COMPREHENSIVE RESEARCH ON RICE

ANNUAL REPORT

January 1, 1975 - December 31, 1975

I. Rice Biology (RB-1) Nutritional and Environmental Factors Affecting High Yield Potential in California Rice.

II. Project Leader: D. S. Mikkelsen.

Principal UC Investigators: D. M. Brandon, Extension Agronomist, J. Hardy and S. Kuo, Staff Research Associates, E. Graetzer, Graduate Student. (Mr. J. Hardy left the project, July 1, 1975, Dr. Kuo Joined the project, October 1975.)

III. Level of 1975 Funding: $8,200

IV. Objectives According to 1975 Proposals and Experiments by Location to Accomplish These Objectives.

Objective I: Identification of nutritional, climatic and cultural factors that influence the growth, development and yield capacity of California rice varieties.

1. Experiments to evaluate early maturing rice varieties (S-6, M-5 and 72/42) at 5 levels of nitrogen application. Butte Co., San Joaquin Co.

2. Experiments to evaluate late maturing rice varieties (CS-M3, D-7, and 72/3764) at 5 levels of nitrogen application - Glenn and Sutter Co.

Objective II. Evaluation of the rice-plant community relationships in commercial field populations, their competitive effects, and relation as a unit to various nutritional, environmental and crop management practices.

1. Field experiment using ^{15}N labelled nitrogen to study nitrogen uptake and patterns of nitrogen translocation and metabolism. Colusa Co.

2. Greenhouse and growth chamber experiments to determine the effects of temperature on plant development and nutrient uptake patterns.

Objective III. To develop a computer model of California rice management systems enabling simulation of commercial rice production. The major controllable managerial and production inputs will be analyzed and boundary conditions established for each.

1. Field, laboratory and literature correlation of production variables affecting the growth and yield of rice. Davis - counties.

V. Summary of Current Year's Work:

Objective 1: Field experiments to evaluate the growth and yield response of 3 early maturing rice varieties and 3 late maturing varieties to 5 levels of nitrogen fertilization were conducted in Butte, Glenn, San Joaquin and Sutter Counties in cooperation with Cooperative Extension, coordinated by D. M. Brandon, Extension Agronomist. Yield results, corrected to 14% moisture are reported in Table 1 by individual county.

The composite yield responses of 3 early and 3 late maturing varieties, each grown at 5 levels of nitrogen fertilization, each at 2 locations, are shown in Table 2.

Crop growth response and nutrient uptake data were obtained from bimonthly field samples at 3 different locations. Data for the following plant characteristics were collected. Dry matter production, dry matter distribution in leaves, culms, panicles and grain, leaf area, leaf area index, grain/straw ratio and nutrient accumulation of nitrogen, phosphorus, potassium, calcium and magnesium.

The chemical analysis of the collected plant materials and computer correlations of varieties x nitrogen rates x locations are not yet completed. These results will be available in the next 2 to 4 weeks. Results of this study together with information accumulated earlier, will be reported in a University of California publication. Additional data on these experiments is reported by D. M. Brandon in the 1975 COMPREHENSIVE RICE RESEARCH REPORTS.

Interpretive results show the varietal patterns of growth and nutrient uptake during the plant growth cycle and how nutrient elements are subsequently translocated to other leaves and organs depending upon their growth stage and condition of physiological activity. The rice leaf is seen to act first as a "sink" and then as a "source" for mineral elements. Nutrient movement patterns depend upon the variety and mobility of the nutrient and its physiological role. Nitrogen, phosphorus and sulfur, all important constituents of proteins, usually accumulate at an early stage in the growth of leaves; they remain relatively mobile and are readily translocated to other organs. Potassium, calcium and magnesium are less mobile. They accumulate at a slower rate and are equally slow in redistribution. In typical rice plant nutrient accumulation and redistribution patterns, the nutrient content of each leaf rises to a maximum corresponding to maximum metabolic activity, then declines to a low level. Each succeeding full expanded rice leaf assumes a similar temporary dominance but the role is shortly taken over by the next leaf in succession.

TABLE 1

Variety x Nitrogen x Location Experiments - 1975

1975 - Butte County

Rice Yields by Variety

N Rates	S-6	M-5	74/42	Nitrogen Mean
	Pounds Per Acre			
N_{60}	4395	4510	5355	4750
N_{90}	5555	5585	6665	5933
N_{120}	5910	6233	7083	6410
N_{150}	6305	6230	7225	6590
N_{180}	6020	6315	7270	6535
Variety Mean	5640	5775	6720	

LSD (.05) Nitrogen rates over varieties - 600 lbs/A

Varieties over nitrogen rates = 310 lbs/A

1975 - San Joaquin County

Rice Yields by Variety

N Rates	S-6	M-5	74/42	Nitrogen Mean
	Pounds Per Acre			
N_{60}	4480	4810	4120	4470
N_{90}	5660	5240	5220	5370
N_{120}	5360	6830	5190	5790
N_{150}	6780	6840	5580	6400
N_{180}	6790	7100	5630	6510
Variety Mean	5810	6170	5120	

LSD (.05) Nitrogen rates over varieties = 650 lbs/A

Varieties over nitrogen rates = 540 lbs/A

1975 - Sutter County

Rice Yields by Variety

N Rates	CS-M3	D-7	72/3764	Nitrogen Mean
		Pounds Per Acre		
N_{60}	7655	8320	7275	7750
N_{90}	7890	8690	8970	8515
N_{120}	9820	8760	9685	9420
N_{150}	7470	9490	9200	8720
N_{180}	9065	8610	9430	9035
Variety Mean	8380	8775	8910	

LSD (.05) Nitrogen rates over varieties = 830 lbs/A

Varieties over nitrogen rates = 1040 lbs/A

1975 - Glenn County

Rice Yields by Variety

N Rates	CS-M3	D-7	72/3764	Nitrogen Mean
		Pounds Per Acre		
N_{60}	4553	5510	4375	4810
N_{90}	5775	5950	5420	5715
N_{120}	6810	6605	5880	6430
N_{150}	6435	7465	6750	6885
N_{180}	7625	8070	7350	7680
Variety Mean	6240	6720	5955	

LSD (.05) Nitrogen rates over varieties = 770 lbs/A

Varieties over nitrogen rates = 500 lbs/A

TABLE 2

Response of Early and Late Maturing Varieties to Nitrogen Fertilization, Each at 2 Locations

	Early Varieties - 2 Locations				Late Varieties - 2 Locations			
N Rates	S-6	M-5	4693	N-Mean	CS-M3	D-7	3764	N-Mean
	Pounds/Acre				Pounds/Acre			
60	4430	4660	4740	4610	6100	6920	5830	6280
90	5600	5410	5940	5650	6830	7320	7200	7120
120	5630	6530	6140	6100	8320	7680	7780	7930
150	6540	6530	6400	6490	7950	8460	7970	7800
180	6400	6710	6450	6520	8350	8340	8390	8360
Variety Mean	5720	5970	5930		7310	7750	7430	

LSD (.05) Nitrogen rates = 370 lbs/A
Varieties = 430 lbs/A

Locations = Significant
Locations x N = N.S.
Locations x variety = Significant

LSD (.05) Nitrogen rates = 470 lbs/A
Varieties = 320 lbs/A

Varieties at same N rate = 720 lbs/A
Varieties-different N rates=750 lbs/A

Locations = Significant
Location x N = Significant
Locations x variety = Significant
Location x variety x N = N.S.

In the rice plant, two major periods of nitrogen requirement occur during its growth cycle. One period corresponds to the early vegetative stage and the second to the reproductive stage beginning with panicle initiation. Adequate nitrogen is essential in the active tiller stage to allow increase in tiller formation and ultimately to provide adequate number of panicles for high yields. Beginning at floret initiation, adequate nitrogen is needed to increase the number of spikelets formed within each panicle, a continuing supply of nitrogen prevents degeneration of differentiating spikelets and expands the hull size for full expression of the varieties yield potential.

Evidence from related experiments indicate that it is not necessary to apply nitrogen at each period of high nitrogen requirement since developing leaves receive translocated nitrogen from both the soil and older tissues. Nitrogen applied as a single basal application can adequately sustain California varieties in our climatic environment for full growth and expression of yield potential.

Objective II: Rice yields are an integration of the genetic constitution of the plant and its environmental influences. Factors of nutrition and environment have been studied to provide better information on how California varieties respond to management and climatic variables.

Tillering in California rice varieties commences soon after seedling establishment at about 32 to 35 days after sowing. The grand period of tillering is relatively short, extending from the 40th to the 52nd day. A high proportion of the tillers produced during this growth stage produce panicles, while those developing after 55 days produce largely invalid panicles. Tillering depends heavily upon the nutritional status of the mother culm, with dependency continuing until 3 to 4 leaves have formed. Each tiller and each leaf become a competitive center for light and nutrients. Tillers which fail to develop become invalid tillers and subsequently translocate nutrients to the more active tillers. High tillering capacity is not an important characteristic in varieties grown under California water-sowing conditions. The number of tillers per plant average about 2.24 per plant.

Each of the approximately 15 total leaves produced per tiller after leaf 3, became active growth centers, reaching a peak in nutrient content, then showing a decline, with the nutrient supply translocated to the next leaf in succession which then repeats the process. The "active center" leaf is the most important one contributing to growth and yield at all stages of development. Carbohydrate analyses show that during the stage of grain formation, the major portion of the carbohydrates deposited in the grain comes from the uppermost leaf and its sheath.

The foliage canopy in California rice varieties increases by the compound interest law until it reaches its highest value just prior to heading about 95 days after which it decreases with the continuation of leaf senescence. Total photosynthetic area has an influence on relative photosynthesis but it is not proportional to total leaf area. Photosynthetic activity, on a leaf area basis, is closely related to the nitrogen supply.

Culm elongation occurs after floral initiation and results in the exertion of the influence. Panicle formation (initiation) occurs about 30-35 days prior to exertion and the booting stage and coincides with reduction-division or meiosis. Rice culms contribute very materially to the developing grain, accounting for about 40% of the weight of the grain. In the established variety M-5, about 35% of the total dry plant weight occurs as vegetative growth and nearly 45% is rough rice grain. This knowledge of the physiology and nutrition of rice will help develop management practices which will influence optimum performance of the rice crop.

The effect of low temperatures on various physiological processes, particularly nutrient uptake, was studied in greenhouse and growth chamber experiments. Previous work has shown that a fundamental and direct relationship exists between the energy released in plant respiration and nutrient accumulation, and that the uptake of certain nutrients is more closely associated with respiration than with others.

Plant growth and nutrient uptake were markedly affected where the variety Earlirose was grown for 30-day periods at water temperatures of 17, 22, 27 and 32°C. Dry matter production was 9.5, 44.1 and 71.2 percent of optimum at 17, 22 and 27°C, respectively. Nutrient uptake patterns showed the percentage nutrient uptake at 17°C, compared with 32°C were in the following sequence $\underset{(52)}{P} < \underset{(32)}{Zn} < \underset{(36)}{Fe} < \underset{(54)}{N} < \underset{(56)}{K} < \underset{(57)}{Mg} < \underset{(61)}{Ca}$. The values in parentheses indicate the percentage of nutrient uptake at the contrasting temperatures.

Zinc x phosphorus x temperature interaction studies were conducted on a Mormon silty clay soil, with levels of 0, 4 and 16 ppm Zn, 0, 25, 100 and 250 ppm P and soil temperatures of 16 and 24°C. Plant growth was severely stunted, and P+Zn gave a better growth response than P or Zn alone. Zinc chlorosis developed after 21 days in the P100 and P250 treatments without zinc and the plants were stunted in growth and showed reduced tillering. At 24°C the rice was healthy without chlorosis. Plants without P were smaller and had fewer tillers than P treated plants.

The application of zinc increased dry matter production at both temperatures although there was no statistically significant difference between zinc rates, except at 24°C. Phosphorus affected an increase in dry matter production at rates up to 100 ppm P. The most important effect was the influence of temperature on zinc uptake at 16°C the application of neither zinc nor zinc + phosphorus had an effect on zinc uptake.

Zinc at the highest rate of application 16 ppm Zn did not increase zinc uptake in the plant tops. At 24°C, however, zinc uptake increased significantly at all rates of application. Temperature exerts a marked influence on zinc uptake and translocation. The high rates of phosphorus application had only a small effect on zinc uptake and did not reduce plant zinc levels below the critical nutrient level.

Analysis of Variance Table

	Dry Wgt.	Zinc Uptake	P Uptake
Zinc (Zn)	SIG	SIG	NS
Phosphorus (P)	SIG	SIG	SIG
Temperature (T)	SIG	SIG	SIG
Zn x P	NS	NS	NS
Zn x T	SIG	NS	NS
P x T	SIG	NS	NS
Zn x P x T	NS	NS	NS

SIG = Significant at .05 level.
NS = No significant difference.

Objective III. Data has been accumulated towards development of a computer model of California rice management systems. The realization of a working model, however, requires the collection and correlation of considerable data and additional time will be required. Mr. B. R. Hewitt, who was undertaking this work as a Ph.D. thesis, has withdrawn from the University to accept an employment opportunity. Long range plans exist to accomplish this objective.

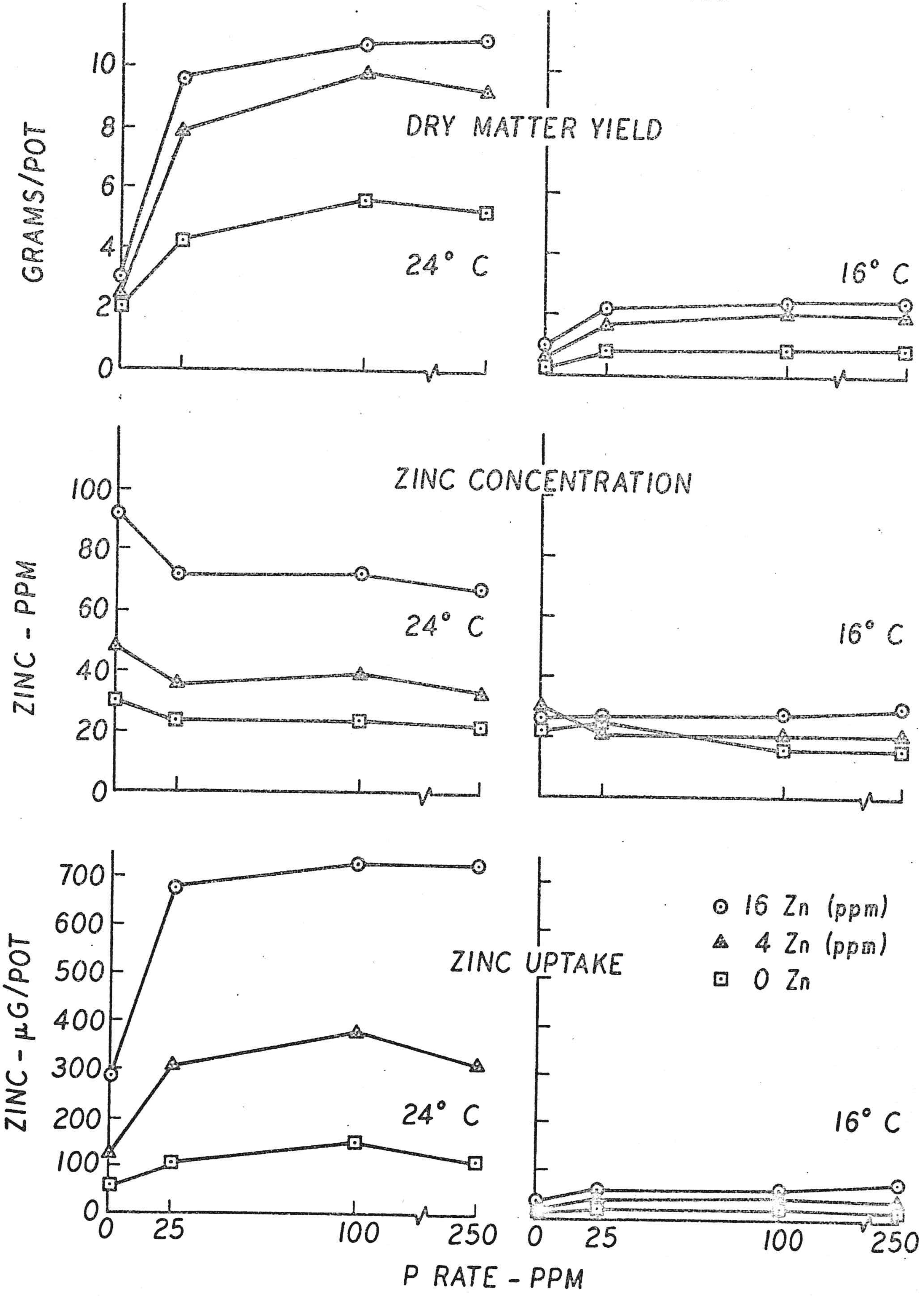
Concise General Summary of Current Year's Results:

1. Traditional and potentially new California rice varieties may show differential responses to climatic variations, especially to temperature and also in fertilizer responsiveness. Zinc, iron, phosphorus and nitrogen are among the nutrient elements most influenced by varietal-temperature interactions.

2. Cool air, water and soil temperatures have a strong retarding influence on nutrient uptake and translocation in rice. At soil temperatures below 68°F nutrient uptake is severely affected and may influence the growth, yield and maturity of rice.

3. Soil temperature is a major factor affecting the availability of zinc to rice. Zinc deficiencies are more severe during cool seasons and necessitate larger zinc fertilizer applications to affect correction. Phosphorus induced zinc deficiency does not appear to be a significant problem in rice.

EFFECT OF P ON GROWTH AND ZINC UPTAKE BY RICE



VI. Publications or Reports:

1. D. N. Rao and D. S. Mikkelsen. Effect of Straw Additions on Production of Organic Acids in a Flooded Soil. Accepted - Plant and Soil.

2. D. N. Rao and D. S. Mikkelsen - Effect of Acetic, Propionic and Butyric Acid on Young Rice Seedling Growth. Accepted - Agronomy Journal.

3. D. N. Rao and D. S. Mikkelsen. Effect of Rice Straw Incorporation on Rice Plant Growth and Nutrition. Accepted - Agronomy Journal.

4. D. N. Rao and D. S. Mikkelsen. Effects of CO_2, CH_4 and N_2 on the Growth and Nutrition of Rice Seedlings. Accepted - Plant and Soil.

5. D. N. Rao and D. S. Mikkelsen. Effects of Acetic, Propionic and Butyric Acid on Rice Seedling Growth and Nutrition. Accepted - Plant and Soil.

6. D. S. Mikkelsen. The soil Environment of Flooded Rice. Rice Production School - Cooperative Extension 1975.

7. D. S. Mikkelsen. Nitrogen Fertilization for Maximum Yields. Rice Production School - Cooperative Extension 1975.

8. D. S. Mikkelsen and D. M. Brandon. Zinc Deficiency in California ~~Rice - California Agriculture 29:8-9. 1975.~~

9. D. S. Mikkelsen. Micronutrient Nutrition of Flooded Soil. Isotope-Aided Micronutrient Studies in Rice Production. International Atomic Energy Agency. IAEA 172:141-159. 1975.

10. D. S. Mikkelsen. Use and Interpretation of Rice Plant Analysis. Proc. 23rd Annual California Fertilizer Conference. pp. 1-12. 1975.

11. R. S. Rauschkolb and D. S. Mikkelsen. Survey of Fertilizer Use in California. Proc. 23rd Annual California Fertilizer Conference. pp. 1-5.

12. D. Pal, F. E. Broadbent, and D. S. Mikkelsen. Kinetics of Rice Straw Decomposition. Accepted - Soil Science.

13. M. D. Miller, M. L. Peterson, D. S. Mikkelsen, et. al. Rice Production in California. University of California 75-LE/2236. pp. 1-11 1975.