# COMPREHENSIVE RESEARCH ON RICE

## Annual Report

## January 1, 1977 - December 31, 1977

I. Project Number and Title: RM-2. Cooperative Extension Rice Variety Adaptation and Cultural Practice Research.

II. Project Leader and Principal UC Investigators:

Project Leader: D. Marlin Brandon, Extension Agronomist (UCD).

Principal UC Investigators: L. A. Post, SRA (UCD), and Farm Advisors J. P. Guerard (Kern), K. E. Mueller (Colusa), T. Prichard (San Joaquin), G. J. St. Andre (Fresno), C. M. Wick (Butte) and J. F. Williams (Sutter).

III. Level of 1977 Funding: $31,538.

IV. Objectives and Experiments Conducted to Accomplish Objectives:

### OBJECTIVE I

Determine adaptability of rice varieties and the promising new rice lines made available by CCRRF-USDA-UC and private plant breeders to the rice production areas of the state.

Tests Conducted in Standard Rice Variety Testing Program

Very Early Maturity Group - Four uniform trials were conducted. These were located on the Rice Experiment Station (Butte), Wylie Farming (Glenn), Demeter Corp (Sacramento) and Sorrenti Ranch (San Joaquin). Twenty-four varietal entries were included in each test.

Early Maturity Group - Four uniform trials were established but only three harvested. These were located on the Rice Experiment Station (Butte), Mohammed Ranch (Yuba), Geer Ranch (Yolo) and Redfern Ranch (Fresno). The Fresno test was lost due to barnyardgrass infestation. Twenty-six varietal entries were included in each test.

Late Maturity Group - Four uniform trials were conducted. These were located on the Rice Experiment Station (Butte), Terhel Farms (Colusa), Tennis Ranch (Sutter) and Costerison Ranch (Kern). Twenty-four varietal entries were included in each test.

### OBJECTIVE II

Characterize differential response of new short stature rice varieties to nitrogen fertilizer, water depth and other factors in different environments. Determine the apparent optimum N rate for short stature varieties and provide information to growers that will encourage management for maximum yield.

Nitrogen X Rice Varieties Experiments

Very Early Maturity Group - Four experiments were conducted to study the response of tall and short stature varieties to nitrogen. Five nitrogen rates and three varieties were used in this group. The experiments were located on Charlie Johnson (Butte), Wylie Farming (Glenn), Dennis Ranch (Colusa) and Lauppe and Son (Sacramento). An experiment that was not uniform with these was conducted on the Plank Ranch (Colusa).

Early Maturity Group - Five experiments were conducted in this group. Five nitrogen rates and three varieties were included in the tests. Experiments were conducted with the McKnight Ranch (Butte), Cenedella Ranch (Yuba), Jimeno Ranch (Colusa), Lodi Ranch-J. Erdman (Colusa) and Tom Treon (San Joaquin).

Late Maturity Group - Three experiments were conducted in this group. Nitrogen rates used were the same as those of the other groups and three late varieties were tested. Experiments were conducted with Gary Gibson (Butte), Terhel Farms (Colusa) and Pat Tennis (Sutter). Grain and straw yields were determined in these three experiments to study grain/straw relationships as effected by nitrogen fertilizer.

Water Depth X Seeding Rate X Rice Varieties Experiments

Two experiments were conducted to study the differential effect of water depth on seedling emergence and production of tall and new short stature rice varieties. The seeding rate factor was included to determine if depressive effects of deep water can be minimized by high seeding rates in relation to varieties. Two experiments were conducted and consisted of two water depths, four seeding rates and eight rice varieties. The experiments were located on the Rice Experiment Station and UCD Rice Research Facility.

Rice Seeding Rate Experiments

Three seeding rate experiments were conducted with new short stature varieties adjacent to the Standard Rice Variety Tests in Yuba, Sacramento and Sutter counties. Varieties used were M9 and M7.

OBJECTIVE III

Determine more efficient sources, rates and methods of plant nutrient application in rice. Cooperate with Dr. D. S. Mikkelsen et al. in the revision of plant tissue and soil critical plant nutrient levels for new rice varieties.

The Early Rice Variety X Nitrogen experiments on the McKnight and Lodi ranches were used by Dr. D. S. Mikkelsen to study the fate of nitrogen fertilizer by $^{15}N$ techniques. This data should be valuable in delineating more efficient methods of nitrogen fertilization. The Rice Variety X Nitrogen experiments on Gibson, McKnight, Johnson, Mohammed, Tennis, Lauppe and Son and Treon ranches were leaf sampled to study the effect of N fertilizer treatment on tissue N. This data will be used to establish N critical levels in the plant tissue in cooperation with Dr. Mikkelsen et al. This data is currently being analyzed and interpreted.

The Rice Variety X Nitrogen experiments conducted on the Johnson, Lauppe and Son, Wylie Farming, McKnight, Terhel Farms and Gibson ranches were used by Dr. R. K. Webster to study the differential effect of nitrogen on the new short stature varieties in relation to stem rot disease. Please refer to RP-2 "Cause and Control of Rice Diseases" for a report of this work by Dr. Webster.

OBJECTIVE IV

Delineate soil phosphorus systems responsible for flood induced phosphorus deficiency in rice rotation crops.

The field and laboratory work required for a Ph.D. dissertation in Soil Science was completed and the dissertation written in 1977. Although the RRB provided no monetary support of this work in recent years, support was received in the early 1970s. Furthermore, because the problem affects all crops grown after rice a brief summary is desirable.

OBJECTIVE V

Provide assistance needed to expedite Agronomy Extension rice research and education programs and field research projects of the Comprehensive Rice Research Program. Maintain a UCD Agronomy Extension based rice project machinery pool designed to seed and harvest rice field experiments.

Thirty-one rice field experiments were harvested with the two rice combines in 1977. Twenty-seven of these experiments were directly related to this project and the remaining ones were in Botany Weed Control, Agronomy and Range Science and USDA Genetic Research. The experiments were located from Nelson (Butte County) to south of Bakersfield (Kern County).

## V. Summary of 1977 Research (Major Accomplishments)

OJBECTIVE I

### Standard Rice Variety Trials by Maturity Group

A total of 12 uniform rice variety trials were conducted in 10 counties from Butte County in the north to Kern County in the south. The trials were designed to measure agronomic performance of new rice lines in various environments when grown under normal cultural practices. Seventy-four varietal entries were tested in either the Very Early Maturity Group (<90 days to 50% heading), Early Maturity Group (90 to 105 days to 50% heading), or Late Maturity Group (>105 days to 50% heading), depending on days to 50% heading at the Rice Experiment Station. Varietal entries included in the trials were made available by the CCRRF-USDA-UC rice breeding program and private plant breeders.

Statewide (over locations) average performance of entries are reported here. References are made to individual experiments when desirable. A detailed summary by location will be prepared later but is not included here in view of desirability for brevity.

### Summary of Very Early Rice Variety Trials

Two of these experiments were located in rather cool areas (Natomas and Escalon) and two in warmer areas (Biggs and Willows). Average grain yield and other important plant characteristics are shown in Table 1. Thirteen of the lines

Table 1. Performance summary of very early rice varieties--means of four locations in 1977.

| 1977 Entry No. | Variety Description | Grain Type[1] | Grain Yield @ 14% $H_2O$ | Seedling Vigor[2] | Days to 50% Heading | Plant Height | Lodging[3] |
|---|---|---|---|---|---|---|---|
| | | | lbs/A | | | cm | % |
| 20 | ESD7-1-B | M | 8200 | 4.1 | 99 | 88 | 22 |
| 22 | ESD7-3 | M | 8100 | 4.1 | 103 | 86 | 19 |
| 6 | 76-Y-11 | P | 8060 | 3.8 | 100 | 96 | 52 |
| 3 | ED7-B | M | 8000 | 4.1 | 104 | 90 | 32 |
| 7 | 76-Y-13 | P | 7970 | 3.8 | 100 | 98 | 58 |
| 23 | 76-Y-36 | M | 7960 | 3.7 | 104 | 84 | 19 |
| 5 | M9 (192#/A) | M | 7950 | 3.8 | 107 | 86 | 20 |
| 2 | ED7-A | M | 7920 | 4.6 | 102 | 90 | 48 |
| 19 | ESD7-1-A | M | 7850 | 4.3 | 100 | 89 | 22 |
| 12 | 76-Y-107 | M | 7780 | 3.6 | 104 | 83 | 8 |
| 9 | 76-Y-17 | M | 7740 | 3.5 | 105 | 82 | 10 |
| 8 | 76-Y-14 | M | 7730 | 3.5 | 101 | 83 | 20 |
| 11 | 76-Y-106 | M | 7670 | 3.3 | 102 | 81 | 10 |
| 21 | ESD7-2 | M | 7660 | 4.0 | 106 | 91 | 31 |
| 4 | M9 (144#/A) | M | 7650 | 3.1 | 106 | 88 | 27 |
| 10 | 76-Y-104 | M | 7580 | 3.5 | 103 | 91 | 19 |
| 13 | 76-Y-111 | M | 7480 | 3.3 | 105 | 85 | 21 |
| 18 | S8158-39 (192#/A) | P | 7400 | 4.7 | 98 | 94 | 73 |
| 15 | 76-Y-124 | P | 7330 | 3.8 | 104 | 94 | 19 |
| 24 | 76-Y-162 | M | 7210 | 3.2 | 105 | 84 | 21 |
| 1 | Earlirose | M | 7150 | 4.4 | 104 | 112 | 66 |
| 17 | S8158-39 (144#/A) | P | 7000 | 4.3 | 98 | 95 | 67 |
| 14 | 76-Y-113 | M | 7000 | 2.9 | 104 | 81 | 6 |
| 16 | S8158-26 | P | 6440 | 4.6 | 97 | 102 | 69 |
| LSD .05 | | | 510 | 0.3 | 1 | 4 | 14 |
| C.V. (%) | | | 9.6 | 12.7 | 2.0 | 5.6 | 65.3 |

[1]P = Pearl, M = Medium, L = Long.

[2]Subjective rating of 1-5, where 1 = poor, 5 = excellent.

[3]Subjective rating of 1-99, where 1 = 1% lodged, 99 = 99% lodged.

including M9 seeded at 192 lbs/A yielded significantly greater than the tall, early, commercial Earlirose variety. The highest yielding lines were ESD7-1-B, ESD7-3, 76-Y-11 and ED7-B. The ESD7's and ED7's appear widely adapted in California in that their performance in both cool and warmer environments is good. They perform exceptionally well in cool environments in comparison with standard varieties and many experimental lines. Most entries in this group were short stature and yielded very well. However, there was a rather high incidence of lodging. Since these trials were usually mature before fields in which they were grown, greater lodging was expected.

## Summary of Early Rice Variety Trials

Six lines in this group yielded significantly greater than M5 and nine yielded signficantly greater than S6. M9 was among the top six highest yielding entries between which there was no significant difference in yields. Table 2 shows the important plant characteristics of the 26 lines tested in this group. The 1977 data indicates there were no new lines tested that have greater grain yield potential than M9. The long grain lines 76-Y-48-2 and 76-Y-48-1 yielded very well.

## Summary of Late Rice Variety Trials

This maturity group contained the commercial variety CS-M3 and the new short stature varieties Calrose 76 and M7. The group was tested in the hot climate of the lower San Joaquin Valley (Kern County), the warm upper Sacramento Valley (Biggs and northeastern Colusa County), and the cooler lower Sacramento Valley (Sutter Basin). The performance of this group is shown in Table 3. Calrose 76 and M7 were among the nine highest yielding entries and there was no significant difference between the yields of these nine entries. The data indicates there was no line tested with greater yield potential than Calrose 76 and M7. The long grain experimentals 75/49536 and 75/45886 yielded significantly greater than CS-M3 and yielded well in comparison to Calrose 76 and M7.

# OBJECTIVE II

## Differential Response of Tall and Short Stature Rice Varieties to Nitrogen Fertilizer

Twelve experiments designed to measure responsiveness of three Very Early Maturity lines, three Early Maturity varieties and three Late Maturity varieties to nitrogen fertilizer were conducted in cooperation with rice farm advisors, Dr. D. S. Mikkelsen and Dr. R. K. Webster. The voluminous data generated from these experiments are only briefly summarized in this report. For a summary of the effect of nitrogen on stem rot disease in relation to rice variety, please refer to Dr. R. K. Webster's report RP-2. The means of all locations are used in this report in the interest of brevity. A more detailed report will be prepared when all computations are complete.

## Response of Very Early Maturing Varieties to Nitrogen

The response of two promising rice lines ESD7-3 and 76-Y-11 were compared to that of Earlirose in a cool (Natomas) and two warmer (Butte and Glenn) environments. ESD7-3 is a short stature, medium grain line and 76-Y-11 is a short stature, short grain line. The mean yields of the three locations are shown in Figure 1 and Table 4. The short stature lines were more yield responsive to N than was Earlirose and required about 30 lbs N/A more for optimum yield. N rates greater than optimum for each line induced lodging, but the effect of N on lodging was more severe in Earlirose

Table 2. Performance summary of early rice varieties--means of three locations in 1977.

| 1977 Entry No. | Variety Description | Grain Type[1] | Grain Yield @ 14% $H_2O$ | Duncan's Test | Seedling Vigor[2] | Days to 50% Heading | Plant Height | Lodging[3] |
|---|---|---|---|---|---|---|---|---|
| | | | lbs/A | | | | cm | % |
| 46 | 76-Y-48-1 | L | 8310 | a | 4.3 | 103 | 91 | 14 |
| 39 | 76-Y-141 | M | 8280 | a | 4.4 | 104 | 87 | 10 |
| 37 | 76-Y-41 | P | 8260 | a | 4.4 | 101 | 81 | 1 |
| 48 | 76-Y-48-2 | L | 8250 | a | 4.6 | 103 | 99 | 7 |
| 47 | 75/55701+05 | M | 8120 | a | 4.7 | 103 | 94 | 8 |
| 36 | M9 | M | 8120 | a | 4.5 | 99 | 92 | 17 |
| 38 | 76-Y-42 | M | 7860 | ab | 4.4 | 101 | 83 | 3 |
| 42 | 76-Y-184 | M | 7840 | abc | 3.9 | 105 | 83 | 14 |
| 40 | 76-Y-156 | M | 7680 | abcd | 4.7 | 103 | 93 | 15 |
| 27 | M5 | M | 7370 | bcde | 4.5 | 111 | 124 | 51 |
| 32 | ED7 | M | 7340 | bcde | 5.0 | 99 | 88 | 29 |
| 45 | 76-Y-232 | M | 7290 | bcde | 4.2 | 111 | 87 | 16 |
| 41 | 76-Y-170 | M | 7240 | bcde | 4.3 | 104 | 90 | 1 |
| 33 | S-8157-51 | P | 7160 | bcde | 4.1 | 103 | 93 | 16 |
| 49 | 76-Y-261 | L | 7100 | cde | 3.6 | 107 | 85 | 3 |
| 31 | S-8157-85 | P | 7040 | de | 4.0 | 106 | 98 | 39 |
| 28 | S-6190-96 | M | 7040 | de | 4.3 | 112 | 93 | 18 |
| 29 | S-6190-110 | M | 6990 | de | 4.3 | 109 | 91 | 21 |
| 43 | 76-Y-186 | M | 6940 | de | 4.5 | 109 | 87 | 4 |
| 34 | S-8157-100 | P | 6900 | e | 3.9 | 106 | 113 | 55 |
| 30 | S6 | P | 6850 | e | 4.4 | 106 | 116 | 59 |
| 25 | Earlirose | M | 6850 | e | 4.7 | 101 | 121 | 82 |
| 50 | 76-Y-298 | L | 6820 | e | 4.1 | 108 | 105 | 11 |
| 44 | 76-Y-189 | M | 6810 | e | 4.3 | 108 | 86 | 3 |
| 35 | S-8157-101 | P | 6740 | e | 4.3 | 107 | 110 | 38 |
| 26 | Earlirose 76B | M | 6670 | e | 3.3 | 104 | 115 | 34 |
| LSD .05 | | | 640 | | 0.4 | 2 | 4 | 13 |
| C.V. (%) | | | 10.8 | | 11.2 | 1.8 | 5.0 | 74.8 |

[1]P = Pearl, M = Medium, L = Long.

[2]Subjective rating of 1-5, where 1 = poor, 5 = excellent.

[3]Subjective rating of 1-99, where 1 = 1% lodged, 99 = 99% lodged.

Table 3. Performance summary of late rice varieties--means of three locations in 1977.

| 1977 Entry No. | Variety Description | Grain Type[1] | Grain Yield @ 14% $H_2O$ | Seedling Vigor[2] | Days to 50% Heading | Plant Height | Lodging[3] |
|---|---|---|---|---|---|---|---|
| | | | lbs/A | | | cm | % |
| 83 | 76-Y-406 | M | 8580 | 3.7 | 110 | 84 | 1 |
| 65 | 76-Y-69 | M | 8560 | 4.1 | 111 | 92 | 2 |
| 78 | 76-Y-378 | M | 8540 | 3.6 | 111 | 85 | 1 |
| 64 | 76-Y-66 | M | 8520 | 4.2 | 114 | 90 | 1 |
| 66 | 76-Y-74 | M | 8480 | 3.5 | 110 | 85 | 1 |
| 62 | Calrose 76 | M | 8470 | 4.1 | 113 | 92 | 6 |
| 63 | M7 | M | 8440 | 4.3 | 113 | 90 | 1 |
| 72 | 75/49536 | L | 8430 | 3.6 | 110 | 79 | 1 |
| 74 | Calrose 76A1 | M | 8370 | 4.1 | 110 | 95 | 1 |
| 68 | 75/45886 | L | 8070 | 3.6 | 105 | 89 | 1 |
| 79 | 76-Y-386 | M | 8000 | 3.7 | 110 | 85 | 1 |
| 76 | 76-Y-367 | M | 7990 | 4.3 | 106 | 88 | 3 |
| 77 | 76-Y-368 | M | 7990 | 3.9 | 105 | 86 | 2 |
| 67 | 76-Y-70 | L | 7900 | 3.6 | 113 | 111 | 1 |
| 70 | 75/46035 | L | 7900 | 3.5 | 112 | 100 | 1 |
| 81 | 76-Y-398 | M | 7900 | 3.8 | 110 | 84 | 1 |
| 84 | 76-Y-418 | M | 7880 | 4.5 | 105 | 93 | 1 |
| 71 | 75/45933 | L | 7840 | 3.5 | 112 | 98 | 1 |
| 73 | 75/49596 | L | 7690 | 4.0 | 112 | 86 | 1 |
| 69 | 75/49491 | L | 7680 | 3.8 | 109 | 85 | 1 |
| 80 | 76-Y-394 | P | 7640 | 3.7 | 111 | 85 | 1 |
| 61 | CS-M3 | M | 7600 | 3.8 | 111 | 124 | 59 |
| 82 | 76-Y-399 | M | 7470 | 3.9 | 111 | 84 | 1 |
| 75 | 76-Y-188 | M | 7470 | 4.0 | 107 | 89 | 3 |
| LSD .05 | | | 340 | 0.4 | 4.0 | 3.0 | 3.0 |
| C.V. (%) | | | 5.2 | 12.1 | 5.0 | 3.6 | 82.9 |

[1]P = Pearl, M = Medium, L = Long.

[2]Subjective rating of 1-5, where 1 = poor, 5 = excellent.

[3]Subjective rating of 1-99, where 1 = 1% lodged, 99 = 99% lodged.

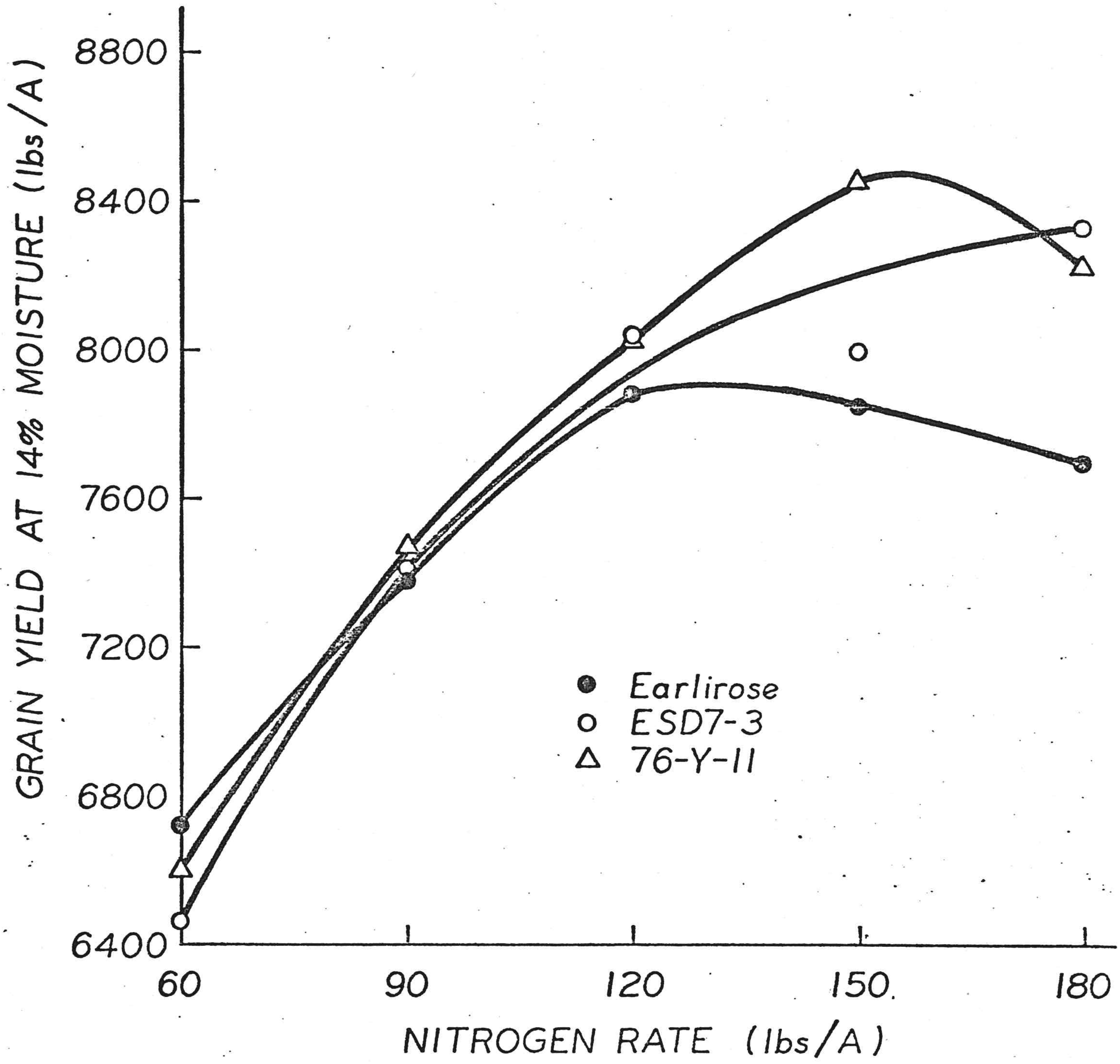


Figure 1. Mean yield response of tall and short stature very early maturing rice lines to nitrogen fertilizer at three locations in 1977.

Table 4. The differential effect of nitrogen fertilizer on tall and short-stature very early rice varieties at three locations in 1977.

| Nitrogen Rate of Application lbs/A | Plant Character | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Days to 50% Heading | | | Plant Height cm | | | Lodging 1-99% | | | Grain Yield at 14% $H_2O$ lbs/A | | |
| | Earlirose | ESD7 | 76-Y-11 | Earlirose | ESD7 | 76-Y-11 | Earlirose | ESD7 | 76-Y-11 | Earlirose | ESD7 | 76-Y-11 |
| 60 | 101 | 100 | 97 | 106 | 87 | 93 | 15 | 2 | 4 | 6720 | 6470 | 6610 |
| 90 | 102 | 100 | 98 | 110 | 89 | 96 | 52 | 2 | 18 | 7380 | 7410 | 7470 |
| 120 | 102 | 100 | 99 | 119 | 93 | 101 | 82 | 37 | 57 | 7890 | 8050 | 8020 |
| 150 | 103 | 101 | 100 | 122 | 97 | 104 | 95 | 56 | 60 | 7850 | 8000 | 8400 |
| 180 | 104 | 102 | 100 | 123 | 98 | 106 | 94 | 75 | 73 | 7700 | 8340 | 8230 |
| LSD .05 for N rate: | | 0.4 | | | 2.0 | | | 8 | | | 260 | |
| LSD .05 for VxN: | | 0.6 | | | ns | | | 12 | | | ns | |
| LSD .05 for VxNxL: | | 1.0 | | | ns | | | 21 | | | ns | |

than in ESD7-3 and 76-Y-11. These two short stature lines appeared more susceptible to lodging than Calrose 76, M7 and M9. The greater lodging observed in this group may have been caused by late havest of the experiments in relation to drainage of the fields in which they were located. Moreover, the results indicate that optimum N rates for ESD7-3 and 76-Y-11 may be less than the optimum rate for the short stature early and late varieties based upon grain yield and lodging. Strong nitrogen x location and variety x location interactions were observed in these experiments.

Response of Early Maturing Varieties to Nitrogen

Differential responses of M5, S6 and M9 to N were studied at 1 cool and 4 warm environments in 1977. A summary of the results is shown in Figure 2 and Table 5. The short stature M9 responded in a linear fashion to increasingly greater N rates up to 180 lbs N/A. The tall M5 and S6 responded in a curvilinear fashion in that maximum grain yield was observed at 150 lbs N/A and an additional 30 lbs/A (180 lbs N/A) decreased yield. There were strong variety x N and variety x N x location interactions in this group which means that response was different in the three locations. Consequently, broad statements about the results are inappropriate. M9 showed extremely high yield potential in the Cenedella (Yuba County) experiment in that yields increased linearly with N rates to 10,900 lbs/A at 180 lbs N/A. However, grain yields were much less in the Erdman (Colusa County) experiment and McKnight (Butte County) experiments because of under fertilization and over fertilization, respectively.

There appears to be a real problem in this group in estimating time of field drainage. In most cases the water was drained too early for these varieties at high N rates and plant lodging occurred because of premature straw desiccation. In experiments that were not drained too early, much higher yields and less lodging were observed than in those prematurely drained. Irrigation water should be left on M9 and perhaps S6 longer after flowering than on Colusa, Calrose and other pubescent varieties for maximum grain fill and yield.

Response of Late Maturing Varieties to Nitrogen

Differential responses of the tall CS-M3 and short stature Calrose 76 and M7 were studied at three Sacramento Valley locations in 1977. Grain yields of Calrose 76 and M7 were much greater than those of CS-M3 in the experiments this year as shown in Figure 3. The effect of N on plant characters are shown in Table 6. Calrose 76 and M7 were much more responsive to N and, as in past studies, required about 30 lbs N/A more than CS-M3 for maximum yield. However, these two short stature varieties yielded greater than the tall CS-M7 at all N rates. Lodging of CS-M3 was not a yield factor at the two lower N rates but lodging did occur at 120 lbs N/A and yield was greatly decreased with increasingly greater N rates. Lodging of Calrose 76 and M7 was observed at the 180 lbs/A N rate but it was not severe enough to greatly effect grain yield. Field drainage before maturity was not observed in these experiments as it was in the early maturity group, probably because of lower temperatures later in the fall.

This data indicates that about 120 lbs N/A was sufficient for optimum yield of Calrose 76 and M7 in 1977. Since there was no significant N x variety x location interaction, we can say the N response in each location was similar to that shown in Figure 3. Although grain yield of Calrose 76 and M7 were not significantly depressed at the higher N rates, the higher N rates (150 to 180 lbs/A) did increase

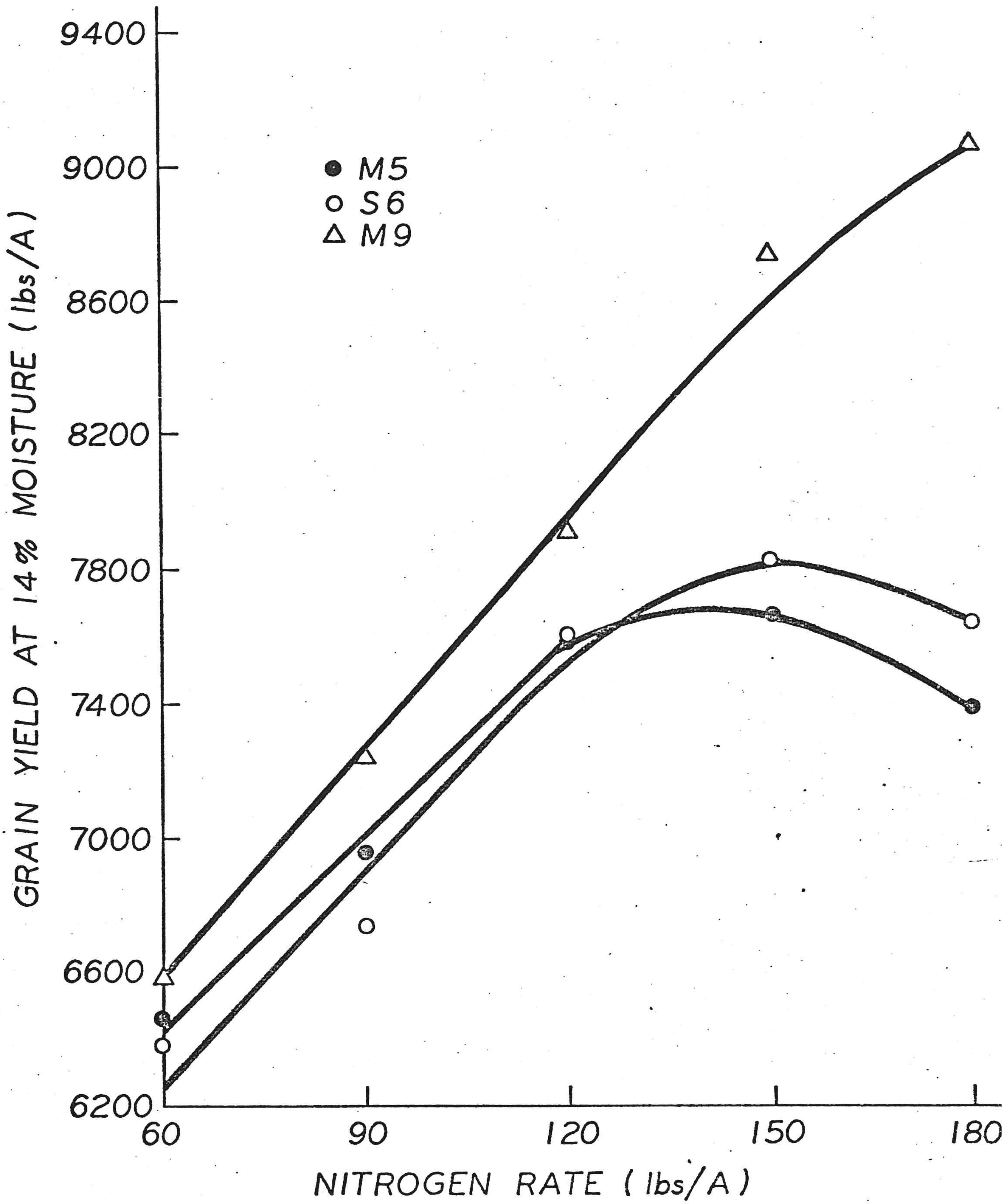


Figure 2. Mean yield response of tall and short stature early rice varieties to nitrogen fertilizer at five locations in 1977.

Table 5. The differential effect of nitrogen fertilizer on tall and short-stature early rice varieties at five locations in 1977.

| Nitrogen Rate of Application lbs/A | Plant Character: Days to 50% Heading | | | Plant Height - cm | | | Lodging 1-99% | | | Grain Yield at 14% $H_2O$ - lbs/A | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M5 | S6 | M9 | M5 | S6 | M9 | M5 | S6 | M9 | M5 | S6 | M9 |
| 60 | 111 | 104 | 100 | 112 | 106 | 82 | 32 | 27 | 21 | 6460 | 6380 | 6580 |
| 90 | 111 | 105 | 100 | 114 | 109 | 85 | 33 | 34 | 22 | 6960 | 6730 | 7240 |
| 120 | 111 | 105 | 100 | 121 | 113 | 88 | 55 | 41 | 22 | 7590 | 7600 | 7910 |
| 150 | 112 | 107 | 101 | 125 | 118 | 90 | 60 | 54 | 32 | 7660 | 7830 | 8740 |
| 180 | 112 | 108 | 101 | 127 | 121 | 93 | 66 | 63 | 37 | 7390 | 7640 | 9060 |
| LSD .05 for N rate: | | 1.0 | | | 2 | | | 4 | | | 250 | |
| LSD .05 for VxN: | | 1.0 | | | 3 | | | 9 | | | 400 | |
| LSD .05 for VxNxL: | | 1.0 | | | ns | | | 19 | | | 900 | |

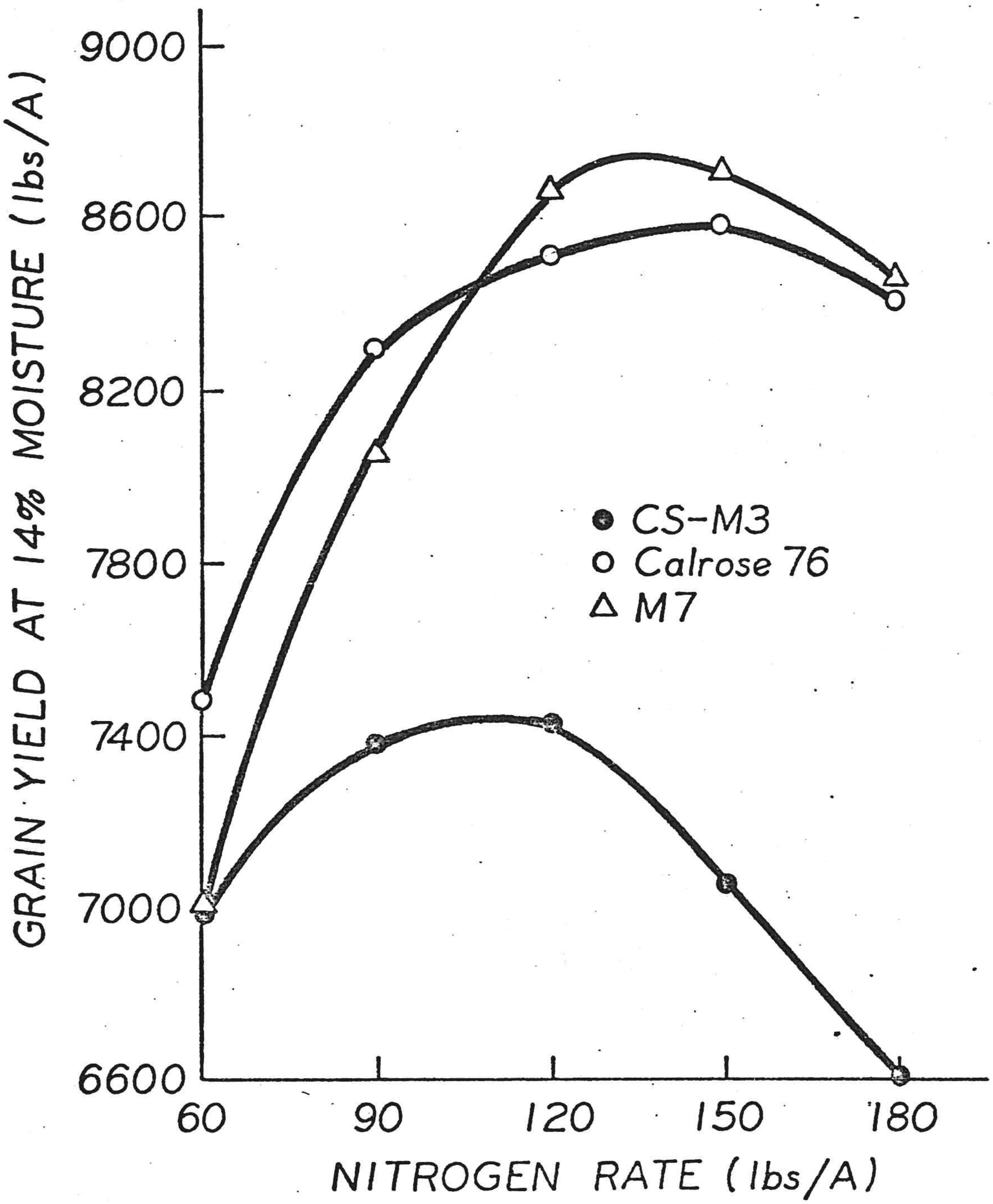


Figure 3. Mean grain yield of tall and short stature late rice varieties to nitrogen fertilizer at three locations in 1977.

Table 6. The differential effect of nitrogen fertilizer on tall and short-sture late rice varieties at three locations in 1977.

| | Plant Character | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen Rate of Application lbs/A | Days to 50% Heading | | | Plant Height cm | | | Lodging 1-99% | | | Grain Yield at 14% $H_2O$ - lbs/A | | |
| | CS-M3 | Calrose 76 | M7 | CS-M3 | Calrose 76 | M7 | CS-M3 | Calrose 76 | M7 | CS-M3 | Calrose 76 | M7 |
| 60 | 112 | 114 | 114 | 113 | 84 | 82 | 27 | 3 | 1 | 6980 | 7480 | 7000 |
| 90 | 112 | 114 | 114 | 117 | 88 | 87 | 48 | 3 | 1 | 7380 | 8300 | 8060 |
| 120 | 113 | 114 | 114 | 123 | 91 | 89 | 71 | 4 | 3 | 7420 | 8510 | 8670 |
| 150 | 113 | 115 | 115 | 129 | 91 | 91 | 94 | 19 | 3 | 7050 | 8590 | 8710 |
| 180 | 113 | 115 | 115 | 128 | 94 | 93 | 95 | 54 | 11 | 6600 | 8410 | 8460 |
| LSD .05 for N rate: | | 0.4 | | | 2 | | | 6 | | | 240 | |
| LSD .05 for VxN: | | 0.4 | | | 3 | | | 10 | | | 330 | |
| LSD .05 for NxVxL: | | 0.7 | | | ns | | | 18 | | | ns | |

the incidence of green kernels in the panicles. This variability in panicle maturity probably reduces overall milling quality of the rice. Moreover, the higher N rates would decrease net profit because they did not significantly increase grain yield above the 120 lbs/A N rate. Excessive N application should be avoided because of economics and inefficiency.

Differential Grain/Straw Response of Tall and Short Stature Rice Varieties to Nitrogen

Six of the late variety x nitrogen experiments in 1976 and 1977 were used to study not only the effect of N on grain yield but also on straw yield. The Rice Research Board established the development of high yielding, short stature rice varieties with less straw production as a high priority in 1969. Since new short varieties have been developed and are currently in seed increase programs, it appeared desirable to compare grain/straw relationships of the tall standards and the new short varieties. A brief summary of this work is shown in Table 7. Biological yield (grain + straw) was determined in 140 $ft^2$ plots harvested with a self-propelled combine.

The short stature Calrose 76 and M7 were more grain yield responsive to N but less straw yield responsive than the tall CS-M3. Straw yield of CS-M3 increased linearly with increasing N rates but a curvilinear relationship was observed between straw yield of Calrose 76 and M7 and N rate. Grain/straw ratio of CS-M3 decreased greatly with increasingly greater N rates but N only slightly decreased the grain/straw ratio of Calrose 76 and M7. Mean grain/straw ratios were .64 and .78 for the tall and short stature varieties, respectively. The short stature Calrose 76 and M7 produced 12% more grain and 10% less straw than the tall CS-M3 at the 150 lbs/A N rate. However, under field conditions straw yield may be reduced 10 to 20% depending on management of growth factors.

The Effect of Water Depth and Seeding Rate on Growth and Production of Tall and Short Stature Rice Varieties

Two experiments were conducted to determine the effect of water depth and seeding rate on growth and yield of tall and new short stature rice varieties. Since deep water is known to depress seedling emergence, tillering and yield of rice, it appeared desirable to determine its effect on new short types. The seeding rate variable was included to determine if higher seeding rates will compensate for the depressive effect of deep water on stand density, tillering and grain yield. One experiment was conducted at UCD because of its cooler environment and one on the Rice Experiment Station in cooperation with Morton Morse.

The effect of 2-4 inch and 6-8 inch water depths on seedling emergence at 28 days after seeding is shown in Table 8. The depressive effect of deep water on seedling emergence was greater in the cool UCD (Table 8) location but deep water significantly delayed emergence at both locations. The depressive effect of deep water was observed on both tall and short stature varieties in both locations. Calrose 76 and ESD7 showed exceptionally good seedling vigor even in the cool UCD experiment and compared favorably with Calrose. Seedling vigor of M7 was comparable to that of CS-M3. M9 exhibited poorer seedling vigor in these experiments and was more severely affected by deep water than other short stature varieties in the seedling stage. However, the ultimate effect of deep water on grain yield will not be known until the statistical analyses of these experimental results are completed. A more detailed report of the results will be made later.

Table 7. Differential grain/straw response of tall and short-stature rice varieties to nitrogen.

| Nitrogen Rate | CS-M3 Grain Yield | CS-M3 Straw Yield | CS-M3 Grain/ Straw | Calrose 76 Grain Yield | Calrose 76 Straw Yield | Calrose 76 Grain/ Straw | M7 Grain Yield | M7 Straw Yield | M7 Grain/ Straw |
|---|---|---|---|---|---|---|---|---|---|
| lbs/A | lbs/A | lbs/A | | lbs/A | lbs/A | | lbs/A | lbs/A | |
| 60 | 3970 | 6040 | 0.68 | 4150 | 5240 | 0.79 | 4470 | 5640 | 0.83 |
| 90 | 4850 | 7040 | 0.69 | 5230 | 6110 | 0.87 | 5070 | 6630 | 0.79 |
| 120 | 5300 | 8040 | 0.66 | 5690 | 7030 | 0.81 | 5660 | 7660 | 0.76 |
| 150 | 5230 | 8760 | 0.61 | 6070 | 7940 | 0.78 | 6070 | 8310 | 0.75 |
| 180 | 5250 | 9700 | 0.56 | 5930 | 7970 | 0.77 | 6150 | 8240 | 0.77 |
| Variety Mean | 4920 | 7920 | 0.64 | 5410 | 6860 | 0.81 | 5480 | 7300 | 0.78 |

LSD .05 for grain (variety) = 130 lbs/A

LSD .05 for straw (variety) = 260 lbs/A

LSD .05 for grain/straw (variety) = 0.029

Table 8. Seedling vigor of tall and short-stature rice varieties as influenced by water depth and location.

| Water Depth | Calrose | Calrose 76 | CS-M3 | M7 | S6 | SS6 | M9 | ESD7 | Depth Mean |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | UCD | | | | |
| cm | | | | | | | | | |
| 5 | 3.9 | 4.1 | 3.8 | 3.6 | 3.6 | 3.0 | 3.6 | 4.5 | 3.8 |
| 20 | 3.9 | 3.8 | 3.4 | 2.8 | 3.4 | 2.3 | 2.7 | 3.8 | 3.3 |
| Variety Mean | 3.9 | 4.0 | 3.6 | 3.2 | 3.5 | 2.7 | 3.2 | 4.2 | |
| | | | | | Biggs | | | | |
| 5 | 4.5 | 4.6 | 4.5 | 4.3 | 4.3 | 4.0 | 4.8 | 4.9 | 4.5 |
| 20 | 4.4 | 4.8 | 4.4 | 4.4 | 4.1 | 3.9 | 3.4 | 4.5 | 4.2 |
| Variety Mean | 4.5 | 4.7 | 4.5 | 4.4 | 4.2 | 4.0 | 4.1 | 4.7 | |
| Grand Variety Mean | 4.2 | 4.3 | 4.0 | 3.8 | 3.9 | 3.3 | 3.6 | 4.4 | |

Seedling vigor rating at 28 days after seeding: 1 = poor emergence, 5 = excellent emergence.

## OBJECTIVE III

Seven of the rice variety x nitrogen experiments were leaf sampled by farm advisors to determine leaf N concentrations at 55 to 80 days after seeding. Although statistical analyses of this data are not complete, it appears the short stature rice varieties absorb N and P more efficiently than tall varieties as indicated by higher leaf concentrations of these nutrients. The significance of the observed higher leaf N and P in short stature varieties has not been determined at this time, but a detailed study of the data in cooperation with Dr. D. S. Mikkelsen will be done in the next few months. Please refer to RB-1 for additional information on rice plant nutrition research.

## OBJECTIVE IV

Research over the past five years into the cause and method of correction of plant phosphorus deficiency in crops following rice culminated in a Ph.D. dissertation in December 1977. A brief abstract that relates the results of these studies is attached. The results show clearly that P deficiency is common in rice rotation crops and that soil flooding and drainage induces chemical changes that make soil P unavailable. The results indicate that P should be band-placed in crops following rice for maximum yield. When this is done, it probably is not necessary to apply P in the subsequent rice crop.

## VI. Publications

The following publications were related directly to the Cooperative Extension Rice Variety Adaptation and Cultural Practice Research Grant from the RRB. Many popular articles also appeared in magazines, newspapers and radio reports.

1. Brandon, D. M., K. E. Mueller, J. N. Rutger and S. B. Ahn. 1977. Differential grain/straw response of tall and short stature rice cultivars to fertilizer nitrogen. Amer. Soc. Agron. Abs., 1977 Annual Meetings, Los Angeles, Calif. p. 97.

2. Brandon, D. M. and D. S. Mikkelsen. 1977. Effect of soil submergence for lowland rice on soil phosphorus availability to rice rotation crops. Abs. Phosphate Work Group, Western Soil-Water Res. Comm., UCR. p. 9-12.

3. Brandon, D. M., L. A. Post, S. D. Murrill, K. E. Mueller, T. Prichard, G. J. St. Andre, C. M. Wick, J. F. Williams and D. R. Woodruff. 1977. California rice varieties: Description and performance summary of 1976 and multi-year standard rice variety trials in California. Agron. Prog. Report 83, UC Agricultural Experiment Station-Cooperative Extension, UCD.

4. Brandon, D. M., K. E. Mueller, T. Prichard, G. J. St. Andre, C. M. Wick, J. F. Williams and D. R. Woodruff. 1977. California rice varieties: Description and performance. Handout at 1977 Winter Annual Rice Meetings.

5. Brandon, D. M. 1977. Phosphorus transformations in alternately flooded soils and their effect on rice rotation crops. Ph.D. Thesis, University of California, Davis.

6. Brandon, D. M. 1977. Cooperative Extension rice variety adaptation and cultural practice research. 1976 Annual Report, Rice Research Board.

## VII. General Summary of 1977 Results

Twelve uniform rice variety trials were conducted in 10 California counties in 1977. Seventy-four varietal entries made available by the CCRRF-USDA-UC Rice Breeding Program and private breeders were tested.

Thirteen very early rice lines yielded significantly greater than the commercial Earlirose variety. ESD7-1-B, ESD7-3, 76-Y-11 and ED7-B appear widely adapted to California environments. The ESD7 and ED7 lines appear to perform exceptionally well in cool environments and these may be good candidates for release in the Very Early Maturity Group. Six lines yielded significantly greater than M5 and S6 in the Early Maturity Group. The newly released short stature M9 was among the top six highest yielding lines between which there was no significant difference in yield. The 1977 data indicates there was no new line tested with greater yield potential than M9. Two long grain lines yielded very well. Calrose 76 and M7 were among the nine highest yielding lines in the Late Maturity Group. These two short stature varieties performed very well in comparison to the tall CS-M3 which yielded 1000 lbs/A less than Calrose 76 and M7.

Results of 12 Rice Variety x Nitrogen experiments indicate short stature varieties may require 30 lbs/A more N than tall varieties for maximum yield expression. Short stature varieties such as Calrose 76, M7 and M9 were more yield responsive to N and contained higher levels of N and $PO_4$-P in their leaf tissue than tall varieties. The mean yield advantage of Calrose 76, M7 and M9 over CS-M3, M5 and S6 was greater in 1977 than in previous years but strong variety x nitrogen x location interaction was observed. Consequently, the performance of a given variety in relation to N depended upon location. For instance, M9 yielded as much as 1900 lbs/A greater than M5 in a Yuba County experiment where conditions were favorable, but the yield differential between the two varieties was only 800 lbs/A in a Colusa County experiment in which M9 was under fertilized with N. Early field drainage of irrigation water probably limited the yield potential of short stature varieties in the highest N treatment. Excessive N appeared to increase the incidence of green kernels and would likely reduce milling quality of the rice. Calrose 76 and M7 lodged slightly at the 180 lbs/A N rate but grain yield was not severely affected.

Straw and grain of six Late Variety x Nitrogen experiments were harvested in 1976 and 1977 to study grain/straw relations of tall and short stature varieties. Grain/straw ratio of the tall CS-M3 was greatly decreased with increasingly greater N rates because of stimulation of vegetative growth, lodging and reduced grain yield. However, grain/straw ratios of Calrose 76 and M7 were greater and more stable over all N rates than that of CS-M3. Better light interception due to less lodging and better grain fill probably contributed to higher grain/straw ratios of the short stature varieties. 1976 data indicates the new short stature Calrose 76 and M7 may produce 12% more grain and 10% less rice straw than CS-M3.

Deep water (6-8 inches) had a depressive effect on seedling vigor of both tall and short stature rice varieties in 1977. Those short stature varieties that exhibited good seedling vigor in shallow water (2-4 inches) also exhibited good vigor in deep water in relation to tall varieties. ESD7-2, Calrose 76 and M7 were equal to or greater in vigor than CS-M3. However, M9 showed poorer vigor than other short types, especially in the cool UCD location. The relative effect of deep water on rice yield in relation to seeding rate and variety is currently being determined.

Flooding soil for rice and subsequent drainage greatly increases the phosphate sorption capacity of soil and induces P deficiency in crops following rice. P fertilizer band-placed under the seed will eliminate the P deficiency in rice rotation crops. Subsequent flooding for rice apparently releases sorbed P and makes it available to rice so that it may not be necessary to apply P to the rice crop when it has been applied to the rotation crop.

Donald Marlin Brandon
December, 1977
Soil Science

# Phosphorus Transformations In Alternately Flooded Soils and Their Effect on Rice Rotation Crops

## ABSTRACT

Upland crops following lowland rice culture grow and produce poorly because of plant P deficiency. Field studies were conducted to determine the general parameters: severity of P deficiency in terms of cereal crop response to P fertilizer on 3 major rice soils, the relative efficiency of banded and broadcast P, and the relative efficiency of MAP and TSP in correcting plant P deficiency following rice. Laboratory studies were conducted to broadly categorize soil P transformations induced by soil submergence (simulated rice culture) and subsequent draiange (simulated upland crops following rice) and determine their relationship to P deficiency of upland crops following rice. Three soils with long rice culture histories were selected for the studies on the basis of management and field experience that indicated differential severity of plant P deficiency.

Results of 3 field experiments provide strong evidence that plant P deficiency limits the growth and production of barley (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L.) following rice culture. The severity of plant P deficiency and magnitude of response to P fertilizer in the test soils were of the order Myers clay > Willows clay > Sacramento clay. Band-placed P fertilizer provided more complete correction of P deficiency than did broadcast P based upon dry weight, plant tissue P and grain yield parameters. MAP was more effective than TSP in the

severely P deficient Myers and Willows soil sites.

A high $NaHCO_3$-P level in the soils at planting coupled with the absence of P deficiency in preceding rice crops indicate soil P transformations may occur during soil submergence and/or drainage that deminish the ability of $NaHCO_3$-P to estimate P availability to crops following rice. The observation that plants on previously submerged levee and rice paddy soil were severely P deficiency while those on levee soil that were not submerged during rice culture were not, indicates that soil submergence and/or subsequent drainage induce P transformations that decrease soil P availability to upland plants.

Soil P fractionation studies showed the distribution of P between Al-P, Fe-P, Ca-P and RS-P fractions differed greatly between the three soils. Inorganic soil P was predominantly in the Ca-P of the Sacramento clay on which less severe P deficiency was observed in the field studies. Inorganic P was predominantly in the Fe-P and Al-P of the Willows and Myers soils on which severe P deficiency was observed. Soil submergence increased the proportion of Fe-P and decreased the proportion of Al-P but it had very little effect on Ca-P in the three soils. Drainage of the soils after 16 weeks presubmergence initially increased the Fe-P and Al-P of the Myers and Willows soils but it had a negligible effect on these fractions in the Sacramento clay. The relative proportion of soil P in the Fe-P of the Sacramento and Willows soils decreased after 1 week of drainage while that in the Myers soil increased greatly during the 10 weeks following drainage.

The Langmuir plot of phosphate adsorption showed the Myers clay had a $PO_4$ adsorption maximum ($K_2$) 33% greater than that of the Sacramento

and Willows soils. Phosphate bonding energy ($K_1$) of the Myers soil was 498% and 391% greater than those of the Sacramento and Willows soils, respectively. Submergence initially increased $PO_4$ adsorption but it decreased to below or near that of pre-submergence at the end of the 16-week submergence cycle. Drainage of the pre-submerged soils greatly increased their $PO_4$ adsorption capacity. Not only were the $PO_4$ adsorption maxima increased but the adsorbed $PO_4$ was held with greater force as a result of drainage. Changes in oxalate extractable Fe induced by drainage were similar to changes in soil $PO_4$ adsorption parameters. Submergence and drainage induced $PO_4$ adsorption is proposed as a possible explanation for plant P deficiency in upland crops following rice.