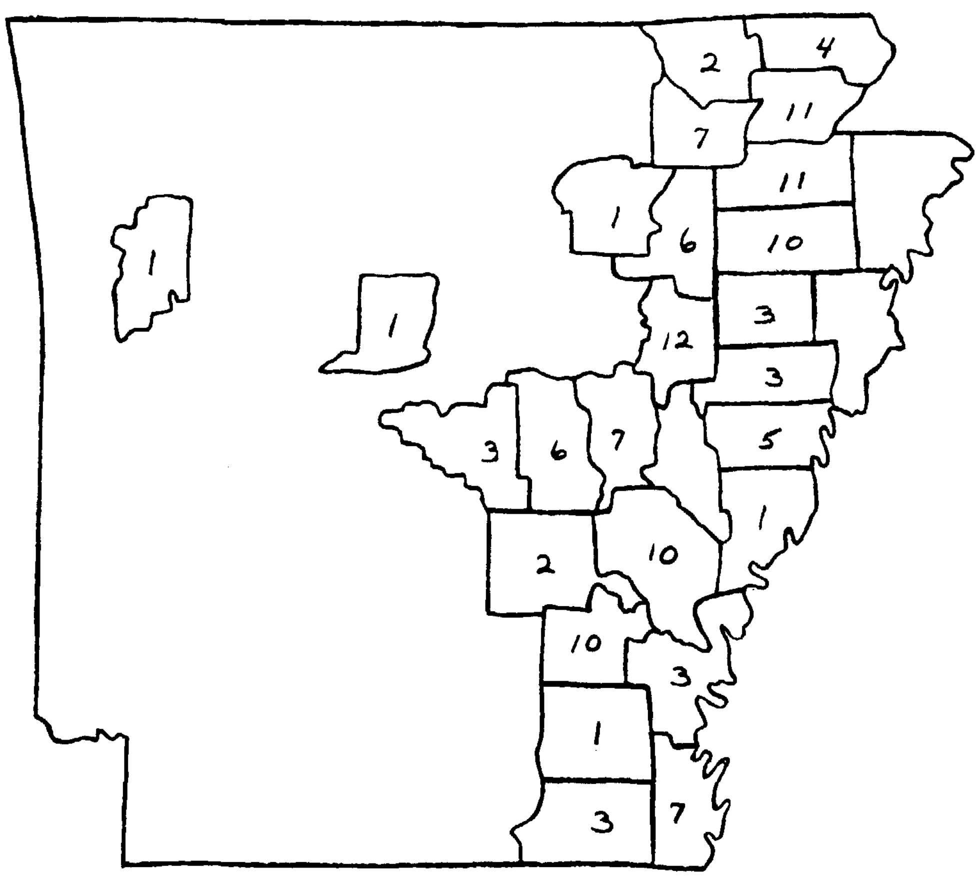
4) establish computer edit guidelines for future rice objective yield surveys.

This paper summarizes the results of the 1981 rice objective yield survey.

DATA COLLECTION

A sample of 130 fields was drawn using the current objective yield sampling scheme. The scheme is to draw the sample of fields with probability proportional to size based on expanded June Enumerative Survey (JES) acres planted (or to be planted) to rice. This procedure allows a field to be chosen for the sample more than once. However, no field was chosen more than once in the 1981 rice sample, and the number of fields and sample size are identical. Figure 1 shows the distribution of sample fields by county. As can be seen, most samples were located in the eastern third of the state.

Figure 1: Distribution of Samples by County



The sample fields were divided into two groups based on sample number. The odd-numbered samples were used only for yield estimation at harvest. Field observations were therefore only necessary immediately before and after harvest. The even-numbered samples were used to develop forecasting models and to study the effect of repeated visits to the sample field, in addition to being used for yield estimation at harvest. Field observations for the even-numbered samples were therefore made at monthly intervals beginning in August as well as immediately before and after harvest.

Field observations during the growing season and prior to harvest were made in two 21.6 inch by 3 row plots or "count units". The plot size was determined based on recommendations from the 1980 feasibility study. The first count unit was located by pacing x - number of steps along the edge of the field and y - number of steps into the field. The second unit was located 30 paces farther along the edge and into the field. If the sample field was visited more than once (an even-numbered sample), the second count unit was relocated each month. Unit 2 was located 30 paces from Unit 1 on the first visit, 35 paces on the second visit, 40 paces on the third visit, etc. Count units were not located on levees or in ditches due to the difficulty in laying out the unit. The number of rice stalks and the number of heads in the units were obtained at each field visit. In addition, all heads were clipped in the count unit when harvest was imminent. These heads were sent to the state laboratory, where they were weighed and tested for moisture content.

Because models were being developed to forecast grain weight at maturity, data on head weight early in the season were collected in "clip areas". A clip area was located near each of the two count units in the even-numbered sample fields only. Each clip area was 21.6 inches by one row. Heads in the clip area were clipped during each monthly visit, and for this reason clip areas were relocated each month.

All heads, partial heads, and loose grain were picked up in two 21.6 inch by 3 row "gleaning units" in each field after it had been harvested. These gleaning units were located approximately five paces farther away from the pre-harvest count units. Gleaning units were not located in deep tire tracks because of the difficulty in recovering grain in this area.

In addition to the field observations described above, farm operators were contacted in early August to obtain information on planting and again after harvest to obtain harvesting information. Appendix I contains a copy of all forms used. More information on unit locations, field observations and laboratory procedures is contained in the 1981 Rice Objective Yield Research Study Enumerator's Manual and the Rice Editing Manual.

The data were edited using the Generalized Edit (GE) System. The Rice Editing Manual describes the editing codes, errors, and record layout. The data were summarized using the Statistical Analysis System (SAS). Copies of the programs and data can be obtained from the Yield Research Branch.

ASSUMPTIONS

Failure to obtain information for a sample, due to farmer refusal or inaccessibility, may introduce bias into sample estimates. Table 1 gives some indication of the magnitude of nonresponse for this study. The amount of bias in the estimates is dependent on both the proportion of samples with missing information and the difference in the estimates between the respondents and nonrespondents. It has been assumed throughout the following analysis that there is no difference in yield component estimates between the nonrespondents and the respondents. Rather than imputing the sample average, as was done, averages based on JES land use strata could have been imputed. The procedure was not used because the distribution of samples (see Table 2) is such that most samples fell in one stratum. Imputations for the other strata would be based on as few as one observation and at most ten observations. Furthermore, it is unlikely that yield estimates differ greatly among land use strata since production practices (land leveling, flooding, etc.) are essentially the same. There would seem to be more variability within strata due to management differences than across strata.

Table 1: Summary of Responses to Farmers Interview

Response	Initial Interview		Post-Harvest Interview	
	Frequency	Percent	Frequency	Percent
Completed Interview	118	90.8	105	80.8
No Rice in Tract	4	3.1	4	3.1
No Rice in Sample but Rice in Tract	2	1.5	2	1.5
Refusal/Inaccessible	6	4.6	15	11.5
Missing	0	0.0	4	3.1
TOTAL	130	100.0	130	100.0

Table 2: Distribution of Samples by JES Land Use Stratum

Stratum	Frequency	Percent
75-100% Cultivated	109	83.8
50-74% Cultivated	8	6.2
15-49% Cultivated	11	8.5
Range (<15% Cultivated)	2	1.5
TOTAL	130	100.0

All variances were computed using the formula for simple random sampling. This is the procedure used in all operational objective yield programs. It was therefore felt that the variances should be computed in the same manner to maintain comparability among the various objective yield programs.

The validity of computing variances in this manner is open to debate since it may not adequately represent the sampling design. The effect of the actual sampling scheme (expanded JES acreages are sorted by JES land use strata and a systematic sample of acres is then taken) in variance computations is being investigated. This problem is the subject of a separate report and is not addressed in this paper. It is recommended that this problem be resolved as soon as possible since the computation of the variances affects all standard errors, tests of hypotheses, and confidence intervals, and therefore all conclusions. Any changes in variance estimation and/or sampling scheme should be made in all operational programs in addition to research projects in order to maintain comparability.

AT-HARVEST ESTIMATION

Yield

A final estimate of the net yield per acre at harvest in bushels adjusted to 12% moisture, was calculated using the data from the final pre-harvest field visit, the laboratory work on the mature samples, and the post-harvest gleaning field work. Yields were reported in bushels because Arkansas uses this unit of measure for rice. The value for moisture adjustment was chosen to be 12% because this value apeared to be a suitable value for all states potentially involved in rice objective yield surveys. Currently, each state adjusts its own rice estimates to a state defined moisture content, and the state estimates are then summed to a U.S. estimate.

Therefore there is no national moisture content, and state moisture levels may vary from state to state and year to year. Arkansas currently uses 10% as the dry weight moisture content value. As can be seen on the forms, the post-harvest gleaning form inadvertently did not ask for the moisture content of the grain. However, verbal instructions were given to the state office and this value was obtained.

The formula used for estimating yield per acre followed the pattern of the formula used in the wheat objective yield program. Basically the formula is as follows:

Net yield per acre = Heads per acre x Weight of grain per head - Harvest loss per acre, where

$$\text{Heads per acre} = \frac{\left(\text{Number of late boot + emerged + detached heads in both units}\right) \times 43560}{\left(\left(\begin{array}{l}\text{Unit 1 5 row widths +}\\ \text{Unit 2 5 row widths}\end{array}\right) \div 5\right) \times 1.8 \times 3}$$

$$\text{Weight of grain per head} = \frac{\left(\text{Threshed weight of grain in grams}\right) \times \left(\text{Threshing loss adjustment factor}\right) \times \left(1 - \text{Moisture content}\right)}{\left(\text{Number of heads threshed}\right) \times 45 \times 453.6 \times (1 - .12)}$$

$$\text{Harvest loss per acre} = \frac{\left(\text{Weight of gleaned grain after threshing}\right) \times 43560 \times \left(1 - \text{Moisture content}\right)}{\left(\left(\begin{array}{l}\text{Unit 1 5 row width +}\\ \text{Unit 2 5 row width}\end{array}\right) \div 5\right) \times 1.8 \times 3 \times 453.6 \times 45 \times (1-.12)}$$

5 adjusts five row widths to one row,
43560 is the number of square feet in an acre,
1.8 is the length in feet of one row (21.6 inches),
3 is the number of rows in one unit,
45 is the number of pounds in a bushel of rice, and
453.6 is the number of grams in a pound.

Originally, the net yield per acre was to be computed for each sample and averaged. However, the state office only put post-harvest gleaning forms in the even-numbered sample kits. The enumerators did not question the absence of gleaning forms for odd-numbered samples, so approximately half of the gleaning data was lost. Therefore, the gross yield (heads per acre x weight of grain per head) and harvest loss were computed for each sample and averaged. The averages were then differenced. The estimates are summarized in Table 3.

Table 3: Summary of Yield Estimates

Variable	n	Mean	Std. Error	C.V.
Heads per acre	112	1,351,675	47,535	3.5%
Wt. per head (gr)	109	1.911	0.0667	3.5%
Gross yield (bu)	109	120.0	4.08	3.4%
Harvest loss (bu)	54	9.3	1.95 3/	20.9%
Net yield (bu) 1/	49	103.6	5.49	5.3%
Net yield (bu) 2/	109	110.8	4.52	4.1%

1/ Calculated on a sample basis and then averaged. Some harvest loss observations did not have corresponding gross yield observations.
2/ Calculated as the average gross yield - average harvest loss.
3/ The large amount of variability in harvest loss is due to lodging in some samples. The distribution of harvest loss per acre is therefore skewed.

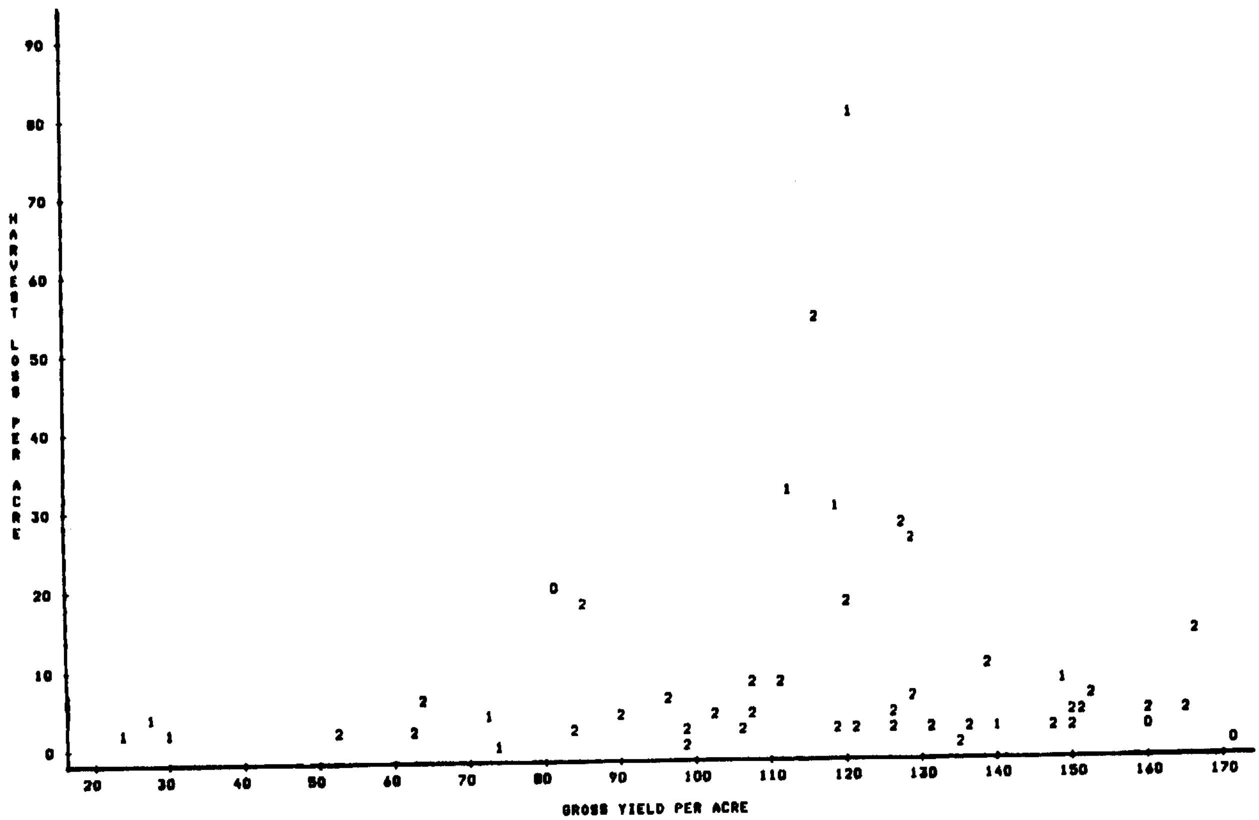
The estimate of net yield expressed as the difference between average gross yield and the average harvest loss has a smaller standard error than the estimate based only on an average net yield for the even-numbered samples. This estimate is used in all subsequent references to net yield. No additional bias is introduced in the "difference" estimates because harvest loss is based on a random subsample of the sample.

Other estimates of net yield were computed in an attempt to find a more precise estimator. One procedure involved double sampling with a regression or ratio estimator. When post-harvest gleaning data were available, a net yield estimate was made using the available data. When gleaning data were missing, a net yield estimate was made by assuming harvest loss was a function of gross yield. The function was determined using the samples for which gleaning and gross yield data were available. This procedure is similar to the one used in the corn objective yield survey. The corn program determines the function based on previous years' data rather than current data, however. As can be seen in Figure 2, there is a problem with the distribution of harvest loss in that there are a few extremely large harvest loss observations. The correlation between harvest loss and gross yield is extremely small (r=.07). For this reason, the double sampling estimator was not more precise that the "difference" estimator.

Figure 2: Plot of Harvest Loss Per Acre vs Gross Yield per Acre

Symbols are:

0 - indicates unknown damage code
1 - indicates farmer reported significant damage
2 - indicates farmer reported no significant damage



A second estimation procedure involved stratifying the harvest loss data based on the farmer's report of significant field damage. Three strata were used: (1) significant damage, (2) no significant damage, and (0) no response. Means were calculated for each stratum based on the available post-harvest gleaning (Form E) data, while the percentage of fields in each stratum was estimated using the available post-harvest interview (Form D) data. The estimate of harvest loss using this procedure was 8.8 with a standard error of 1.98, as compared to the estimate based on available Form E data of 9.3 (S.E.=1.95). The problem with the stratification used is that there is no way to identify whether the damage occurred at harvest or during the growing season (and thereby affected the gross yield estimate rather than harvest loss estimate). Half of the respondents with significant field damage did not specify the source of the damage. Those who did, cite various reasons for damage. The most common reason was lodging, which would affect the harvest loss estimate. However, other reasons included bird damage, grasshopper damage, smut, and lack of water early in the season, which would affect the gross yield estimate. Future work should continue the investigation of stratification with more detailed responses to the significant damage question being required.

In order to assess the accuracy of the net yield estimate, the farmer's estimate of yield per acre adjusted to 12% moisture was calculated based on the data from the post-harvest interview. Approximately half (49.5%) of the farmers used weight tickets for calculating yield. The average net yield reported by the farmers was 105.3 bushels per acre with a standard error of 2.12 (n=107). Using a paired t-test and assuming average harvest loss when gleaning data were not available, the average difference in yield (objective yield - farmer reported) was 5.9 bushels, which was not significantly different from zero at the $\alpha = .05$ level (t=1.385, n=99, std. error=4.26). However, because the standard error is large in relation to the mean (72%), this test is not very powerful. A difference of approximately 8.5 bushels per acre would have to occur in order to find a statistically significant difference in the two estimates. Another estimate of net yield is the final Crop Reporting Board Estimate, which was 100.89 bushels per acre at 10% moisture (103.18 when adjusted to 12% moisture).

Two problems concerning rice estimates at harvest were not addressed in this study. No units were located on levees or ditches, thus creating a potential bias in the yield estimate. Rice grown on levees is more subject to damage from weeds and moisture stress, and may have a larger or smaller plant stand depending on whether or not the levee was reseeded. Samples were not located in the levees and ditches for two reasons;

(1) Working on the levees may damage them and thus cause considerable damage to the field. Cooperation with the farmers would probably become strained.

(2) Laying out units on the levees or ditches would be difficult, time consuming, and subject to error. This is particularly true if the unit only partially fell on the levee or ditch.

It was felt that the bias caused by not locating units on the levee or ditches should remain constant over the years and therefore "read out" once an historical data base has been established. At this time, there are no data to support this assumption. Future work should examine this problem at the final pre-harvest visit. However, risk of damage to the levees is too great to examine the problem earlier in the growing season.

The second problem not investigated was that no post-harvest gleaning units were located in tire tracks. Rice fields are still muddy at harvest since the field is flooded earlier in the season. The wide tires of the combine therefore push the loose rice grain deep into the mud where it is extremely difficult, if not impossible, to extract. For this reason, no data collection method which accurately defined units and allowed enumerators to glean from the units in tire tracks could be designed. When the combine used a straw spreader, it was felt that the harvest loss would be relatively uniform. Therefore, little or no bias would be injected into the estimate if plots were not located in tire tracks. Informal observation supports this belief; however, no data were collected to test this hypothesis. The bias in estimated harvest loss when the combine is not equipped with a straw spreader was not assumed to be zero, because all harvest loss would be located in two lines parallel to the tire tracks. Harvest loss was expected to be overestimated in these cases. An unpaired t-test to compare harvest loss per acre for the two combine capabilities had been planned. However, because only four gleaning samples were harvested using a combine not equipped with a straw spreader, no conclusions could be drawn, and this analysis has been omitted from this paper. Because so few operators in Arkansas (7.6%) do not use straw spreaders, it is not recommended that the difference in harvest loss due to combine capabilities be investigated further. If the program is extended to states where combines without straw spreaders are more common, or if these combines become more common in Arkansas, then further investigation is warranted. It is also not recommended that bias in harvest loss when combines are equipped with straw spreaders be formally studied because any conclusions from a study of this type would be suspect due to possible bias and error in the data collection procedures in the tire tracks.

Acreage Estimates and Production Estimates

The estimate of planted acres of rice from the June Enumerative Survey was revised to reflect the acres for harvest. Data from the two objective yield interviews (Forms A and D) were used to make the revisions. The first revision was made in August, and involved calculating the average ratio of rice acreage to be harvested in the tract as stated on the A Form to the rice acreage planted (or to be planted) in the tract at the time of the JES. Refusals were excluded from the calculations. The ratio was calculated to be 0.95, and the revised estimate was 1,510,513 acres of rice for harvest in Arkansas (the JES estimate was 1,583,344). The standard error of the adjusted acreage was approximately 142,000.

The second acreage adjustment was based on field level data from the post-harvest interview (Form D). The ratio of rice acres for harvest as stated on the D Form to the rice acres for harvest in the field as stated on the A Form was computed. Refusals and missing data were excluded from the computations. The average ratio was 1.005, so that the second adjusted acreage estimate was 1,518,083 acres with a standard error of approximately 144,000.

Production estimates from objective yield surveys are not traditionally made. However, using the objective yield indications for yield and acreage, the total production in Arkansas was estimated to be 168,238,589 bushels. The Crop Reporting Board estimate was 155,395,600 bushels (158,927,300 if adjusted to 12% moisture). The objective yield estimate is therefore 5.9% higher than the Crop Reporting Board estimate. The Board estimate is within the 95% confidence interval around the objective yield estimate, however.

Handling Effect

According to information obtained on the initial interview, 46% of the rice acreage is planted using a broadcast method of seeding. The remainder of the acreage is sown in 6 inch drill rows. It is therefore difficult to walk through and make counts in a rice field without coming into a great deal of contact with the plants. In addition, the flooded field conditions early in the season make walking even more difficult, and cause the root systems of the plant to remain close to the surface. Thus walking in the mud should affect the root system and will knock plants over. When the field is flooded, the plant will usually rebound after being knocked over. However, later in the season when the field is drained, the plants do not recover after being knocked down.

These unfavorable conditions create a situation where the sample unit and its surrounding areas are likely to be damaged due to repeated handling. If the damage is severe enough, the unit may no longer be representative of the unhandled areas. The yield in the unit may be reduced due to damage to the plants in the unit, or it may be increased due to damage to the surrounding competition. One method of eliminating the handling effect is to relocate the unit each month so that only previously unhandled plants are observed. This not only requires additional work by the enumerator to lay out a new unit each month and additional destruction in the field, but it also requires that different plants be observed each month. While relocation would reduce any nonsampling errors due to repeated handling of the plants, the variability of the plants within the field will affect the usability of the counts in relocated plots in constructing forecast equations.

In order to investigate the effect of repeated handling on the unit and the surrounding areas, units 1 and 2 in the even-numbered samples were treated differently. Unit 1 was located on the first visit and repeatedly observed each month until maturity, while Unit 2 was relocated each month. The relocation was such that Unit 2 could not be located in a previously observed area.

A multiple paired t-test (Bonferroni method) was used to test the hypothesis that there is no difference between the units. This test takes into account that high correlations among variables affect the significance levels of the comparisons when several tests are made concurrently. The null hypothesis that the difference in counts between the units for a single variable equals zero is rejected if

$|\bar{d}/s_{\bar{d}}| > t(1-\alpha/2K, n-1)$, where

$\bar{d}$ is the mean difference between units 1 and 2

$s_{\bar{d}}$ is the standard error of the mean difference

K is the number of variables being concurrently tested

n is the number of observations

The multivariate hypothesis that there is no difference between units over all variables, is rejected with a significance level less than or equal to α if at least one of the individual comparisons is rejected.

The multiple paired t-test was done for each month since this indicates the number of times Unit 1 had been handled. In addition, the test was done on all mature samples since a significant difference between units at maturity would indicate a significant effect on the estimate of yield at harvest. The counts were converted to a per acre basis in order to eliminate any plot size effects due to differing row widths, while the weight of the heads (late boot and emerged) was put on a per head basis. As can be seen in Table 4, no significant differences exist for any month or at maturity. This would indicate that no damage to the unit occurred, or that the damage within the unit was offset by damage to the surrounding competition. One warning is in order however: the rice crop matured quickly in 1981 so that most fields were only visited twice. In future years, three visits should be more common, and one would expect the damage to be more apparent with additional visits. It is therefore recommended that this problem be studied for an additional year.

Table 4: Summary of Handling Effects

Month	Variable	n	Mean of Unit 1	Mean of Unit 2	$\bar{d}$ (Unit 1-2)	Std. error	t 1/
Aug	Stalks	62	1,171,400	1,128,100	43,300	52,019	0.83
	Late Boot	62	224,935	247,197	-22,262	35,349	-0.63
	Emerged	62	660,619	635,988	24,631	50,670	0.49
	Detached	2	0	0	0	---	---
	Head Wt.	39	0.856	0.807	0.049	0.6804	0.72
Sep	Stalks	9	1,595,901	1,169,101	426,800	286,676	1.49
	Late Boot	54	66,958	34,440	32,518	14,630	2.22
	Emerged	54	1,265,284	1,202,320	62,964	74,454	0.85
	Detached	39	2,326	3,256	-930	1,320	-0.70
	Head Wt.	48	2.224	2.247	-0.022	0.1020	-0.22
Oct	Stalks	1	1,317,556	1,169,667	147,889	---	---
	Late Boot	11	1,222	0	1,222	1,222	1.00
	Emerged	11	1,325,039	1,275,331	49,708	76,032	0.65
	Detached	10	0	0	0	---	---
	Head Wt.	10	2.190	2.105	0.085	0.1403	0.61
Mature	Stalks	--	---	---	---	---	---
	Late Boot	51	2,966	3,427	-461	4.007	-0.12
	Emerged	51	1,377,330	1,265,802	111,528	62,833	1.78
	Detached	51	1,779	2,490	-711	1,008	-0.70
	Head Wt.	50	2.232	2.208	0.024	0.0802	0.30

1/ No significant differences in paired means at the overall multiple-t significance level of α =.05.

Grain Type Effect

As can be seen in Table 5, 80% of the acreage is planted to long grain rice, 18% to medium grain, and 2% to short grain rice. With such small percentages planted to short and medium grain varieties, it is advantageous to be able to group all grain types together when creating forecast equations. However, if there is a large difference in weight per head for the grain types, it may be necessary to build the regression equation for each grain type separately, or to build regression equations for one grain type and adjust them for other types. This is particularly true if early season weights are not correlated with late season weights, and historic averages must be used for forecasting.

Table 5: Summary of Varieties of Grain Type

Variety	Frequency	Percent	Standard Error
Nortai	2	1.7	1.19
Total Short Grain	2	1.7	1.19
Mars	16	13.6	3.16
Nato	5	4.2	1.86
Total Medium Grain	21	17.8	3.54
Labelle	29	24.6	3.98
Lebonnet	9	7.6	2.45
Starbonnet	57	48.3	4.62
Total Long Grain	95	80.5	3.66
Total All Types	118	100.0	

The mean weights of grain per head in grams for each grain type are as follows:

Grain Type	n	Mean	Std. Error
Short	2	1.79	0.378
Medium	20	2.04	0.121
Long	84	1.90	0.080
Total	106	1.93	0.068

Because there are so few observations in the short grain category, no conclusions can be drawn. It appears that grain types can be grouped together. This problem should be investigated further if grain type is more evenly distributed in the future.

FORECASTING MODELS

In order to provide forecasts of yield per acre early in the season, three components of yield must be forecast: heads per acre at maturity, weight of grain per head at maturity, and harvest loss per acre. Using early season counts and weights from the even-numbered samples, attempts were made to build multiple regression models which would forecast heads per acre and weight of grain per head at maturity.

Separate models were built for each maturity category (see Appendix II for a description of maturity categories) because the relationships between early season and late season variables are often dependent on the growth stage. It has been assumed that the relationships between early season and late season counts are not dependent on JES land use stratum or on the size of the tract or field. Therefore, no adjustments in the regression equations were made due to sampling design. If this assumption is not correct, estimates of the regression coefficients as well as all variances may be biased. It is therefore recommended that this problem be investigated more fully in a separate report, since it is beyond the scope of this paper.

Heads per Acre

The number of heads (late boot, emerged, and detached) at maturity in Unit 1 was used as the dependent variable. The data from Unit 2 were not used since this unit was relocated every month. The early season counts of number of stalks, late boot heads, and emerged heads were used as independent variables. The correlations between the various independent and dependent variables were obtained for each maturity category. The following correlations between variable 1 and variable 2 were significant at the $\alpha = .05$ level:

Maturity	Variable 1	Variable 2	n	r	Pr > |r|
Early Boot (2)	late boot heads	emerged head	10	.94	.0001
Late Boot (3)	heads at maturity	stalks	27	.70	.0001
	heads at maturity	emerged heads	27	.40	.0362
Milk (4)	heads at maturity	stalks	11	.92	.0001
	heads at maturity	late boot heads	11	.74	.0087
	heads at maturity	emerged heads	11	.91	.0001
	stalks	late boot heads	12	.77	.0032
	stalks	emerged heads	12	.97	.0001
	late boot heads	emerged heads	12	.63	.0282
Soft Dough (5)	heads at maturity	emerged heads	7	.93	.0026

As can be seen, the dependent variable, heads at maturity, is correlated with an early season count beginning with the late boot or flower maturity stage. In addition, significant correlations between the so called "independent" variables exist in the early boot, late boot and milk stages. Appendix

III presents plots of the "independent" vs "independent" variables which also illustrate the problem of collinearity. In an attempt to eliminate the problem of collinearity among the independent variables, the number of late boot and emerged heads were summed to form the variable, number of heads. The correlations among heads at maturity, number of stalks, and number of heads, which were significantly different from zero at the α =.05 level, were:

Maturity	Variable 1	Variable 2	n	r	Pr > |r|
Late boot (3)	heads at maturity	stalks	27	.70	.0001
	heads at maturity	heads	27	.62	.0006
	stalks	heads	30	.52	.0032
Milk (4)	heads at maturity	stalks	11	.92	.0001
	heads at maturity	heads	11	.93	.0001
	stalks	heads	12	.99	.0001
Soft Dough (5)	heads at maturity	heads	7	.93	.0024

Several stepwise regressions were run by maturity category, using α =.50 as the significance level for entrance into the model and α =.10 as the significance level for staying in the model. One model used numbers of stalks, its squared value, and its square root as the independent variables. The natural log of number of stalks for the late boot maturity category was also used as an independent variable, since this function appeared appropriate based on a plot of the data (Figure 3). Another model used number of heads, its squared value, and its square root as the independent variables. A third model used all of the above independent variables. The "best" equations were then compared for each maturity category. One regression per maturity category was chosen based on a comparison of R^2's and mean square errors. This equation was then evaluated to determine whether the stepwise regression had successfully eliminated the collinearity problems, and whether influential data points (i.e., points which exert substantially more influence in model fitting than other points) were contaminating the results. If collinearity remained in the regression equation, one of the redundant variables was deleted and the model rerun. Plots of the residuals against the predicted values and independent variables were obtained. If the residual plots indicated that the assumptions of normality and constant variance were violated, the equation was not considered "best". The residual plots are not reproduced here because of space considerations. However, plots of the data (Figures 3 and 4) are presented. Since there were so few observations in each maturity category, similar maturity categories were combined (i.e., categories 1 and 2, and 4 and 5). This was a logical decision since the relationships between variables appeared similar from inspection of the plots. The additional data should provide more stable and more precise parameter estimates. In addition, influential data points which were contaminating the results were deleted. For example, the two points circled in Figure 7 were completely determining the slope of the regression line. Because they were also very distant from all other points, and thus may have represented a different sub-population of the data, they were deleted from the analysis. An iterative procedure which would have used these points in model fitting but given them less weight was not employed because of cost. Table 6 lists the "best" forecasting regression equations.

Figure 3: Plot of Heads at Maturity vs. Number of Stalks
Symbol is the Maturity Category

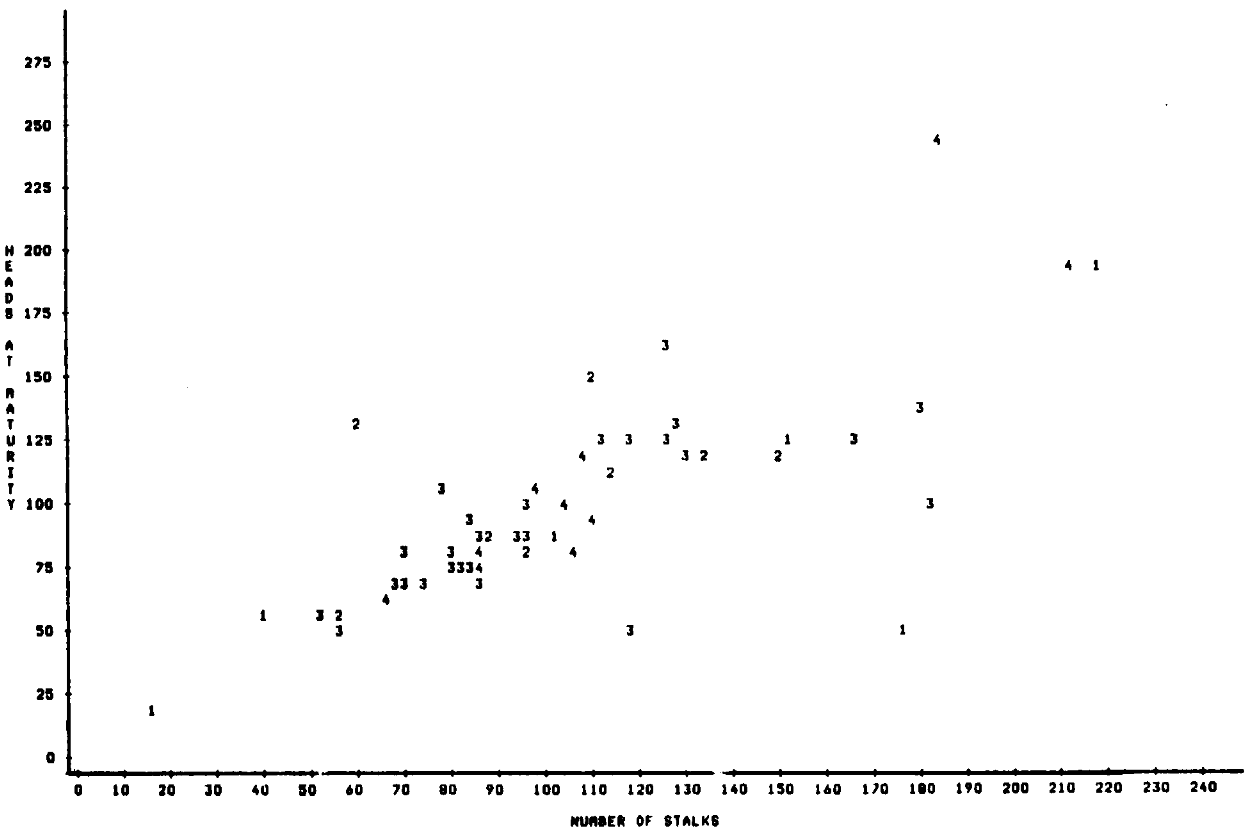


Figure 4: Plot of Heads at Maturity vs. Number of Heads
Symbol is Maturity Category

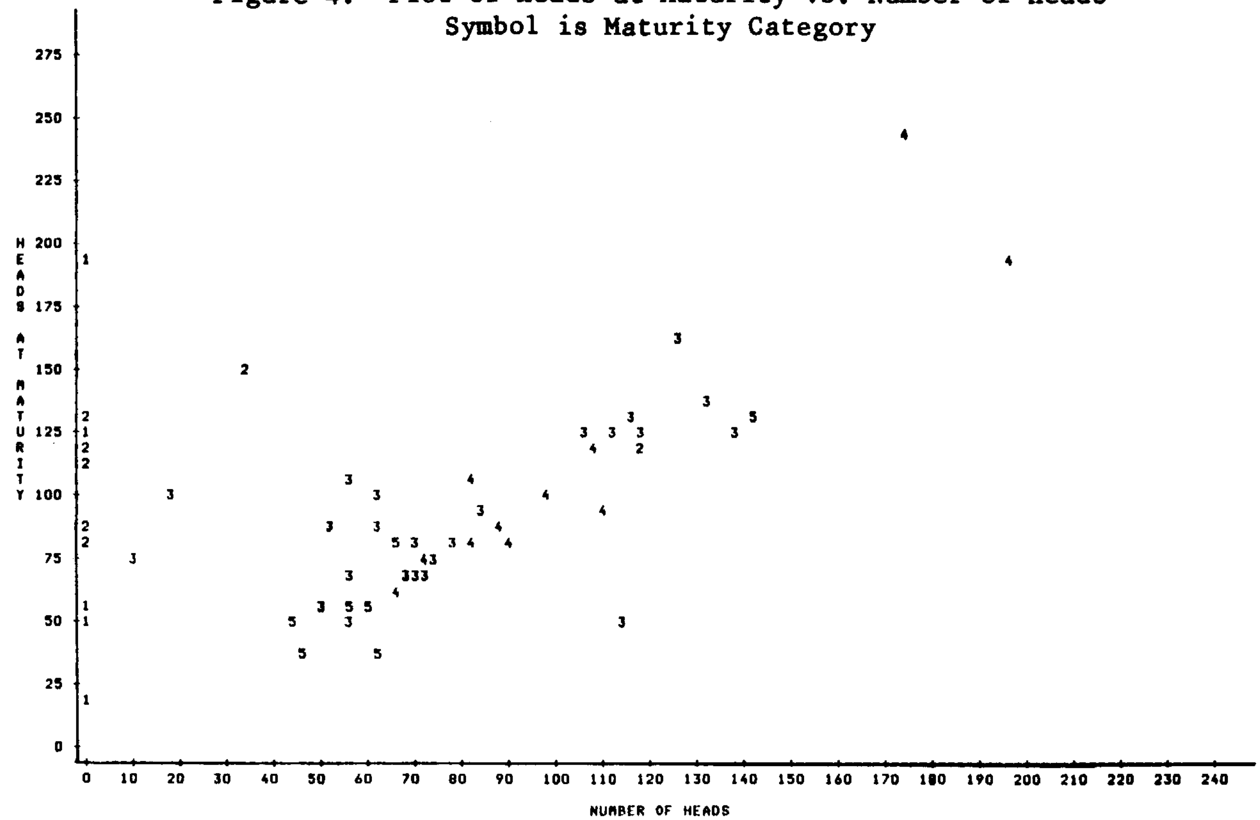


Table 6: "Best" Regression Equations - Number of Heads

Maturity Category	R^2	n	MSE	Equation
Pre-boot (1)	.61	6	1982.174	37.5882 + 0.0027 (# stalks) ^{2}
Early boot (2)	-	8	-	Historic average
Pre-boot & Early boot (1&2)	.88	12*	285.961	15.9234 + 0.800884 (# stalks)
Late boot (3)	.61	26*	364.897	-251.949 + 76.2098(ln(#stalks))
Milk (4)	.85	11	465.284	-17.9716 + 1.2327 (# heads)
Soft dough (5)	.86	7	190.211	1.6405 + 0.9377 (# heads)
Milk and Soft dough (4&5)	.83	16*	141.538	2.7930 + 0.9560 (# heads)

* Some observations were deleted when building the model

Plots of the data with the regression equations are found in Figures 5 through 7. Influential data points which were not used during model building are circled. It should be noted that Methods Staff traditionally forces all intercepts and slopes to be positive, since the dependent variable (in this case, number of heads) must be positive. If a parameter estimate is negative, the model is rerun without an intercept. This philosophy was not used in this study, as can be noted in the equations for maturity categories 3 and 4.

Strong conclusions cannot be drawn from only one year's data with so few observations. However, it does appear that the number of heads at maturity can be forecast early in the season by using number of stalks and number of heads as independent variables. With additional data, the exact nature of each forecasting equation can be more firmly established.

Figure 5: Plot of Predicted (P) vs Actual (A)
Heads at Maturity - Maturity Categories 1 and 2

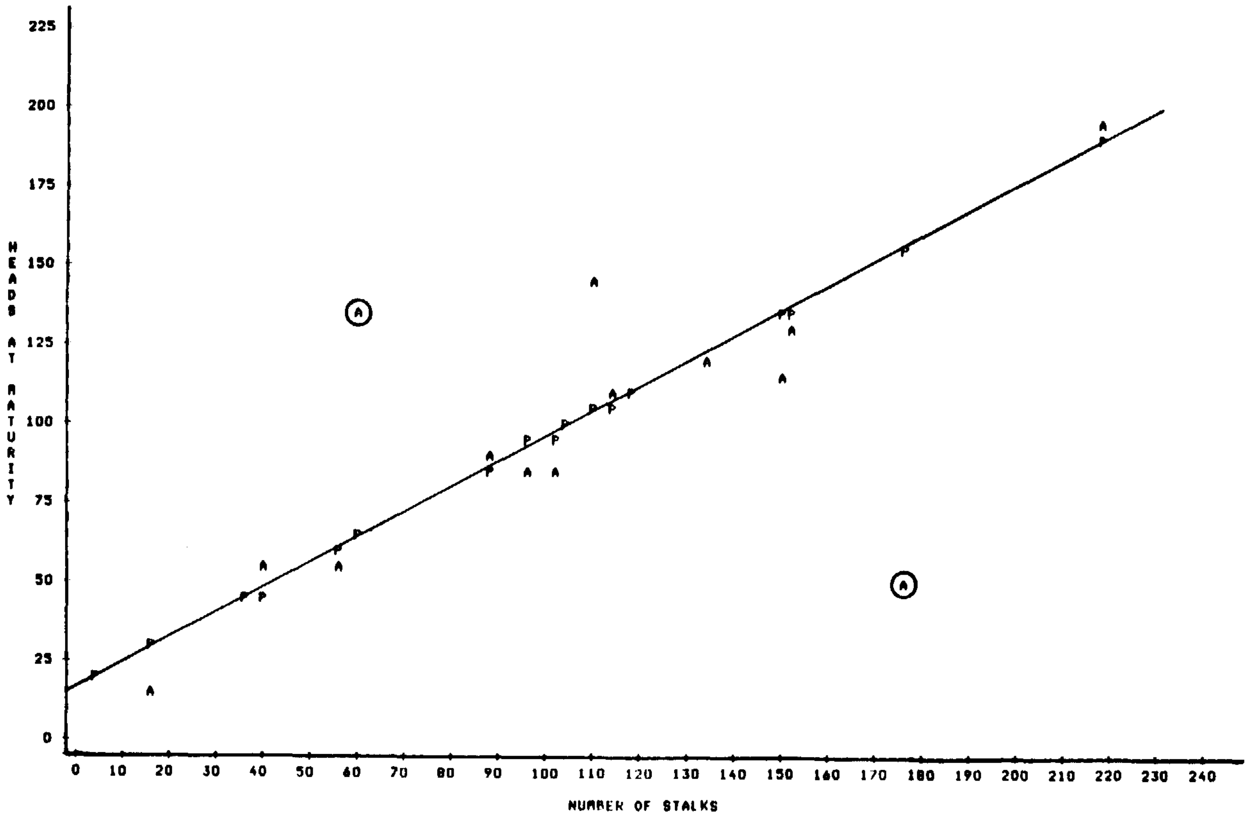


Figure 6: Plot of Predicted (P) vs Actual (A)
Heads at Maturity - Maturity Category 3

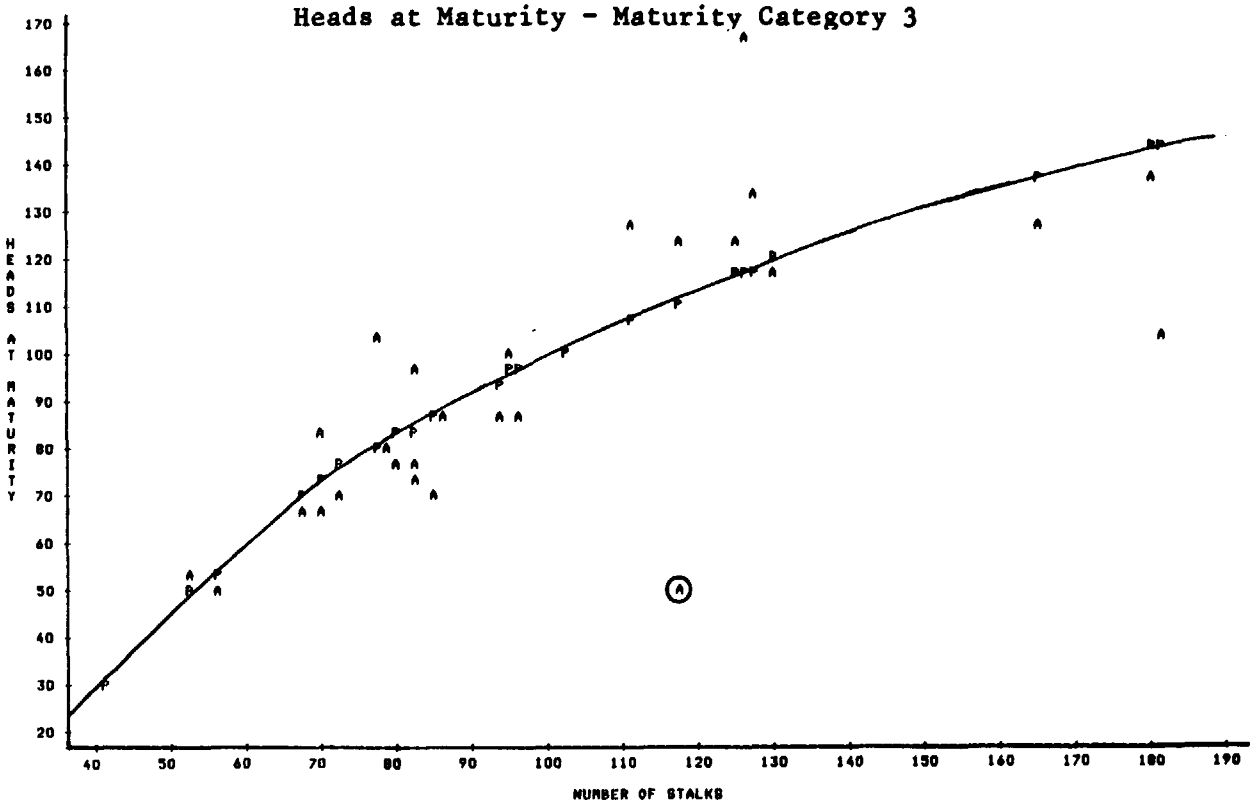
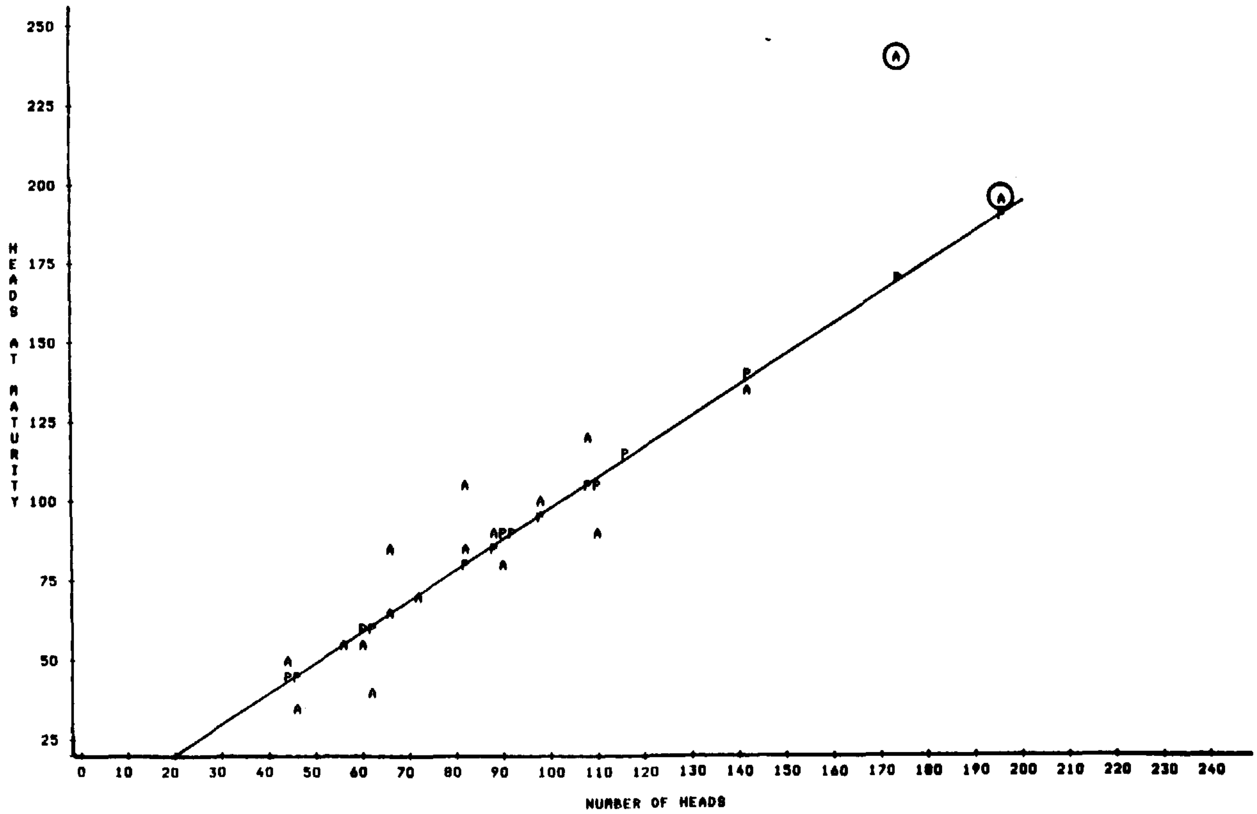


Figure 7: Plot of Predicted (P) vs Actual (A)
Heads at Maturity - Maturity Categories 4 and 5



Weight per Head

The grain weight per head at maturity, adjusted to 12% moisture, was used as the dependent variable. Early season weights of late boot and emerged heads, and the count of grains per head were obtained for use in building the forecasting regression equation. The correlations between these variables and the dependent variable were obtained for each maturity category. The following correlations were significant at the $\alpha = .05$ level:

Maturity	Variable 1	Variable 2	n	r	Pr>|r|
Late boot (3)	Weight at maturity	Weight per emerged head	23	.49	.0182
Milk (4)	Weight per late boot	Weight per emerged head	12	.60	.0387
	Weight per late boot	Grains per head	12	.68	.0140
Milk & Soft dough	Weight per late boot	Grains per head	24	.58	.0029

As can be seen, the dependent variable was significantly correlated with the independent variable for the late boot (or flower) maturity stage only. Looking at the data (see Figures 8 through 10), it becomes apparent that various functions of the independent variable (such as quadratic or logarithmic functions) may be correlated with the dependent variable. There are also significant correlations between "independent" variables as is evident in the table above and the plots in Appendix III.

In order to determine the "best" forecasting equation, the following variables were examined: weight per emerged head and its squared value, weight per late boot head and its squared value, elapsed time from field work to lab work and its squared value, grains per head and its squared value, square root, and the natural log of grains per head. The procedures used to find the "best" regression equation for weight per head were the same as the procedures used to find the "best" regression equation for heads per acre. The "best" equations involved the following variables:

Maturity Category	Variables
Late boot or flower	Weight per emerged head
Milk	Grains per head or its log or square root
Soft dough	The squared value of grains per head

Since the number of grains per head does not change once the rice plant has passed the flower stage, the data from the milk and soft dough stages were combined.

The models were then examined for influential data points. For the late boot stage, two points which are circled in Figure 11, were found to be very influential in fitting the model. However, since these points do not seem to be too distant from the other data points, these points were not deleted or given less weight in the model. For the milk and soft dough stages, two points, which are circled in Figure 12 were found to be substantially influencing the model parameters. Because these points were forcing a quadratic equation to be fit when the remaining points did not appear to fit the model, these points were deleted. The "best" regressions, based on these data, are given in Table 7.

Figure 8: Plot of Weight of Grain at Maturity vs Weight per Late Boot Head
Symbol is Maturity Category

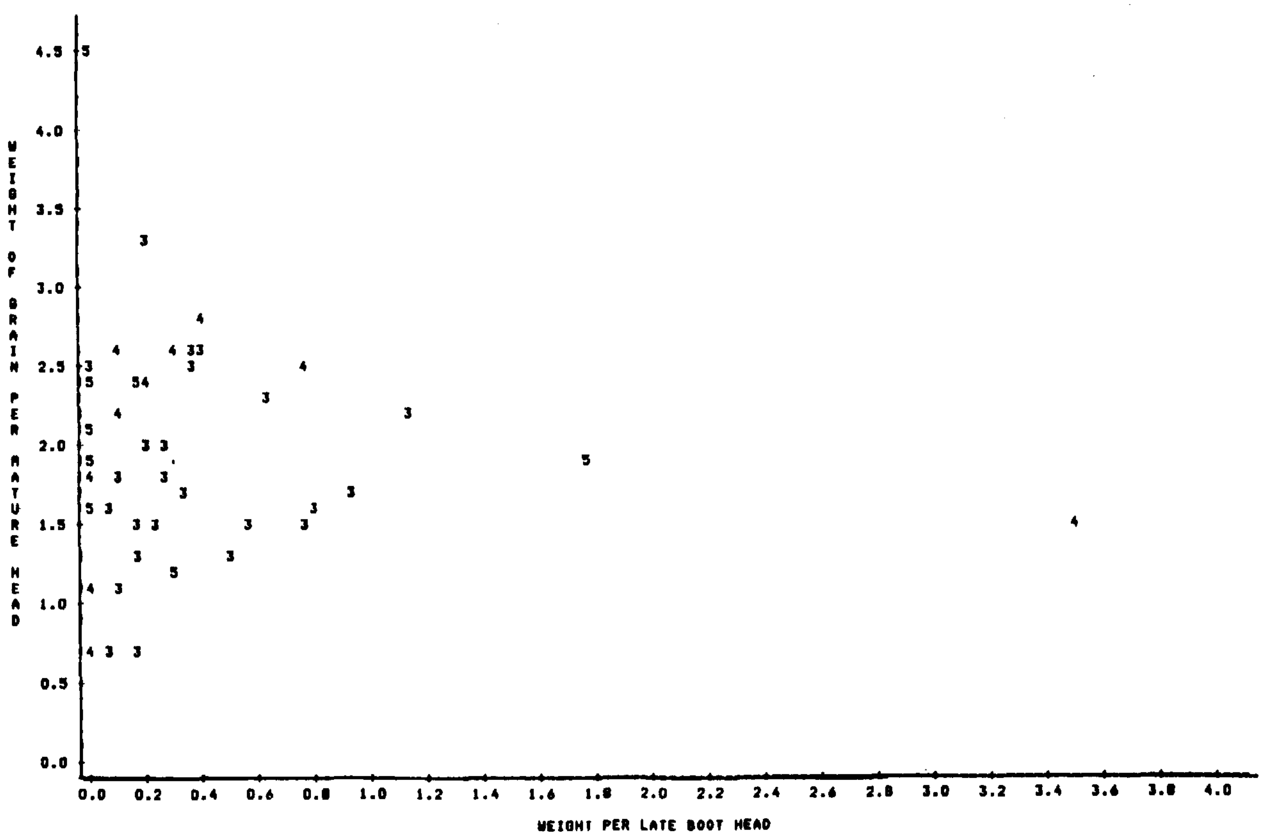


Figure 9: Plot of Weight of Grain at Maturity vs Weight per Emerged Head
Symbol is Maturity Category

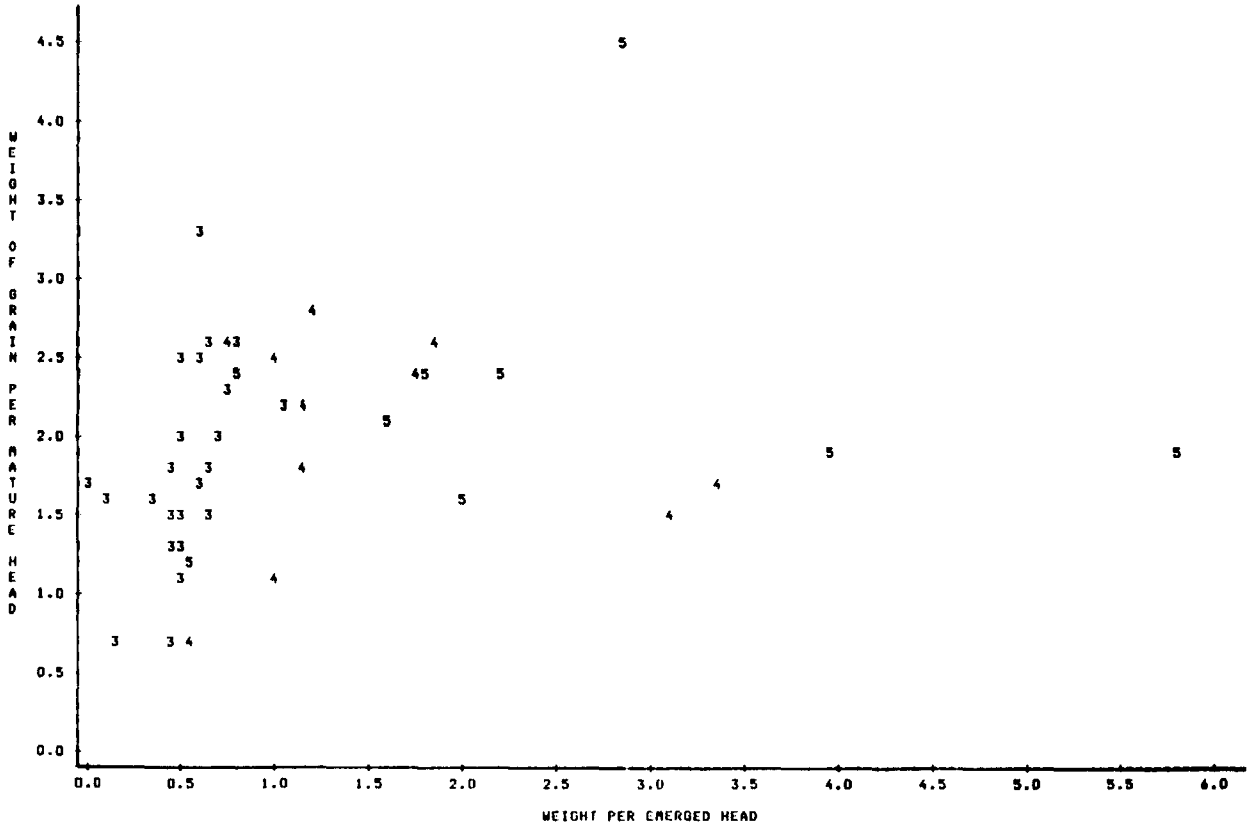


Figure 10: Plot of Weight of Grain at Maturity vs Grains per Head
Symbol is Maturity Category

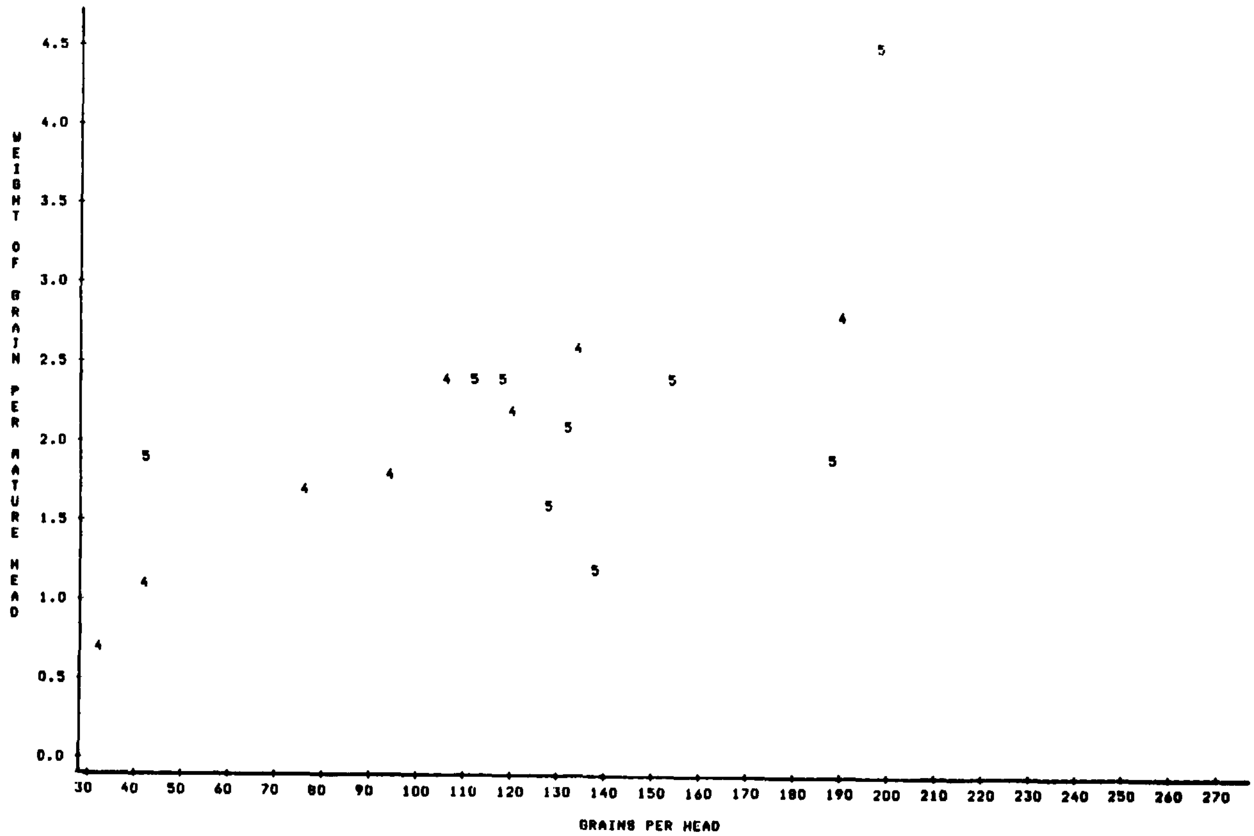


Table 7: "Best" Regression Equations - Weight per Head

Maturity	R^2	n	MSE	Equation
Late boot	.24	24	0.312166	1.1001 + 1.3482 (wt/emerged head)
Milk	.46	10	0.303889	-1.5314 + 0.7524 (ln(grains/head))
Soft dough	.30	9	0.692630	$1.3947 + 0.00004\ (\text{grains/head})^2$
Milk & Soft dough	.46	17*	0.202503	-1.6044 + 0.7774 (ln(grains/head))

* Some observations were deleted when building the model.

Plots of both the actual and predicted values are shown in Figures 11 and 12. Additional data at both the low and high values of grains per head may clarify whether this regression should be replaced with a linear regression on grains per head.

Figure 11: Plot of Predicted (P) vs Actual (A)
Weight of Grain at Maturity - Maturity Category 3

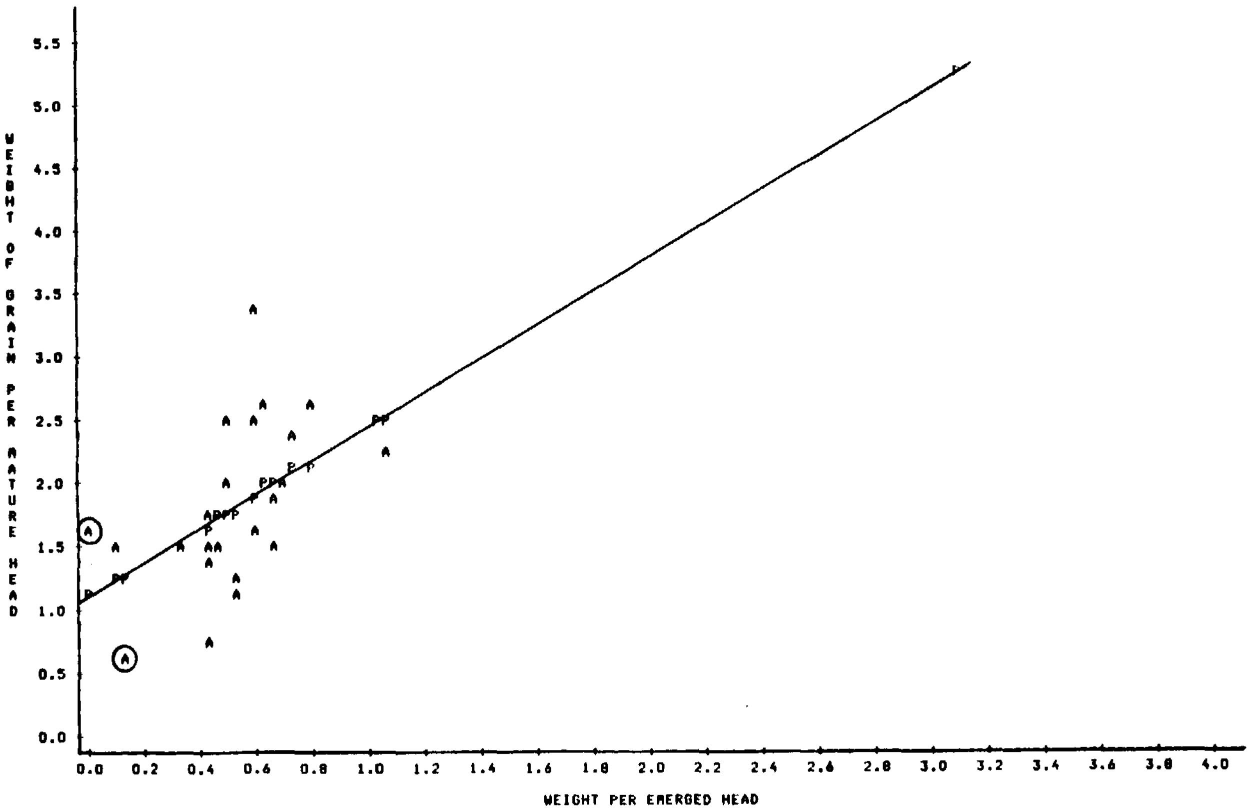
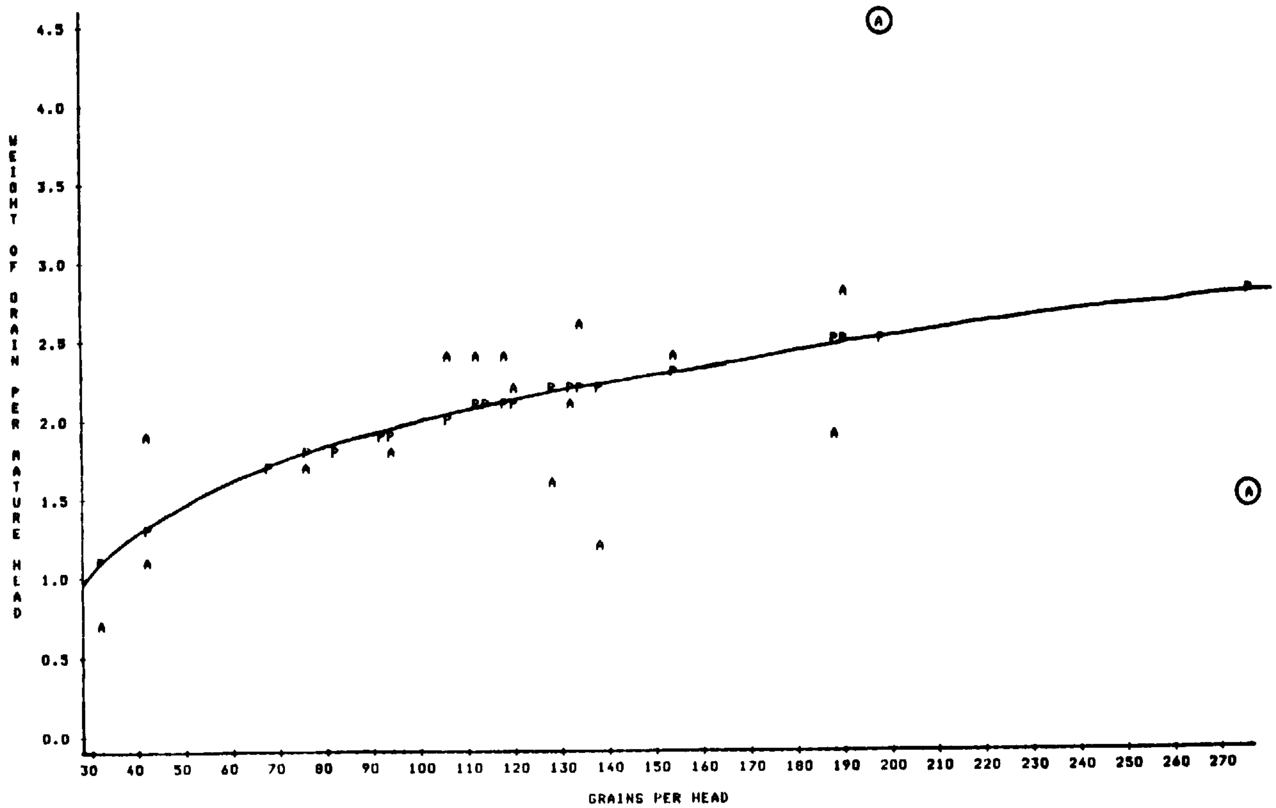


Figure 12: Plot of Predicted (P) vs Actual (A)
Weight of Grain at Maturity - Maturity Categories 4 and 5



No conclusions can be drawn from the limited data present here. It should be noted however, that none of the models appear to perform at the same level as the models for heads per acre. Since the heads must be destroyed to obtain their weight, the inability to observe the same plants throughout the season is one factor reducing the usefulness of the weight per head models. Since observing different plants introduces measurment errors, the relationships between early season and late season weights are expected to remain moderate even with the collection of additional data. It is therefore recommended that future work balance the data collection and laboratory expenses of collecting these early season weights against the usefulness of the data in forecasting. Thus if early season weights of late boot and emerged heads continue to be only marginally important in forecasting, the elimination of this data should be considered. The usefulness of collecting data on grains per head early in the season appears more promising, but should also be evaluated for cost effectiveness.

ENUMERATOR AND STATE OFFICE COMMENTS

The enumerators were asked to fill out a survey evaluation form which solicited comments and suggestions on data collection procedures at, or near, the end of the survey. See Appendix I for a copy of this form. Only nine out of sixteen people returned a completed form. A summary of the comments and suggestions by the enumerators and office personnel is given below.

Field Work

There were major concerns about field damage, with six out of the nine enumerators expressing this sentiment. While the field is flooded, the plants can rebound after being knocked over. However, once the field is drained, the plants do not recover. Moreover, if the wind blows while the plants are still prone, additional plants around the path may become lodged. One person mentioned seeing a swath approximately six feet wide when this occurred. The farm operators were understandably upset when they saw this type of field damage. Some enumerators were ordered out of the field and instructed not to return. There was also some concern that some operators may become refusals for all objective yield surveys, not just rice.

The status codes on the forms did not indicate a particular problem with refusals. However, because field damage becomes obvious once the field is drained, the field work may have been completed or near completion before the farm operator refused permission to enter the field again.

Several enumerators made suggestions as to how to reduce the field damage. The most common suggestion was to reduce the number of paces into the field. The number of paces had been assigned as is done in the wheat objective yield survey. One person suggested randomly selecting levees and then walking down the ditch, rather than down the side of the field. A random number of paces from the ditch into the field (but without crossing another ditch) would then be paced off. A modification of this procedure would be to assign the number of paces into and along the edges of the field as they were assigned in 1981 but to locate the plot by

1) finding the nearest levee to the plot location by pacing along the edge of the field (perpendicular to the levees) the assigned number of paces along the edge of the field,

2) walking down the ditches the assigned number of paces into the field, and

3) then walking into the field from the levee until the assigned number of paces along the edge of the field is reached.

Techniques of this type would still randomly locate the plot in the field, but would reduce the field damage as well as make the damage less obvious from the field's edge. Walking in ditches may present some problems, however, because of the additional difficulty in walking due to water depth, and the presence of snakes in ditches. These suggestions as well as other alternatives will be considered and discussed with Data Collection Branch. It is apparent that some alternative method of unit location needs to be devised in order to reduce field damage.

Another concern of enumerators is safety, and for this reason they strongly resisted working rice objective yield surveys alone. Fear of snakes, problems with working in flooded fields which make the humidity and heat a more serious problem, and difficulty in carrying equipment were the primary reasons given for preferring to work in pairs. Some people mentioned that once the field is drained, working alone was tolerable, but not necessarily preferable. For example, on the final preharvest visit, the plants in the unit can be pulled up and counted outside the field. Enumerators also felt that working in pairs would save money because the field time is reduced and some mileage costs are eliminated due to carpooling. Originally, this cost in terms of time in the field for those working in pairs as opposed to those working alone was to be evaluated. However, it was learned that some enumerators, who were assigned to work alone, were taking family members or friends with them. Because it was not known exactly how much assistance was given by the friends or for which visits this assistance was given, this evaluation was not done. It is recommended that in future rice surveys, enumerators be assigned to work in pairs, but encouraged to work alone for final preharvest visits and other late season field visits if they feel comfortable doing this.

There were no comments concerning the post-harvest gleaning field work.

Other comments included:

(1) Lay out clip areas as needed, i.e., time was wasted laying out all three clip areas on the first visit when only one or two were used.

(2) Spend more time discussing procedures when the field was planted using a broadcast method of seeding.

(3) Emphasize the need for using a bamboo pole to mark sample location so that the sample is easier to find in later visits.

(4) Include a wooden tripod, made by a supervisory enumerator for a nominal fee, as optional field equipment. The tripod kept all equipment dry and seemed to work well for those enumerators who had one.

Laboratory Work

The state office did not have any major problems with the Form C-1 (early season). However, these samples are green and therefore difficult to thresh. Each sample took approximately 30 minutes to complete.

Form C-2 (final pre-harvest) caused more trouble. The thresher did not work adequately. Both rice and soybean heads were used on the thresher, but neither worked well. The office tried drying the heads before threshing, but this did not improve the situation. The moisture content of the rice in the laboratory ranged from 11 to 23 percent. Each sample took approximately two hours to thresh.

A micro-thresher was borrowed from the Texas SSO to use instead of the thresher. Each sample took approximately 30 minutes to thresh with the micro-thresher. The Arkansas SSO felt the micro-thresher worked adequately for a one state survey, but it would not be adequate if they had to process samples for several states. Part of the problem may have been due to the lack of a high voltage line, so that neither the thresher nor the micro-thresher could be run at a high enough speed in the Arkansas laboratory.

EDIT LIMIT RECOMMENDATIONS

During the objective yield field and laboratory work, many variables are counted or calculated. Machine edits are therefore necessary in order to insure the quality of input data. Based on the 1981 data, the following error limits are suggested for rice:

Form	Variable	n	Mean	Std. dev.	Range	Noncritical error limit	Critical error limit
A	Interview length (min)	124	33	--	1-63	5-60	--
B	Stalks/row	297	30	14.8	0-75	1-60	0-90
	Late boot heads/row	1104	2	5.6	0-46	0-25	0-50
	Emerged heads/row	1104	25	16.6	0-89	0-60	0-90
	Detached heads/row	223	0.1	0.6	0-4	0-3	0-5
	5 row widths (ft)	552	2.8	0.29	1.7-3.5	2.2-3.4	1.5-4.0
	Time in field (min)	180	80	--	20-220	10-150	--
C1	Wt/emerged head	97	1.2	1.10	0.1-6.1	0.1-3.5	0.05-5.5*
	Wt/late boot head	64	0.5	0.86	0.06-6.0	0.05-2.2	0.05-4.0*
	Grains/head	47	126	55.7	33-275	30-235	1-350
C2	Moisture content (%)	107	15.0	2.3	10.9-22.6	10-25	--
	Loss adjustment (%)	107	101	0.6	100-103	100-105	--
	Wt/head (gr)	213	2.3	1.0	0.6-7.0	0.5-4.5	0.5-6.0*
	Percent threshed	107	0.86	0.12	0.3-0.96	0.6-1.0	0.1-1.0
D	Yield/acre (bu)	105	104.9	21.8	45.4-167.2	40-180	--
	Moisture content (%)	105	17.4	2.4	12.0-25.0	10-25	--
	Interview length (min)	105	10	--	1-75	5-60	--
E	Wt in bag (gr)	54	42.1	67.5	2.2-368.8	0.1-300	--
	Threshed wt (gr)	54	25.3	38.8	1.7-209.7	0.1-200	--
	Time in field (min)	54	70	--	22-165	10-150	--

* The distribution of the data indicates that values above these limits are most likely outliers even though values above these limits were obtained in 1981.

SUMMARY AND RECOMMENDATIONS

Before summarizing the conclusions and recommendations, the assumptions should be summarized. It was assumed that land use stratum and tract or field size have no effect on the estimates when dealing with nonresponse. This same assumption was made again when building regression equations to forecast yield components. In addition, variances were computed using the formula for simple random sampling. These assumptions are also made in the operational objective yield programs. However, because these assumptions affect all conclusions, it is recommended that the validity and effect of making these assumptions be thoroughly investigated and documented as soon as possible.

Based on the 1981 rice objective yield survey in Arkansas, the following conclusions can be made:

(1) It is possible to estimate final yield per acre at harvest using an objective yield procedure. The objective yield estimate was 110.8 bushels per acre, which compares favorably with the farmers' reported yield of 105.3 and the Crop Reporting Board estimate of 103.2. The coefficient of variation of the objective yield estimate was 4.1%.

(2) No statistically significant effect (α =.05) on yield components due to "handling" was found in 1981. However, the crop season was shorter than usual, thereby reducing the number of times each sample was visited. Moreover, enumerators were very concerned about the damage to the field, as were some farm operators. It is therefore recommended that alternative methods of sample location be investigated and that the handling effect be studied for another year.

(3) Two problems with at-harvest estimation were not addressed in this study. Future work should investigate whether a significant bias is introduced by not locating units on levees or ditches, and if a bias does exist, whether this bias can be assumed to be constant at the state level over time. In contrast, it is not recommended that future work study the difference in harvest loss based on combine capabilities, because there are so few operators who do not use combines without straw spreaders. At this point the problem is not severe enough in Arkansas to warrant the additional resources.

(4) Early season forecasts of heads per acre at maturity can be made using early season counts of stalks and late season counts of number of heads. Additional data need to be collected before stable models can be built.

(5) Early season forecasts of weight of grain per head at maturity can be made but not with a great deal of precision (particularly in the late boot stage). If additional data are collected and it is found that the forecasting ability for the late boot category continues to be only marginal, it is recommended that historic averages be used for this category. The limited benefits of using early season weights may not justify the cost of enumerators' salary for clip unit location and layout, and laboratory weighing.

(6) Since the distribution of harvest loss is skewed, it is difficult to forecast harvest loss other than by using an historical average. However, methods of stratifying the harvest loss data should be investigated further, particularly if more detailed Form D (farmer reported) answers on field damage can be obtained.

(7) It is recommended that enumerators work in pairs during early season flooded conditions. Later in the season when the field is drier, enumerators should be encouraged to work alone. These recommendations are based on the enumerators' strong concern over safety.

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1. Belsley, David A., Edwin Kuh and Roy E Welsch, Regression Diagnostics, John Wiley and Sons, Inc., 1980.
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3. Cochran, William G., Sampling Techniques, John Wiley and Sons, Inc., 1963.
4. Steel, Robert G.D., and James H. Torrie, Principles and Procedures of Statistics, McGraw-Hill Book Company, Inc., 1960.
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6. Statistical Reporting Service, 1981 Rice Objective Yield Research Survey Enumerator's Manual, May 1981.
7. Statistical Reporting Service, 1981 Rice Editing Manual, May 1981.
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APPENDIX I

Forms

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

Form Approved
O. M. B. Number 535-0088
C.E. 12-31A-1W

FORM A: RICE YIELD SURVEY – 1981

INITIAL INTERVIEW

SURVEY MONTH CODE
August 1 = 1
September 1 = 2
October 1 = 3
November 1 = 4

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

1 1 1 ___

Last June a representative from our office obtained information about your farming operations including your seeded acreage of rice. Now we would like to verify the rice seeded acreage and obtain your estimate of the acreage to be harvested for grain.

Date (________________) 171

Starting Time (Military time) . . . .

JUNE TRACT ACRES

1. At the time of the June visit you had seeded or intended to seed 101
acres of rice in ________ fields in this tract. *(Do not change)*

SHOW operator his tract and fields on PHOTO.

VERIFY the fields and the acreages of rice which were actually seeded in this 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 rice was seeded in tract, correct Table A.

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

TABLE A

FIELD NUMBER *(Sample field number is circled.)*	TOTAL ACRES IN FIELD	ACRES OF RICE SEEDED	Acres in USES or CROPS other than rice to be harvested for grain. *(For example: bare spots, roads, other crops, etc.)* USE	ACRES	ACRES OF RICE TO BE HARVESTED FOR GRAIN
1	2	3	4	5	6

2. The total rice acreage *(Col. 6)* to be harvested for grain is . . . . Acres 102

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

IF ITEM 2 HAS
- *A ZERO entry - - return all forms.*
- *An ACREAGE entry - - TURN PAGE.*

Form A: RICE (Cont'd)

Items 3 to 8 apply to the SAMPLE FIELD ONLY.

If no Rice is intended to be harvested for grain in the designated sample field, BUT a NEW field to be harvested for grain is listed in Table A, this new field then becomes the sample field to enter in Item 3. If no new field is obtained select the most easily accessible field.

3. Acres of Rice to be harvested for grain in Sample Field Number ________ .... Acres [103]

4. What variety of Rice did you seed in this field? ... ________________ OFFICE CODE

5. Is this rice, short grain (1) medium grain (2) long grain (3) .... ENTER CODE [105]

6. Was this field sown by: Air ☐ - 1 Drill ☐ - 2 .... ENTER CODE [106]

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 ☐ NO ☐

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 ☐

8. "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 rice 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 ......

Enumerator ________________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

Form Approved
O. M. B. Number 535-0088

FORM B: RICE YIELD COUNTS – 1981

SURVEY MONTH CODE

August 1 = 1
September 1 = 2
October 1 = 3
November 1 = 4

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

UNIT LOCATION

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

Date (____________) ..

Starting Time *(Military Time)* 371

	UNIT 1	UNIT 2
Is this the same unit that was laid out last month?	Yes ☐ No ☐	No ☐

Check NO if this is the first visit to lay out unit 1 or if this is unit 2.

For unit(s) checked: Yes — skip to Item 2.
No — complete Item 1.

	UNIT 1	UNIT 2
1. Width across 5 row spaces (measure distance from stalks in Row 1 to stalks in Row 6) .... Feet and Tenths	301 .	303 .

2. STAGE OF MATURITY: (Circle one stage code for each unit)

Maturity Stage	Pre-Flag	Flag or Early Boot	Late Boot or Flower	Milk	Soft Dough	Hard Dough	Ripe
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 the highest maturity code of either unit is Code 1 through Code 4 start counts with 3.				*If the highest maturity code of either unit is Code 5, 6 or 7, start counts with 4. For codes 6 or 7, first see Items 7 and 9.*		

COUNTS WITHIN UNITS

	UNIT 1			UNIT 2		
	Row 1	Row 2	Row 3	Row 1	Row 2	Row 3
3. Number of stalks (stems) in row	311	312	313	314	315	316
4. No. of heads in LATE BOOT	351	352	353	354	355	356
5. a. Number of emerged heads on all stalks	331	332	333	334	335	336
b. No. of detached heads in UNIT (complete ONLY on FINAL PRE-HARVEST VISIT)		341			344	

6. COMMENTS on condition of field and sample units: ______________________________

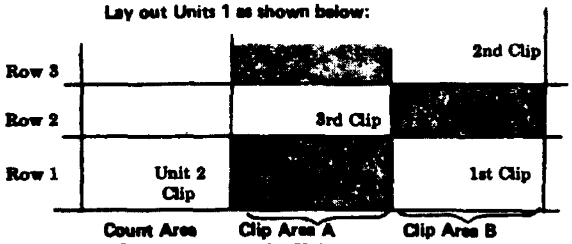
____

____

(See back — CLIPPING INSTRUCTIONS — Ending Time.)

FORM B: RICE (Cont'd)

Lay out Units 1 as shown below:



Lay out only the count area for Unit 2

CLIPPING ORDER

Unit 1 (Item 8)

First Clipping – Row 1 in Clip Area B

Second Clipping – Row 3 in Clip Area B

Third Clipping – Row 2 in Clip Area A

7. If the HIGHEST MATURITY CODE circled in Item 2 for EITHER Unit is:

   (a) Code 1 or 2: SKIP Items 8 and 9. Enter time and sign name.

   (b) Code 3, 4 or 5: Go to Item 8.

   (c) Code 6 or 7: Go to Item 9.

8. WITHIN CLIP AREAS – Make clippings in the designated ROW within Clip Areas of EACH unit following steps below.

   Step 1 – MOW *(cut stalk within 2 inches of base)* all stalks in specified row until 5 Emerged Heads *(if that many)* are obtained OR until the row is completely mowed. Begin mowing at end of row farthest from count area and mow in direction of count area. Examine each stalk for emerged head as it is mowed; if present, clip stalk one inch below the head. Place the 5 *(or less)* emerged heads in 3# bag. Record count on State *(yellow)* I.D. tag. Also when mowing, clip and count any heads in late boot and place in 5# bag.

   Step 2 – MOW remaining stalks in row. Examine each stalk and determine which ones are emerged heads and which ones are late boot heads. CLIP the stalk one inch below the head. Place the remaining emerged heads in the 8 # bags and the late boot heads in the 5 # bag.

   Step 3 – Record the count of the remaining emerged heads and the late boot heads on the State *(yellow)* I.D. tag.

Repeat steps 1 thru 3 for Unit 2 using different bags for emerged heads and late boot heads than used in Unit 1.

Prepare two I.D. tags. Label all bags with sample and unit number. Seal and place 3 # and 5 # bags in the 8 # bag.

Verify State *(Yellow)* I.D. tags and attach to outside of 8 # bags.

Check here ☐ *after placing 8 # bags in a cloth mailing sack addressed to* STATE LAB.
ENTER time and sign name.

9. WITHIN COUNT AREAS – Clip and Count all heads in count area of BOTH units following steps below.
   Use a separate 8 # bag for each unit.

   Step 1 – Clip and Count all Heads in Late Boot in Row 1 – Record in Item 4.

   Step 2 – Clip and Count all Emerged Heads in Row 1 – Record in Item 5a and place emerged heads in same bag with late boot heads.

   Step 3 – Repeat steps 1 and 2 for ROW 2 and 3. – Record counts.

   Step 4 – Pick up and Count all Detached Heads on ground in unit and Record in Item 5b. Place in bag with clipped heads.

Record heads clipped in Items 4 and 5 of Form B and on I.D. Tags. Attach one I.D. Tag to each 8 # bag. Check here ( ) after placing bags in cloth mailing sack addressed to STATE. *Enter time and sign name.*

ENDING TIME *(Military Time)*	372
STATUS CODE	380

Enumerator ________________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

Form Approved
O. M. B. Number 535-0088

FORM C–1: STATE LABORATORY DETERMINATIONS– 1981 RICE YIELD SURVEY – CLIPPING AREA SINGLE ROW HEAD SAMPLES

MONTH CODE

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

YEAR, CROP, FORM, MONTH (1-4)
114__

Date __________ (Sample Processed) | 470 [redacted]

1. From Identification Tag

		UNIT 1	UNIT 2		
a. All Heads (Emerged and Late Boot)	Number			. . . . Total Number	401
b. Stage of Maturity	Code			. . . . Highest Code	402

2. Laboratory Determinations, Subsample of emerged heads (3-# Bag)

	UNIT 1	UNIT 2
a. Heads in sample. (5 or fewer)	403	404
b. Total weight of heads . . . *(One decimal)*	405 .	406 .

Complete 2c for MATURITY STAGES 4 and 5 ONLY.

c. Total grains	407	408

3. Laboratory Determinations on All Remaining Heads

a. Emerged Heads (8 # bag):

(1) Total number, laboratory count.	409	410
(2) Total weight of heads	411 .	412 .

b. Heads in Late Boot (5 # bag):

(1) Total number, laboratory count	413	414
(2) Total weight of late boot heads	415 .	416 .

Lab Technician ______________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

Form Approved
O. M. B. Number 535-0088

FORM C–2: REGIONAL LABORATORY DETERMINATIONS – 1981 RICE YIELD SURVEY – HARVESTED UNIT HEAD SAMPLES

MONTH CODE

Aug 1..... 1
Sept. 1..... 2
Oct. 1..... 3
Nov. 1..... 4
Dec. 1 or later 5

YEAR, CROP, FORM, MONTH (1–4)
115__

570

Date ______________________
(Sample Processed)

1. From Identification Tag

		UNIT 1	UNIT 2		
a. All Heads (Emerged, Late Boot and Detached	Number			...... Total Number	501
b. Stage of Maturity	Code			...... Highest Code	502

2. Laboratory Determinations, all clipped heads from Units 1 and 2

a. Unit 1: (1) Total weight of all heads .... *(One decimal)* .... 503 [.]

(2) Heads in sample .... 504 [ ]

b. Unit 2: (1) Total weight of all heads .... *(One decimal)* .... 505 [.]

(2) Heads in sample .... 506 [ ]

c. Total weight of all heads ... 2a (1) + 2b (1) .... Grams [.]

Combine all heads from Units 1 and 2.

3. Threshed grain, all heads from Units 1 and 2

a. Weight immediately after threshing ... *(One decimal)* .... Grams 507 [.]

Is item 3a less than 2c? ....
YES ☐ *Go to 3b*
NO ☐ *STOP – Notify Supervisor.*

b. Weight immediately before moisture test ...... *(One decimal)* .... Grams 508 [.]

c. Moisture content 1/ ... *(One decimal)* .... Percent 509 [.]

d. Threshing loss adjustment factor *(One decimal)* .... Percent 510 [.]

1/ If sample weight is too small for moisture test, sufficient grain of known moisture content will be added to the sample so that a moisture test can be made. The moisture content of the sample can then be derived using the following formula:

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

Where
A = Weight of small sample (item 3b) ________.________ *Grams*
B = Weight of additional grain required for moisture test. ________.________ *Grams*
C = Moisture percent of B ________.________ *Percent*
D = Moisture percent of A + B combined . ________.________ *Percent*
E = Result — — Moisture percent of small sample (enter in item 3a) ________.________ *Percent*

Lab Technician ______________________________

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS, AND STATISTICS SERVICE

Form Approved
O. M. B. Number 535-0088

FORM D: RICE YIELD SURVEY – 1981

POST–HARVEST INTERVIEW

MONTH CODE

Sept. 1 2
Oct. 1 3
Nov. 1 4
Dec. 1 or later .5

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

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

Date (____________) . . . . [671]

Starting Time . . . .

1. *Enter from (Form A, Table A, Column 6)*

   Sample Field Number (____________)   Acres for Grain (_______._)

2. How many acres of rice were (or will be) harvested for grain 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 grain. Can you give me a reason for the difference?

   ____

   ____

4. How many bushels were harvested from these (Item 2) ____________ acres? . . . . Total Bushels [607]

   If operator indicates yield per acre, multiply by harvested acres to determine total bushels. Show your work.

5. Was production determined from weight tickets Yes ☐ = 1 No ☐ = 2 . . . . Enter Code [609]

6. How many bushels do you still expect to harvest from this field . . . . .Total Bushels [608]

7. Then the total bushels harvested (or expected) from this field is (Items 4 + 6) . . . . Total Bushels (____________)

8. What was the moisture content of the harvested rice . . . . [610]

9. On what date was or will harvest be completed in this field? ____________ OFFICE USE
   (Month and Day)

10. Was this field harvested with a combine equiped with a straw spreader? Yes ☐ = 1 No ☐ = 2 . . . . .Enter Code [611]

11. Was there any significant damage in this field from insects, birds, disease, lodging or other causes? Yes ☐ = 1 No ☐ = 2 . . . . .Enter Code [612]

Ending Time [672]

STATUS CODE

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMICS AND STATISTICS SERVICE

Form Approved
O. M. B. Number 535-0088

FORM E: RICE YIELD SURVEY – 1981

POST–HARVEST GLEANINGS

MONTH CODE

Aug. 1 1
Sept. 1 2
Oct. 1 3
Nov. 1 4
Dec. 1 or later 5

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

1 1 7 ___

Date (______________) ....

Starting Time (Military Time) 771

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

UNIT LOCATIONS

	Unit 1	Unit 2
Number of paces along edge of field		
Number of paces into field		
Width across 5 row spaces (measure distance from stalks in Row 1 to stalks in Row 6)........................... Feet and Tenths	704 .	705 .

GLEANINGS *(Place all gleanings from both units in one paper bag.)*

		Unit 1	Unit 2
1. PICK UP IN BOTH UNITS:	a. All unthreshed whole heads b. All partly threshed heads c. All loose rice grains	CHECK ( )	CHECK ( )

FIELD NOTES: If post-harvest observations cannot be made, give reason here. Indicate if alternate field was selected.

____

____

Enumerator ______________________________ Ending Time (Military Time) 772

MAIL gleanings in cloth mailing sack and this Form E in addressed envelope to STATE LABORATORY.

REGIONAL LABORATORY DETERMINATIONS

2. Total weight of heads, kernels and chaff in paper bag .... *(One Decimal)* .... Grams

3. Weight of threshed grain ...... *(One Decimal)*... Grams

If samples combined for moisture test, show sample numbers combined: ______________

STATUS CODE ....

Lab Technician ______________________________

SURVEY EVALUATION FORM

Please fill out this questionnaire at the end of the survey period. Your comments will be used in planning future Rice Objective Yield Surveys. Please give a great deal of thought to your answers. If you need more space for your answers, write on the back, or attach another sheet of paper.

1. Were the instructions in the enumerator's manual clear?

2. Do you have any suggestions as to how to improve the count, unit location, or post-harvest gleaning procedures?

3. Are the supplies and equipment you were given adequate? If no, what other supplies do you need?

   Are there supplies and equipment that you have now that you do not need?

4. Did you work with a partner? alone? Were you able (or do you think you could) work alone? If no, why?

   If no, could you work alone if some equipment or instruction were changed? Which ones?

5. Was farmer refusal a problem?

6. Do you have any major concerns with the rice work (safety, field damage, etc.)?

APPENDIX II

Maturity Code Descriptions

CODE 1 - PRE-BOOT

This is a general category in which you will record all units where tillers are only an inch or two high, up to where stalks do not indicate any swelling and DO NOT HAVE the definite flag leaf or other evidence of a partly developed head inside the leaf sheath.

CODE 2 - EARLY BOOT

Stalks are starting to joint and joints can be seen easily. A partly developed head may be detected by noting that the stem has started swelling below the foliage leaf. This swelling may also be felt inside the sheath. Be careful not to damage the partly developed head by squeezing the stem or sheath.

In most cases the presence of heads enclosed in the leaf sheath could be verified by going outside the unit and examining stalks that are similar in appearance to the doubtful ones before classifying the unit in the EARLY BOOT stage. Clip a few stalks, unroll the leaf sheath and see whether or not there is a small, partially developed head encased in the sheath.

CODE 3 - LATE BOOT-FLOWER (HEADS EMERGED) INCLUDES WATERY KERNELS

The head has moved up the stem and swelling has occurred above the base of the top foliage leaf. The sheath will split and the head will partially or wholly emerge. The flower stage occurs soon after the head emerges and small blooms or flowers begin to open at the base of the head and blooming progresses toward the tip. For our purpose, consider the unit to be in the late boot or flower stage from the time swelling can be seen or felt above the top foliage leaf until the head emerges and the watery clear liquid in the kernel has begun to turn milky.

CODE 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. The plant is still generally green.

CODE 5 - SOFT DOUGH

The grains can be crushed between the thumb and fingernail; the contents of most of the GRAIN are SOFT with ONLY A FEW GRAINS PER HEAD containing any milky liquid.

CODE 6 - HARD DOUGH

The grain is FIRM and though it may be dented by pressure of the thumbnail, it is NOT EASILY CRUSHED.

CODE 7 - RIPE

Ripe -- straw and leaves may be green or partly green but average moisture in grain is about 20%. Grains at base of panicle may be in hard dough stage whereas riper grains in upper portions of the panicle will be relatively hard. Most of grains will have taken on a mature color but there may be a slightly green color on basal grains. The straw, and to a lesser extent the leaves, may remain fairly green when the grain is considered mature.

CODE 8 - BLANK

This maturity code is used for fields with blank areas where the sample fails. There will be no plants in the sample unit.

APPENDIX III

Plots of Independent Variable Relationships

Figure A: Plot of Number of Stalks vs Number of Late Boot Heads
Symbol is Maturity Category

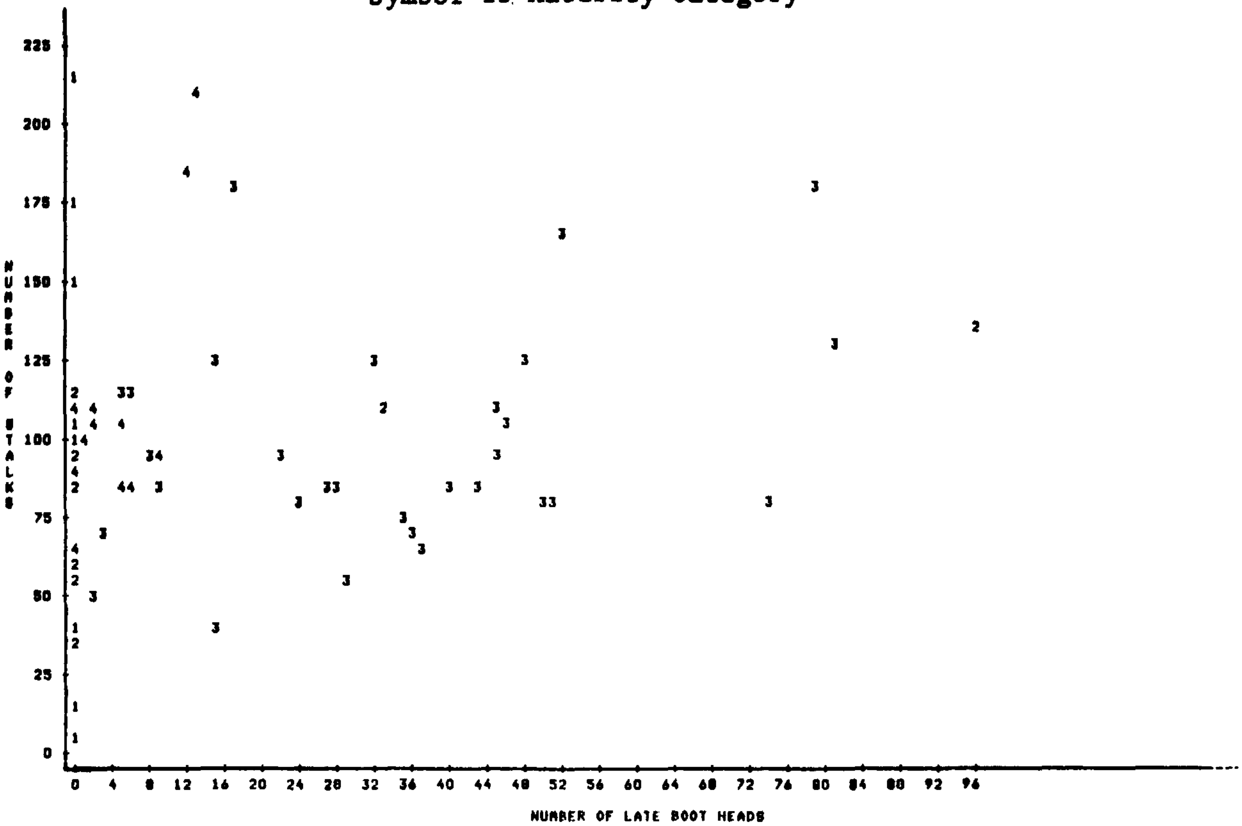


Figure B: Plot of Number of Stalks vs Number of Emerged Heads
Symbol is Maturity Category

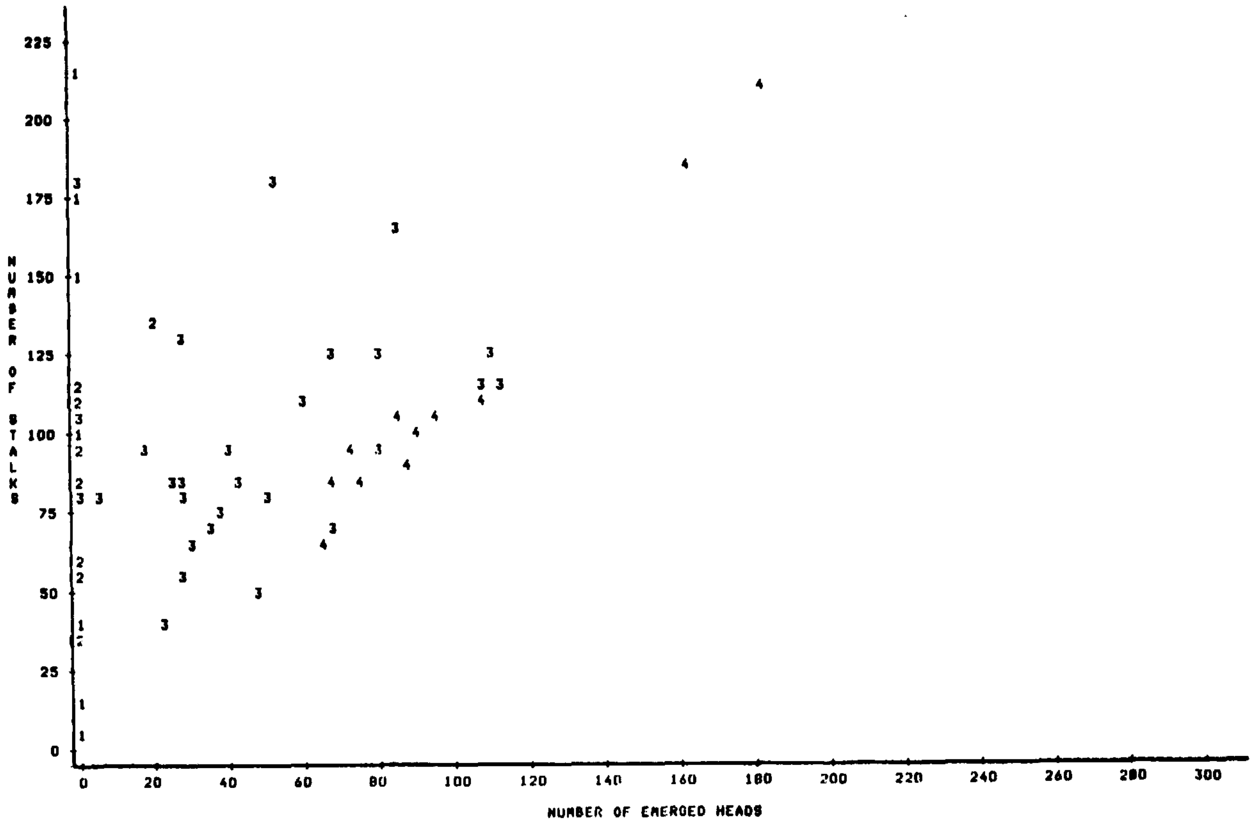


Figure C: Plot of Number of Late Boot Heads vs Number of Emerged Heads
Symbol is Maturity Category

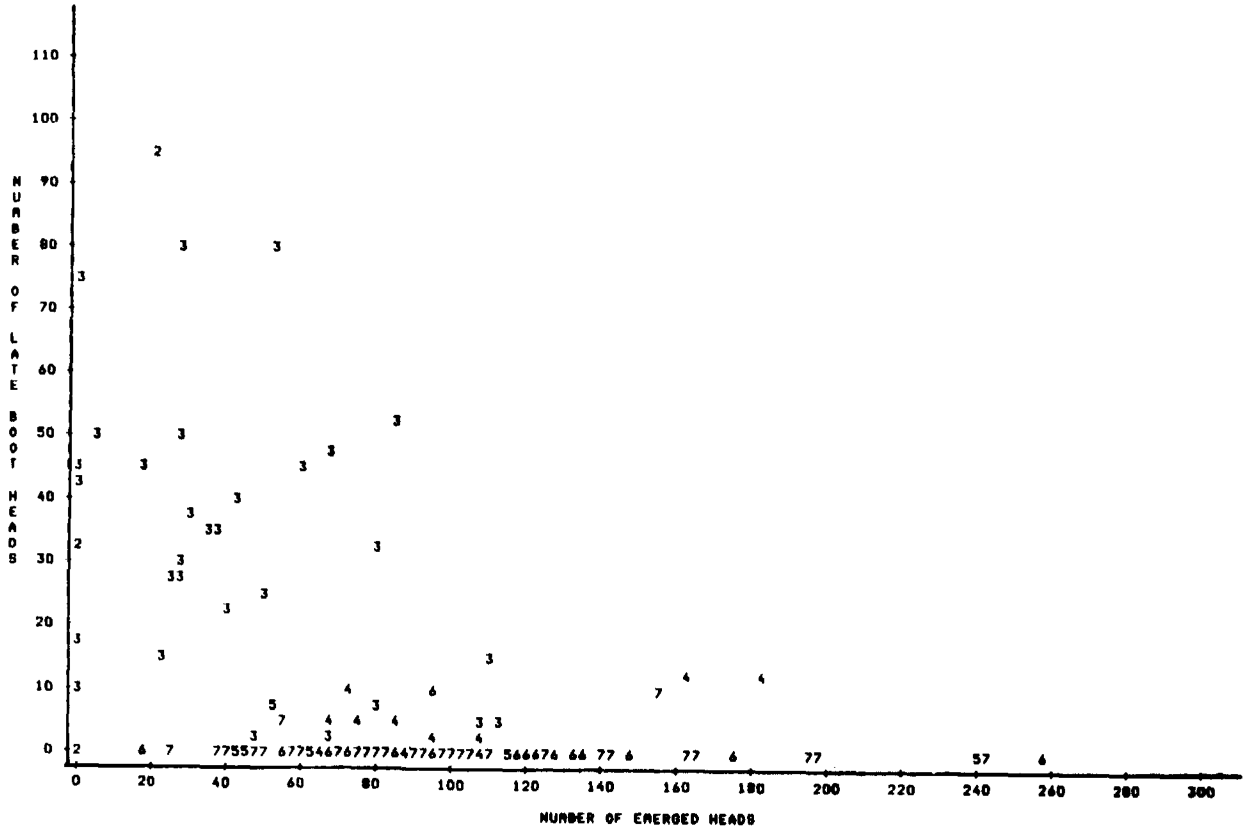


Figure D: Plot of Number of Stalks vs Number of Heads
Symbol is Maturity Category

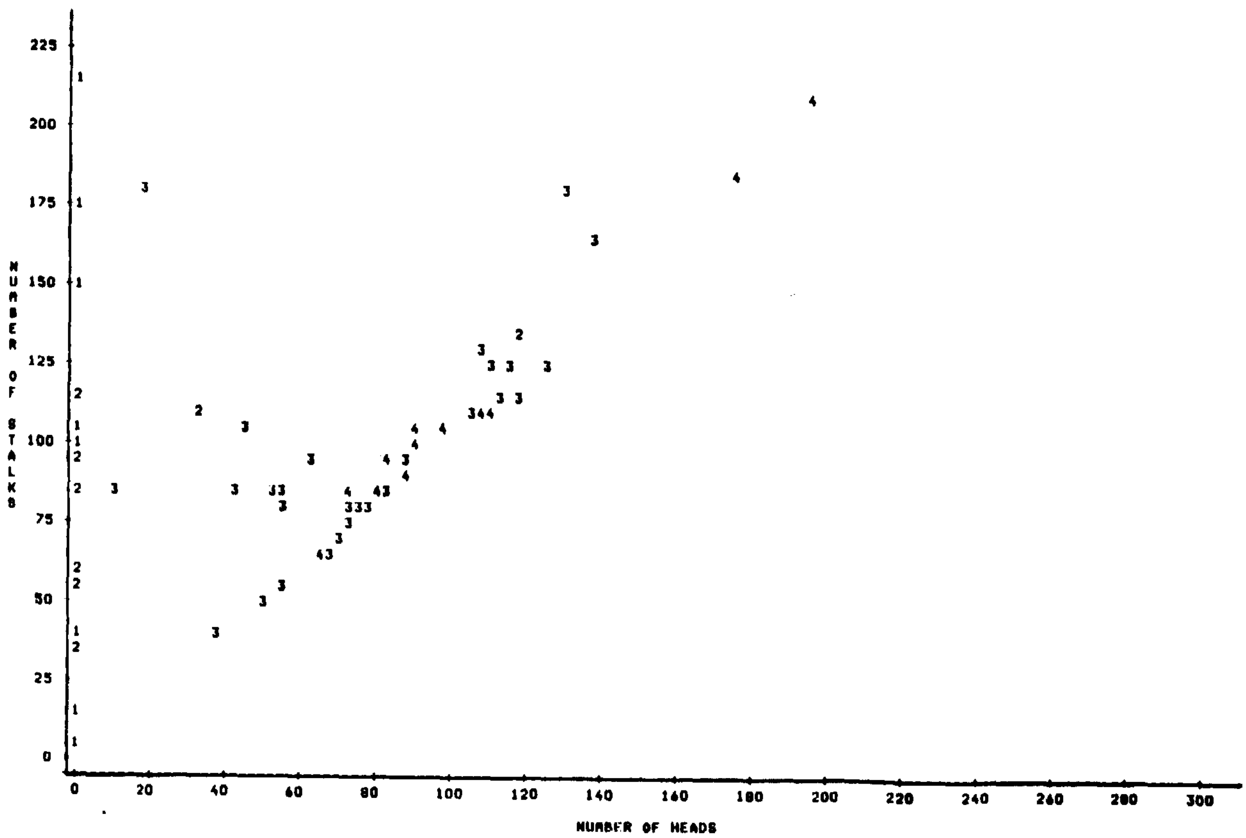


Figure E: Plot of Weight per Late Boot Head vs Weight per Emerged Head
Symbol is Maturity Category

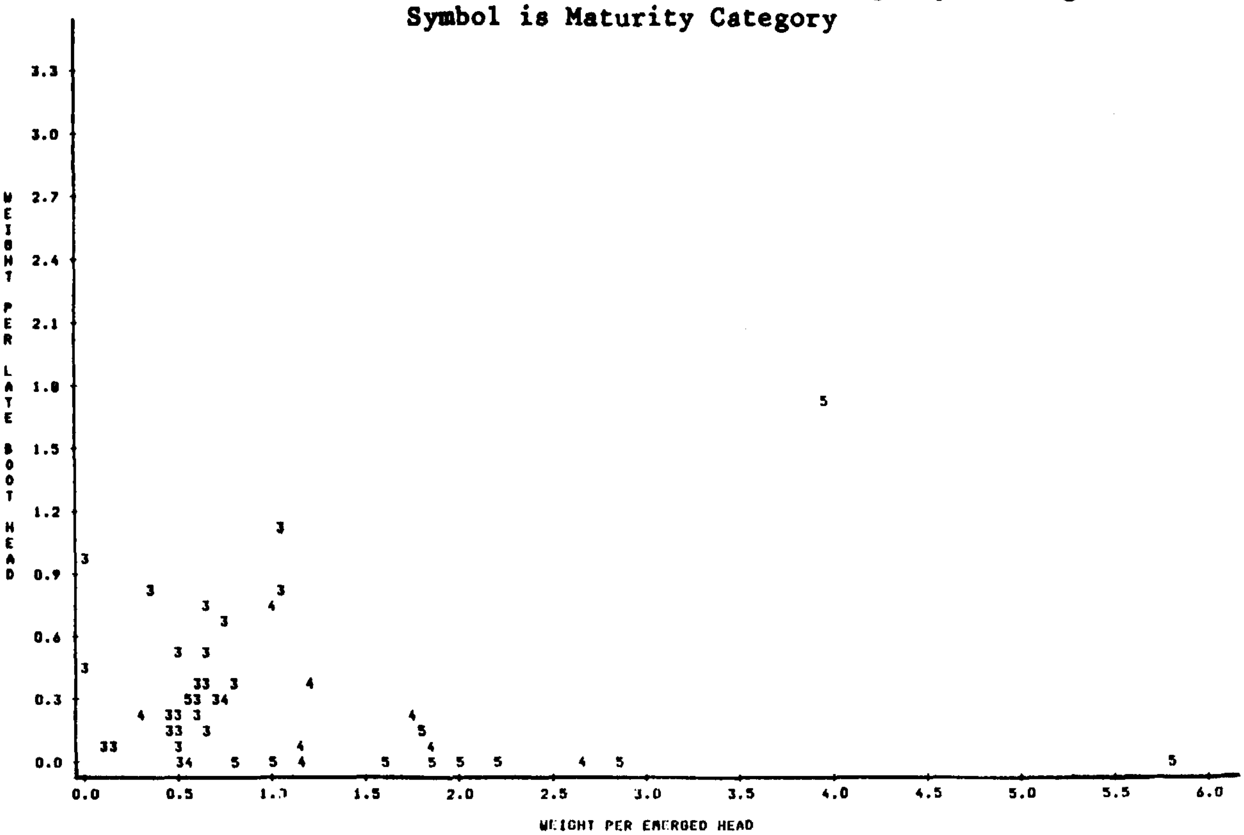


Figure F: Plot of Grains Per Head vs Weight per Late Boot Head
Symbol is Maturity Category

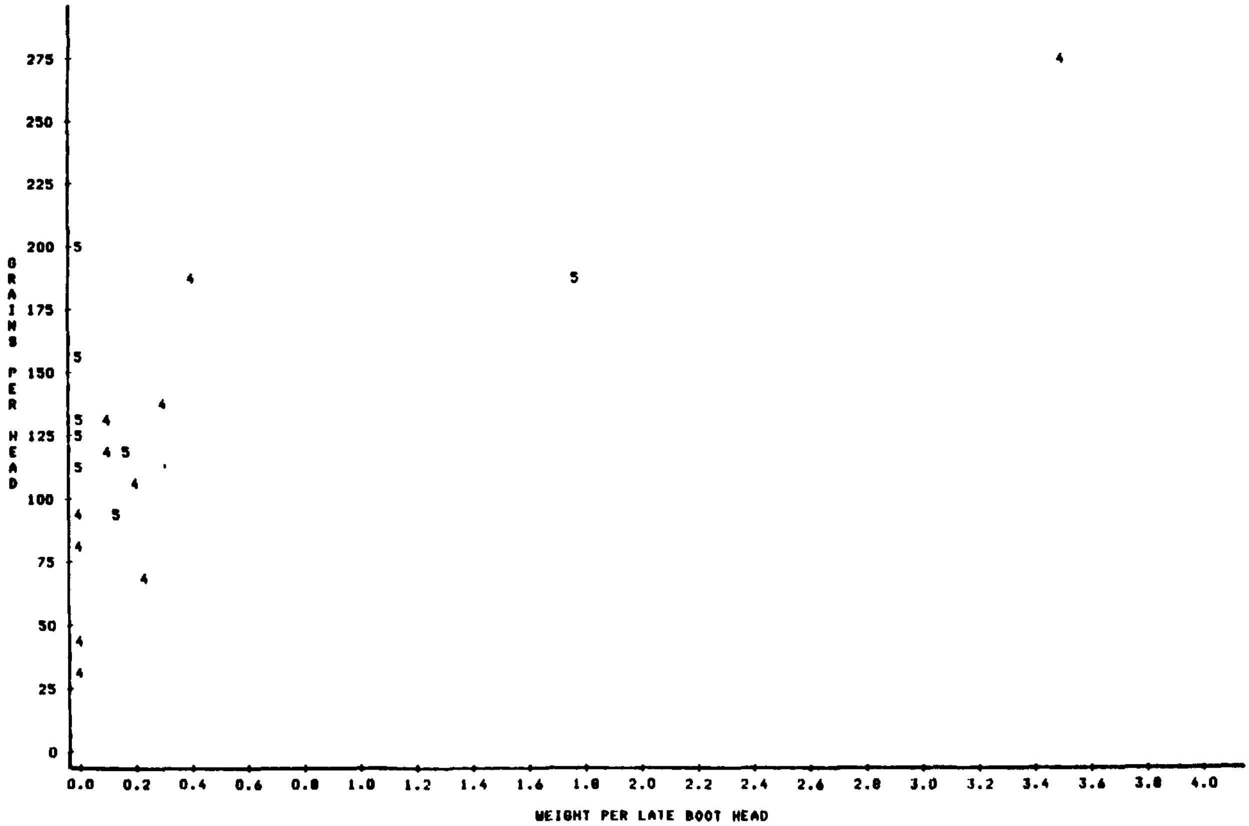
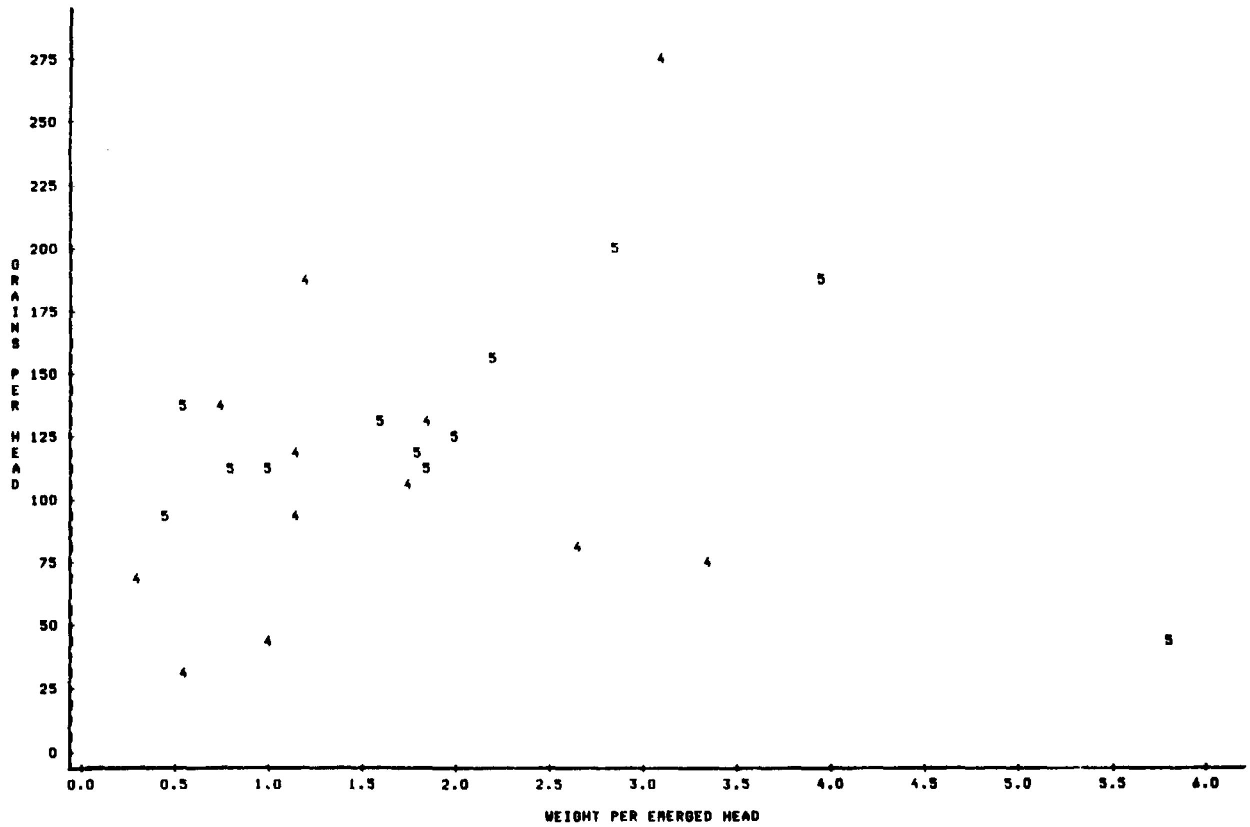


Figure G: Plot of Grains per Head vs Weight per Emerged Head
Symbol is Maturity Category



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