PROJECT NO. RB-6

Comprehensive Research on Rice
Annual Report
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PROJECT TITLE:

Cultivar and Environmental Influences on Head Rice in California

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OBJECTIVES AND EXPERIMENTS CONDUCTED TO ACCOMPLISH OBJECTIVES:

1. Investigate the effects of cultivar type, time of drainage and rate of nitrogen application on the growth and development of panicles, kernel uniformity characteristics and head rice yields.

In 1987, experiments were conducted at two locations, Biggs and Davis. Three cultivars (S-201, M-201 and L-202) in combination with three nitrogen levels (low, medium and high) were arranged in a split-plot design with five water drainage treatments as the main-plot treatment. Panicle samples were taken weekly from 100% flowering through harvesting time. The panicles were then divided into three parts (upper, middle and lower) to evaluate the uniformity of grain development.

2. Evaluate the relationship between heat unit accumulation (degree days) and rice growth and development for possible use as a crop management model.

   Phenological data from 24 fields in Butte County were collected in the summer of 1986. Micrologger weather recorders were placed in three fields such that air, water and soil temperatures were recorded at the exact fields where phenology data were collected in order to construct the leaf developmental model.

3. Develop and implement computer programs by which cultural practices can improve rice management.

   Information on rice production costs, cultural practices and farm operations were taken from the 1983 and 1986 reports of Cooperative Extension Services. Moisture and head rice response functions were obtained from our previous annual reports. The aforementioned information was integrated in a FORTRAN computer program called "RICEECON." At this stage, the program can produce a balance sheet of cost and revenue for a rice farm based on the harvesting moisture of the grain. It can also search for the optimal harvesting moisture which will maximize the net income.

SUMMARY -- MAJOR ACCOMPLISHMENTS OF 1987 RESEARCH:

OBJECTIVE 1

A split-split plot design was used in Davis and Biggs for 1987 trials. Three nitrogen levels were applied to subplots, and cultivars were arranged in the sub-sub plots while drainage treatments were assigned to the main plots.

Seeds of S-201, M-201 and L-202 were sown in Davis on May 5 and in Biggs on May 11, 1987. The three nitrogen levels were 25, 100 and 175 lbs/acre in Davis and 50, 125 and 200 lbs/acre in Biggs. Fifteen panicles were taken weekly after the 100% flowering time of a plot. Fresh weight, dry weight and dimensions of 100 randomly selected grains were taken from each of the three parts (upper, middle and lower) of the panicle samples. The criteria of determining the timing of drainages were defined as follows: 1) the first drainage would take place when one of the three cultivars showed 100% tipping in the low nitrogen treatment; 2) the second drainage would take place when one cultivar in the medium nitrogen treatment showed 100% tipping; 3) the third drainage would take place when all cultivars in the medium nitrogen treatment showed 100% tipping; 4) the fourth drainage time would be when one cultivar showed 100% tipping in the high nitrogen treatment; and 5) the fifth drainage would be when all cultivars reached 100% tipping in the high nitrogen treatment.

At harvest, one square meter panicle samples were taken from each plot to measure the yield and yield components. Another one square meter of panicles was taken for milling quality determinations. 25 square centimeter panicle samples were taken to measure plant density. A total of 378,000 seeds were evaluated and over a million data points were generated from the experiment. Results of the analyses of these data will be presented in future reports.

Similar experiments were done in 1986 and part of the results of the data analysis of 1986 trials are highlighted in the sequel.

Grain Growth Curves: Figures 1-3 and Figures 4-6 represent grain growth curves derived from the experiments in Biggs and Davis. It is clear from the figures that the upper part of the panicle usually has faster grain filling and also that its grains reach greater weight than those of the middle and lower parts. As expected, drainage treatments have little effect on the duration and rate of grain filling. In contrast, high nitrogen treatment prolongs grain filling by 2-7 days and slows down the filling rate by about 0.09 mg per grain per day. There are significant differences found among the cultivars themselves. The grain filling rate of L-202 is faster and the duration is shorter than for M-201 and S-201. The maximal weight of L-202 is also less than the other two cultivars. On the other hand, S-201 tends to fill its grains slower and for a longer period of time but produces heavier seeds than the other cultivars. It can also be seen from Figures 1-6 that the growth curves of L-202 have more variation between parts than the other cultivars.

Head Rice: Figures 7 and 8 show the percent head rice means for each cultivar and treatment from the experiments in Biggs and Davis, respectively. The overall means of head rice are 61.8%, 63.8%, 64.5% and 65.1%, respectively for drainages 1, 2, 3, and 5. Thus, drainage time seems to be important to rice milling quality, and late drainage is, in general, favorable to the yield of head rice. Nitrogen effect on head rice is less clear than the drainage effect. This is because cultivars respond to nitrogen differently and that nitrogen effect is easily confounded with the maturity or moisture content of the grain. Nevertheless, the data seem to suggest that a high level of nitrogen must be accompanied by late drainage treatment to maximize the opportunity for a high head rice return. On the other hand, a high level of nitrogen combined with early drainage time could be detrimental to the head rice yields. Among the cultivars, L-202 is shown to be more variable in head rice between the parts within panicles and is also smaller in mean head rice than the other two cultivars.

Milling Quality Model: Based on the results of the last three years of experiments (1984-1986, see 1985 and 1986 annual reports), we can now propose a milling quality model to explain the cause-and-effect relationships of the grain characteristics and the head rice yields. Basically, the structural variables (shape, volume, % hull, etc.) affect the physiological processes (grain filling duration and rate) of the grain and, therefore, the weight and density of the rice kernel. In turn, the structural variables and the weight and density of the kernel will directly determine the potential head rice percentages (Figure 9). It was also demonstrated from these data that variations of the structural variables will induce variations of the physiological process variables and decrease the head rice.

OBJECTIVE 2

The concept that the developmental stages of a plant can be expressed as a function of the degree-day summation or heat units has been well accepted by plant scientists in general and has been documented for many crops. A computer model, developed in southern U.S. rice growing regions, used the temperature summation as a predictor for the developmental stages of rice and seems to work well for their purposes.

In the last annual report, we showed that there was a large difference in terms of required degree days to maturity between years for California rice, and that the summation of degree days from planting to harvesting was linearly related to the days from planting to harvesting. These results seem to indicate that a simple degree-day approach may not be adequate in predicting developmental stages of a rice plant.

To further investigate the applicability of the degree-day concept, phenological data were collected from 24 rice fields in Butte County in 1986. Part of the analysis of the data was reported in the 1986 annual report. Additional analyses are presented hereafter.

Figure 10 shows the fitted curves of the leaf stages as a function of the degree-day summations. The upper left picture of Figure 10 illustrates the fitted curves for M-201 and S-201 from fields where both temperature and phenological data were collected. The other three pictures in Figure 10 show the predictability of the fitted curves to other general fields. The predictive equations are as follows:

$$LS = 1.4d - 0.0385d^2 + 0.00025d^3 \quad \text{for M-201}$$

or

$$= 4.3d - 0.0472d^2 + 0.00047d^3 \quad \text{for S-201,}$$

where LS is the leaf stage of a rice plant and d is one hundreth of the degree-day summation. The R^2-values of the above equations are greater than 0.9%. When these equations are used to predict leaf stages in other general fields, over-estimations are obvious, particularly for M-201 in fields 7, 8 and 9.

Figure 11 shows the fitted curves of leaf stages as a function of the days-after-planting (upper left picture) and the usefulness of these functions as predictors of leaf stages in other general fields (the other three pictures). The fitted equations are as follows:

$$LS = 1.68p + 0.1510p^2 - 0.001p^3 \quad \text{for M-201}$$

or

$$= 2.21p + 0.0195p^2 - 0.0115p^3 \quad \text{for S-201,}$$

where LS is the leaf stage of a rice plant, and p is one tenth of the days-after-planting.

In comparison with Figure 10, a small improvement was made in predicting leaf stages by using days-after-planting. Based on the preliminary analysis, we have to conclude that the best predictor for California rice phenology seems not to be the simple degree-day summations but rather the days-after-planting. The coefficients of the prediction equation are cultivar specific. Further analysis such as including day length corrections may be necessary before we can draw a more definite conclusion. But if we are correct, the validity of using the degree-day concept for crop phenology prediction would require serious re-examination.

OBJECTIVE 3

We wrote a FORTRAN computer program called "RICEECON" which can be run on an IBM compatible computer to perform certain economic analyses and produce an accounting report of a farm's net gain or loss. It can be used for the following purposes: 1) At a fixed level of harvesting moisture, to estimate the percent head rice. Together with other input information of yield and farm size, an economic analysis is performed to show the net return of the farm operation; 2) For a given variety, the program can search for the optimal harvesting moisture and show the economic consequence of this operation.

An example run of the program is shown in Diagram 1. In this example, L-202 is used to illustrate the procedure and output of the program. The program is interactive and easy to run and will be released soon, pending further tests.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

1. Field experiments were conducted to evaluate the effects of nitrogen inputs and drainage time on grain characteristics and milling quality.

2. Nitrogen delays maturity and slows down grain filling rate. On average, high nitrogen application reduces grain filling rate by about 0.09 mg per grain per day and increases the number of grain filling days by about 2-7 days.

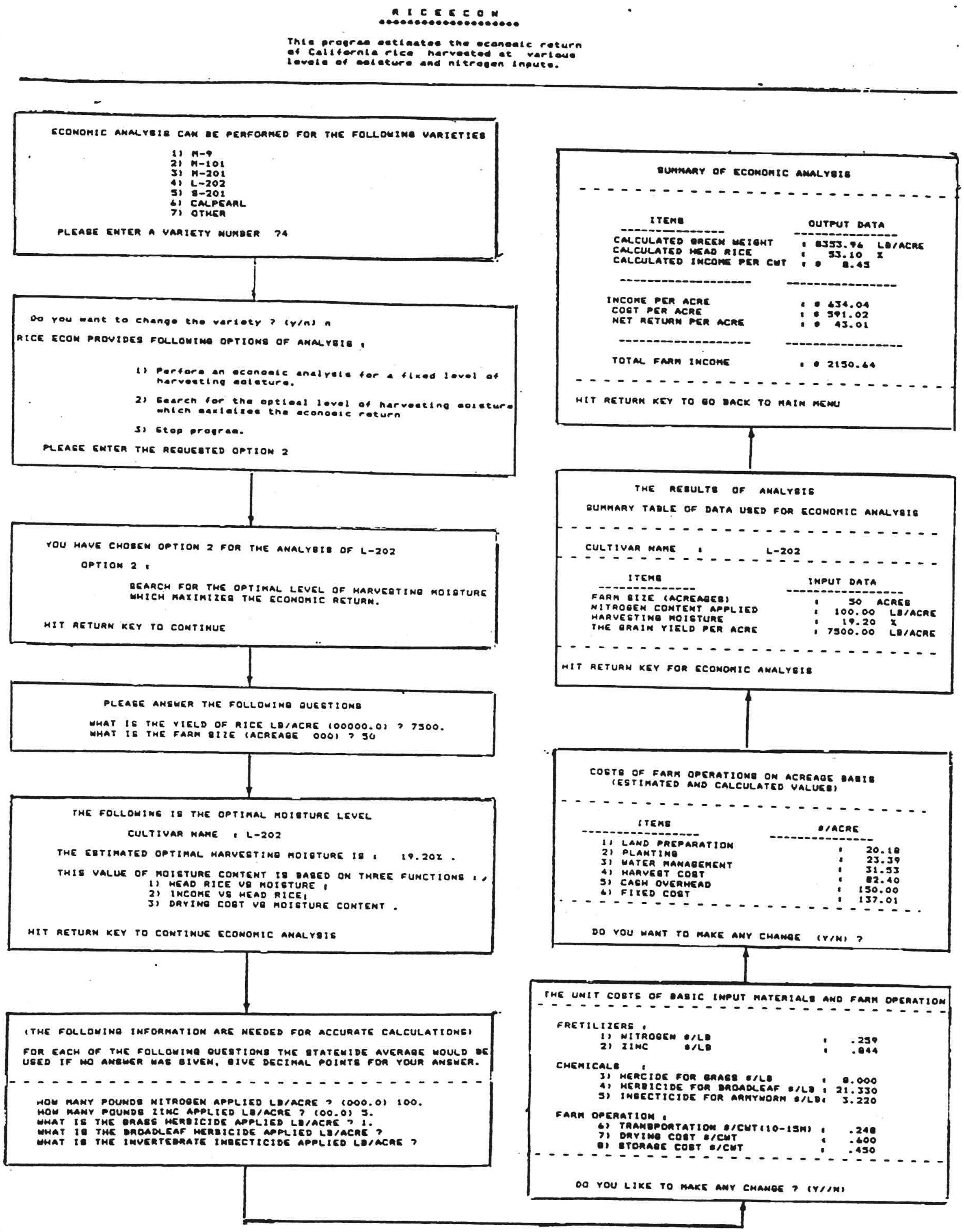
3. Grain filling duration is shorter for L-202 than for M-201 and S-201. The grain filling rate of L-202 is the fastest among the three cultivars, but also has the greatest variations.

4. Late drainage tends to be favorable for high milling quality. This is particularly important when the level of nitrogen is high.

5. Rice developmental stages can be better predicted by days-after-planting than by degree-day accumulation.

6. A computer program "RICEECON" has been developed to provide economic evaluations of farm operations at various levels of harvesting moisture.

Diagram 1 Computer output of RICEECON.



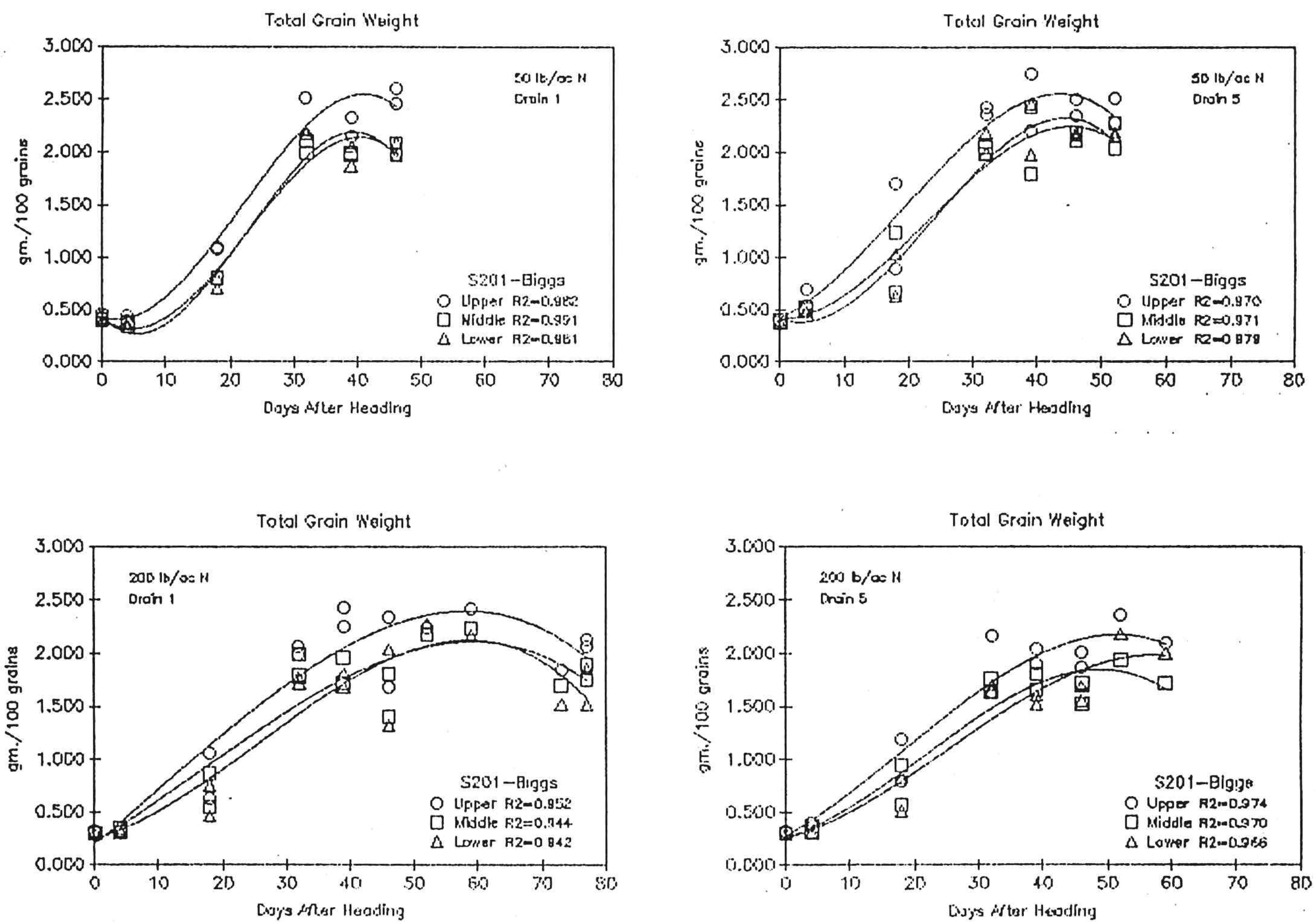


Figure 1 Grain growth curves at low and high nitrogen applications and at early and late drainages for S-201 at Biggs.

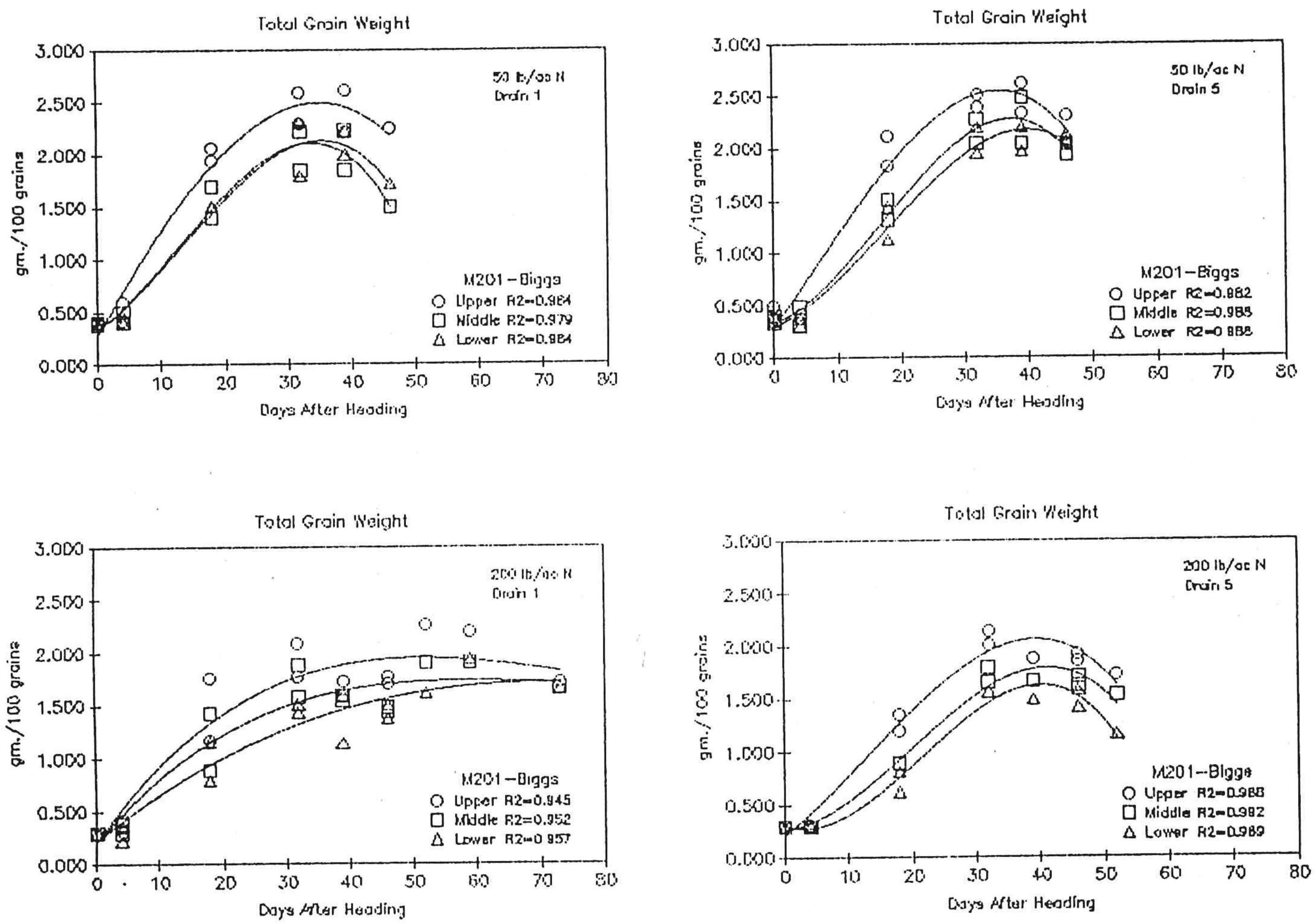


Figure 2 Grain growth curves at low and high nitrogen applications and at early and late drainages for M-201 at Biggs.

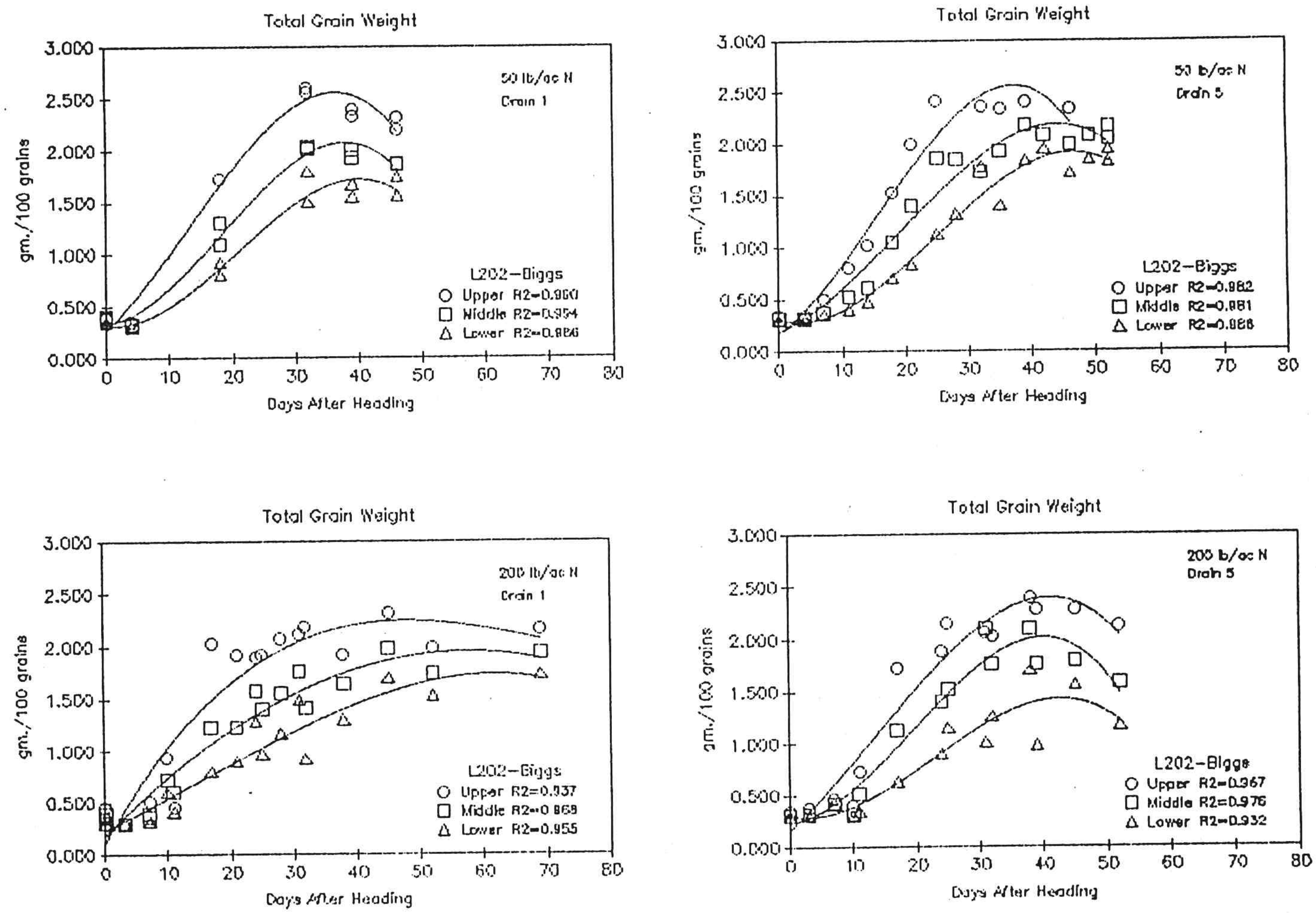


Figure 3 Grain growth curves at low and high nitrogen applications and at early and late drainages for L-202 at Biggs.

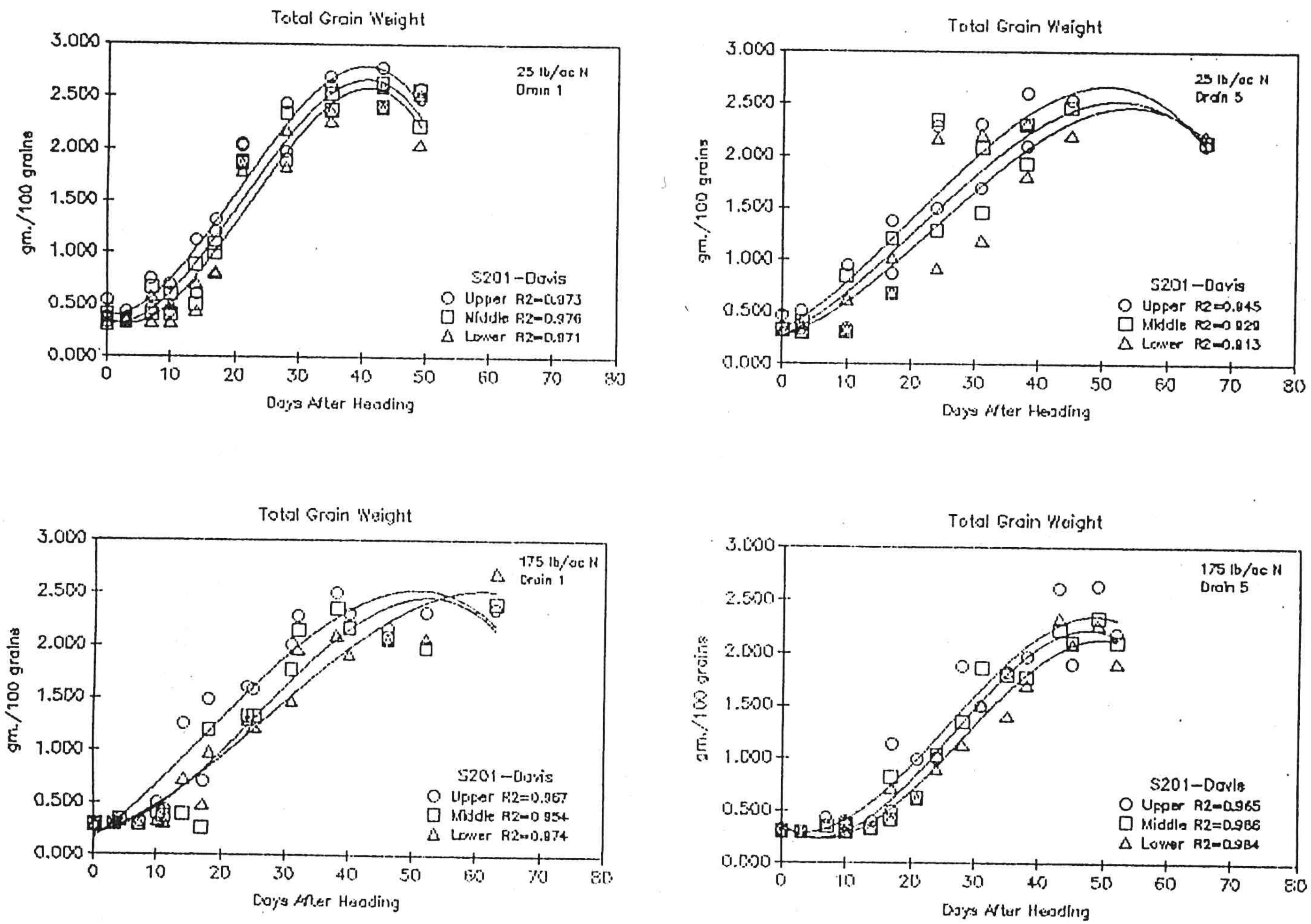


Figure 4 Grain growth curves at low and high nitrogen applications and at early and late drainages for S-201 at Davis.

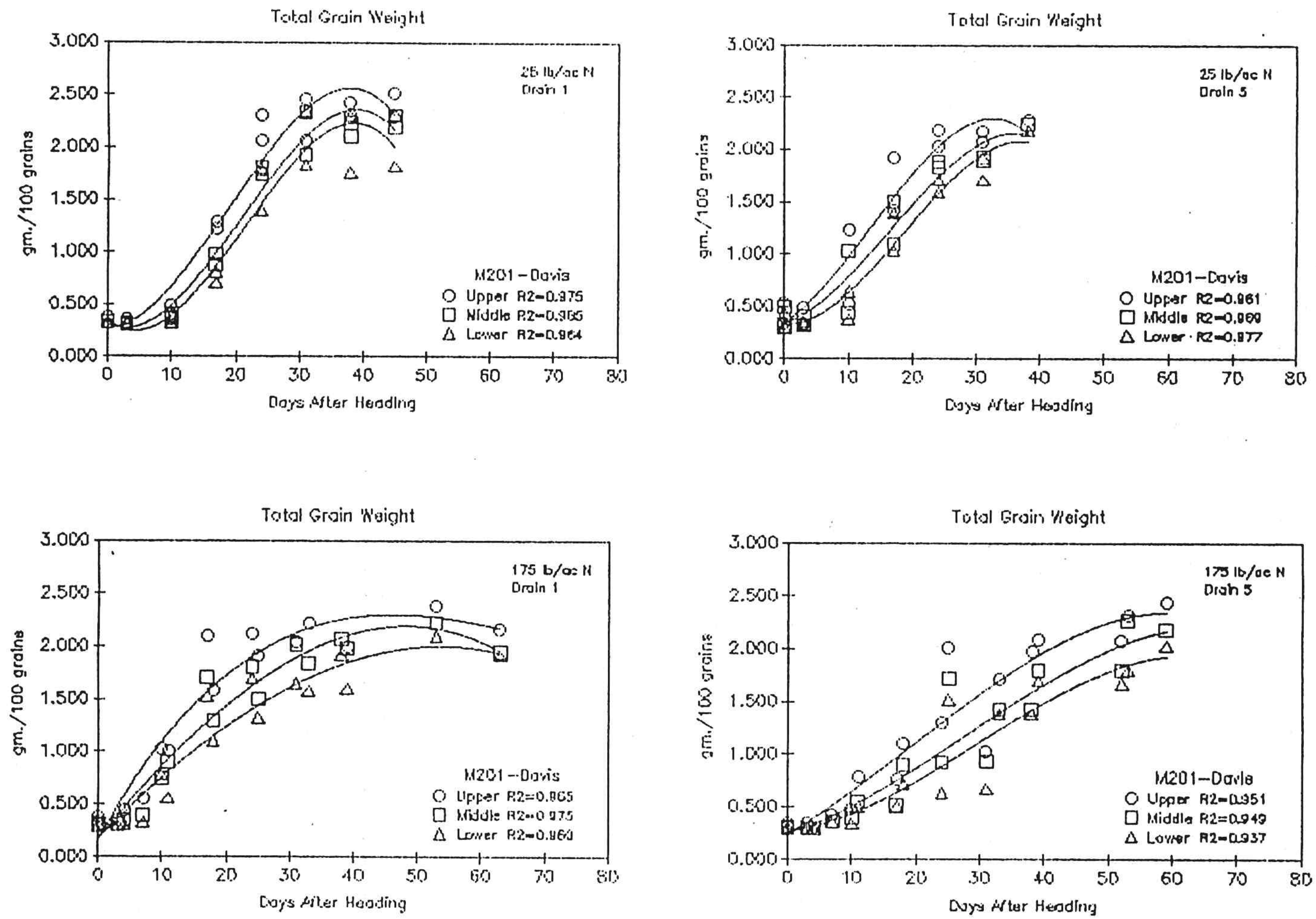


Figure 5 Grain growth curves at low and high nitrogen applications and at early and late drainages for M-201 at Davis.

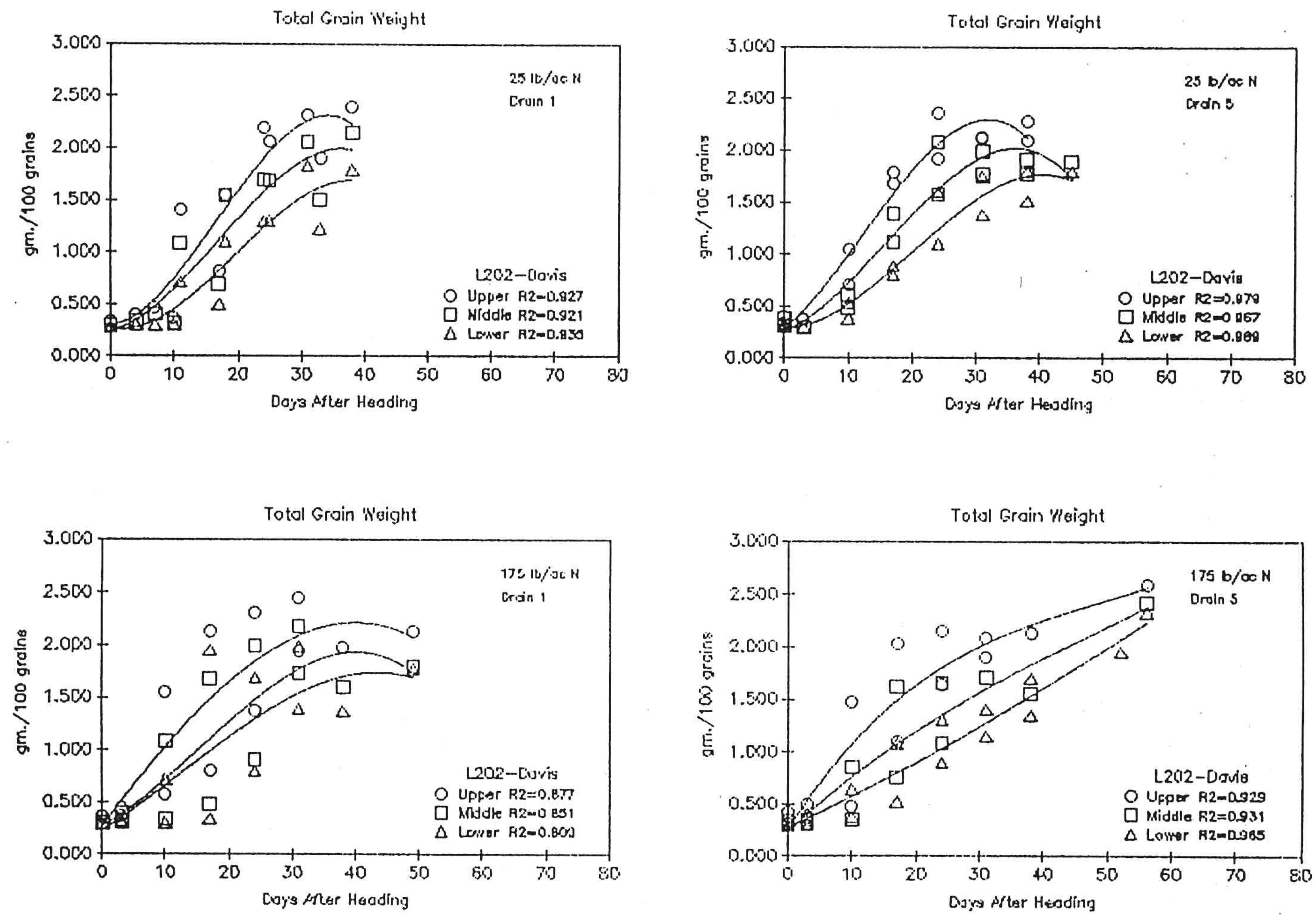


Figure 6 Grain growth curves at low and high nitrogen applications and at early and late drainages for L-202 at Davis.

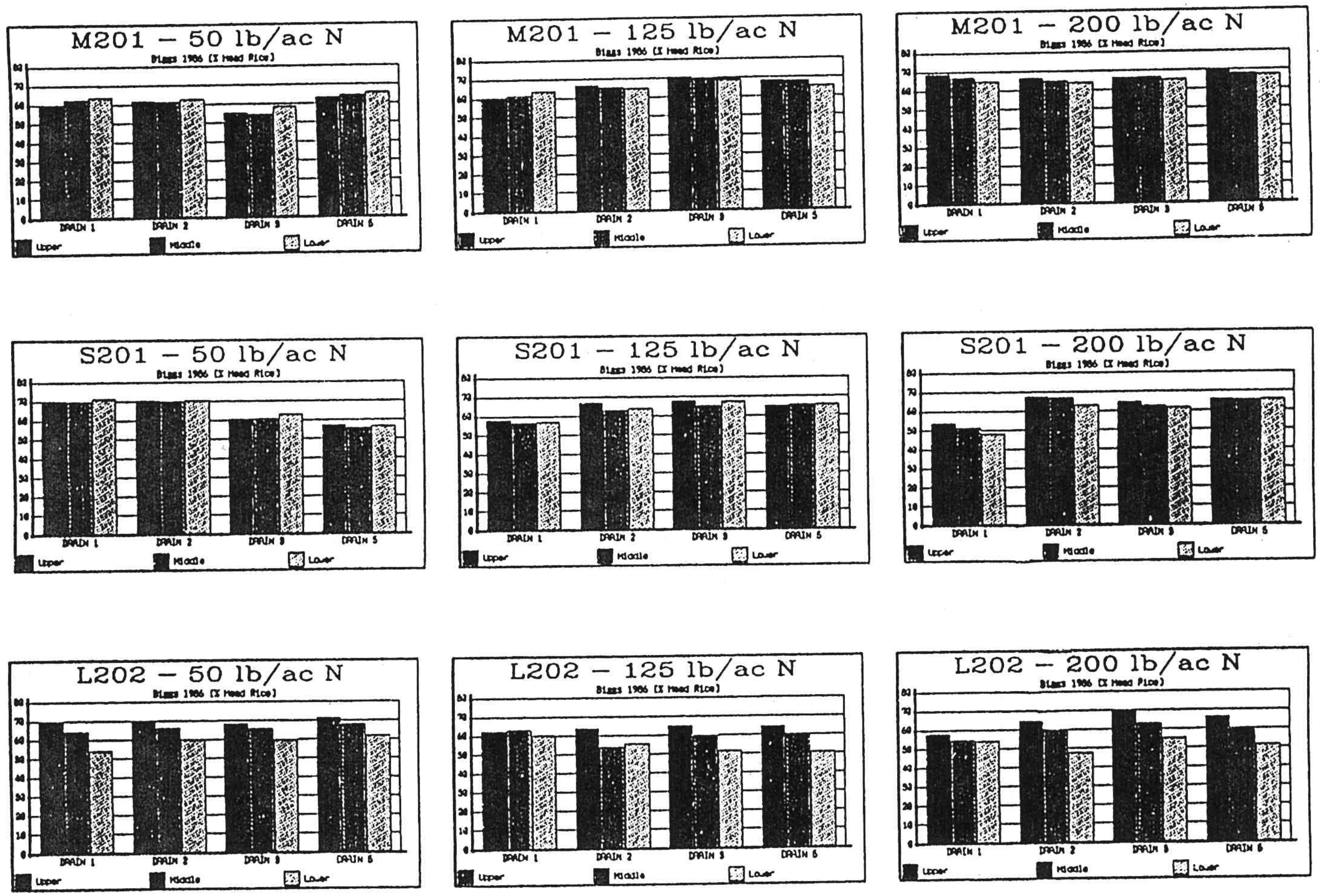


Figure 7 Means of percent head rice of nitrogen and drainage treatments at Biggs.

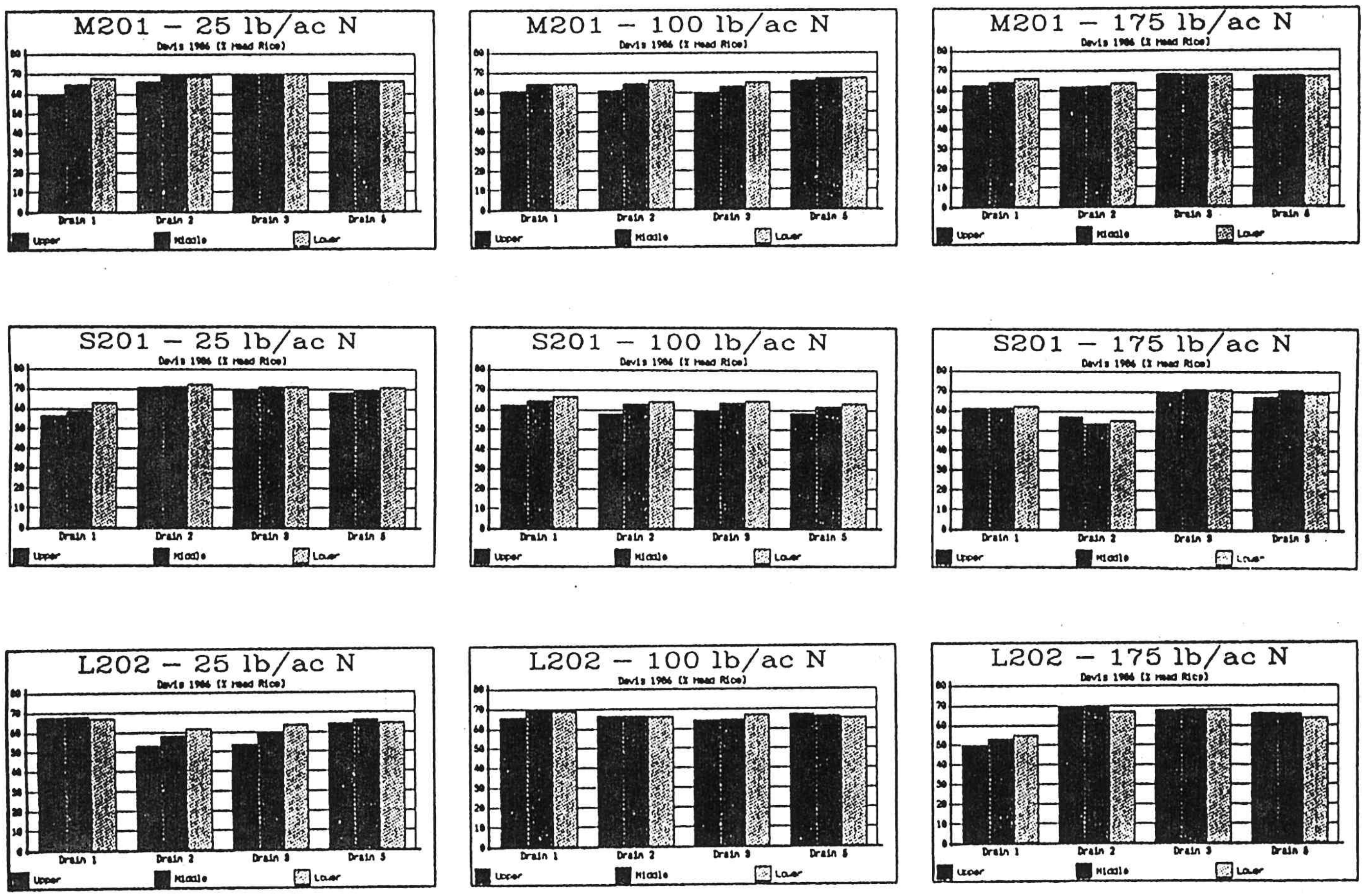


Figure 8 Means of percent head rice of nitrogen and drainage treatments at Davis.

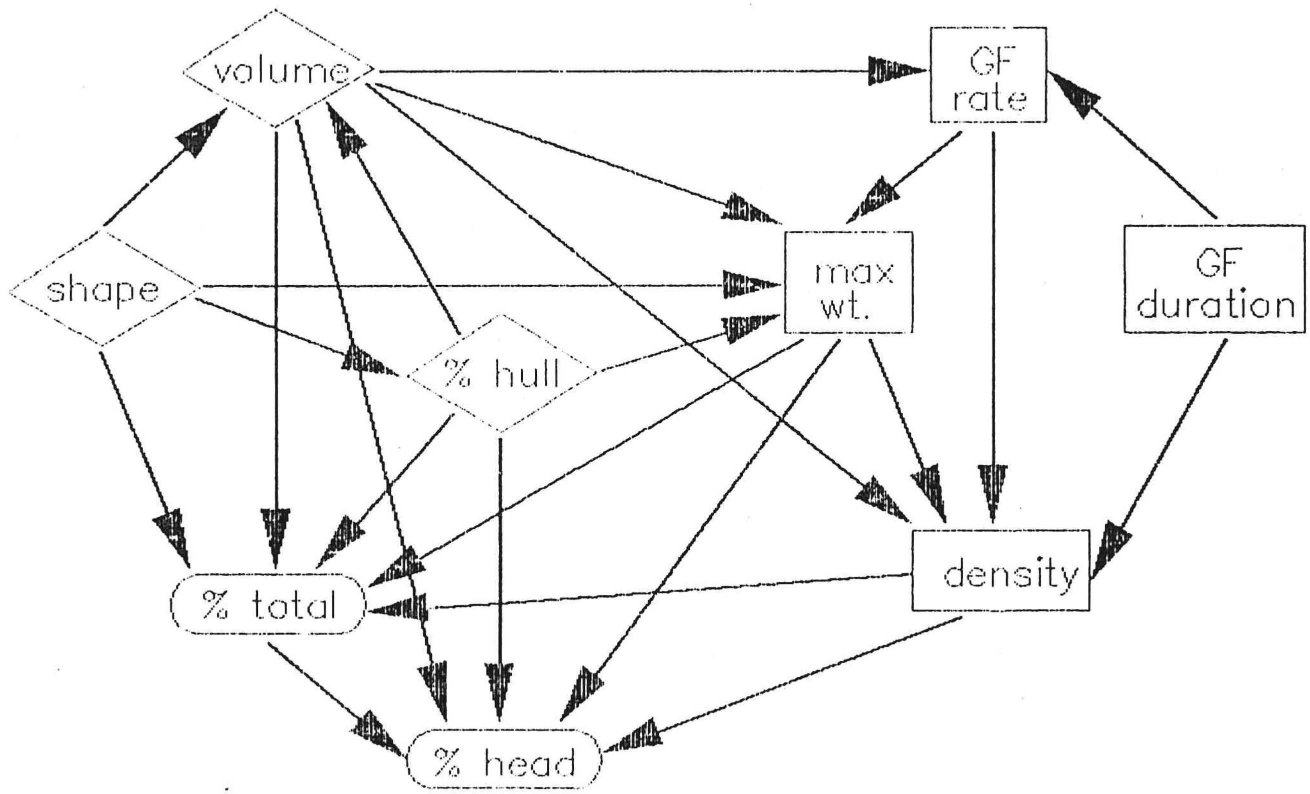


Figure 9 Interrelationships among grain structural and grain filling parameters and their effects on head rice.

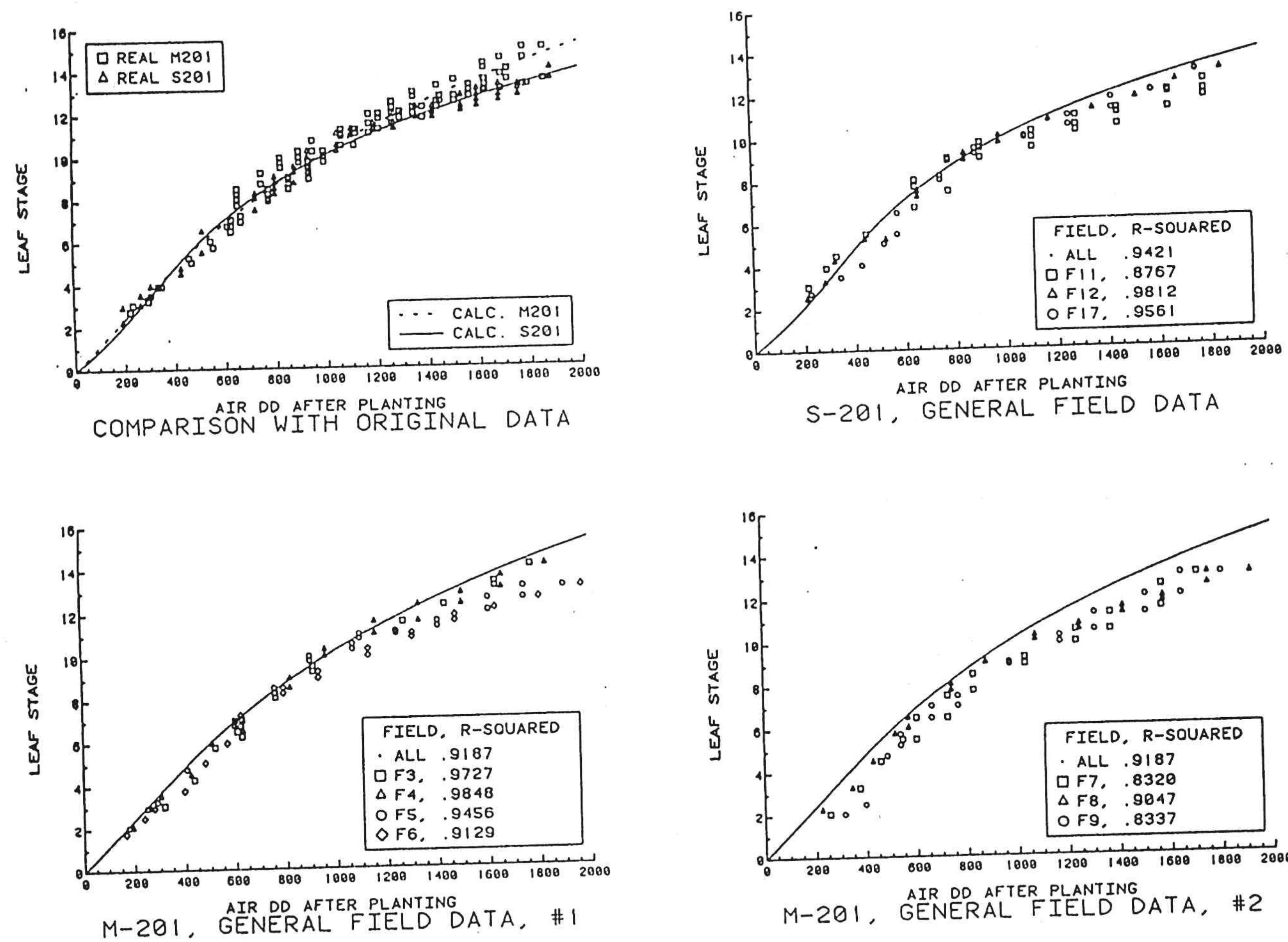


Figure 10 Degree day models for leaf stage predictions.

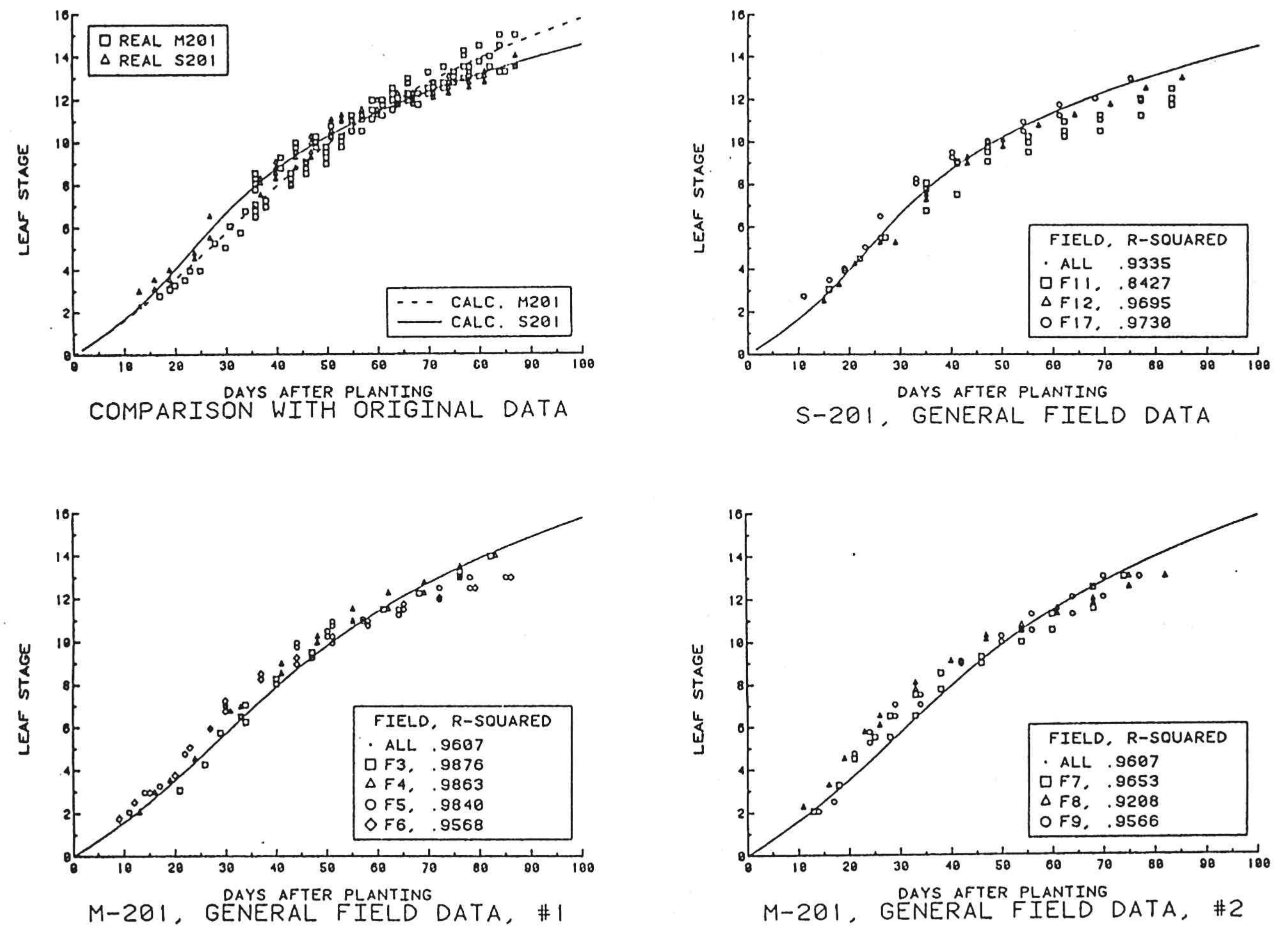


Figure 11 Days-after-planting as predictors for leaf stages.