COMPREHENSIVE RESEARCH PROGRAM ON RICE

1971-72 Rice Contract

PROJECT NUMBER AND TITLE:

Project RB-1, Fertilization of Rice and Diagnosis of Nutritional Problems

PROJECT LEADER: D. S. Mikkelsen

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OBJECTIVES:

1) To optimize the yield potential and quality of new and existing California short and medium grain rice varieties through proper fertilizer use and fertilizer management.

2) To improve fertilizer use efficiency through superior fertilizer sources, proper rates, optimum methods and time of application in relation to rice yield and quality. Fertilizer use efficiency will be emphasized to minimize production costs and environmental pollution.

3) To determine the best systems of fertilizer management consistent with alternatives to continuous flood methods of rice culture and non-burning of rice residues.

4) Improve methods of diagnosing the nutritional problems of rice, involving soil and plant tissue testing methods.

WORK IN PROGRESS:

1) Studies of the physiological response of the rice plant to nitrogen fertilizer applications made at different stages of plant development as it influences plant growth, grain yield and rice quality.

2) Studies of the micronutrient fertilizer requirements of rice with special emphasis on zinc and iron nutrition. Micronutrient carriers, placement and availability are being evaluated in respect to agronomic efficiency.

3) The effects of water quality, soil pH, phosphorus and bicarbonate ion levels on iron and zinc deficiency in rice are examined to determine causes of plant chlorosis.

4) Susceptibility to micronutrient deficiencies as an inherited characteristic of rice varieties.

5) Reversion of available soil phosphorus as a consequence of alternate flooding and draining rice soils.

EXPERIMENTS COMPLETED:

1) Studies of zinc availability for water-sown rice as related to source, rate and method of zinc application.

2) Response of California medium-grain rice varieties to mid-season nitrogen applications.

3) Effect of mid-season nitrogen top-dressing on the yield and quality of rice.

4) The effect of pH, soil phosphorus level, and bicarbonate ion concentrations on the iron nutrition of rice.

WORK PLANNED:

1) To determine the fertilizer requirements and various crop management practices best suited to new, improved rice types being developed by the plant breeders.

2) To investigate the effect of plant type, plant population (plasticity index value) and fertilizer interrelationships on plant characteristics and yield performance..

3) To determine the applicability of established critical levels of nitrogen, phosphorus and potassium to the nutrient needs of new rice varieties.

4) To investigate improved practices of fertilizer use technology and crop management in new systems of rice culture.

MAJOR ACCOMPLISHMENTS AND IMMEDIATELY APPLICABLE RESULTS:

Zinc Nutrition of Rice Under Water-sown Cultural Conditions:

Experiments have been conducted on three zinc deficient soils commonly planted to water-sown continuously flooded rice to determine the effects of source, rate and method of zinc fertilization. Zinc sulfate, ZnO, ZnEDTA and Zn-Fermix (a ligno-sulfonate) were compared at rates of 0, 2.25, 4.5 and 9.0 kg/ha of zinc. Seedling response and plant zinc uptake with surface, pre-flood zinc treatments increased in the following order: Zn Fermix > $ZnSO_4$ = ZnO > ZnEDTA. Source differences decreased as zinc rates were increased to 9.0 kg/ha. Field experiments comparing surface applied and soil incorporated zinc sources and greenhouse experiments comparing an additional banding treatment, showed the superiority of broadcast applications as measured by seedling growth response, plant zinc uptake and grain yield. The effect of method of application was greatest at zinc levels considered minimal for optimum growth. Particle size is an important characteristic of surface applied zinc materials since zinc does not move appreciably from the point of application. Zinc extracted from profile samples receiving various sources showed concentration differences as affected by soil flooding. Zinc EDTA applied pre-flood was leached below the effective root zone of rice as measured by DTPA extraction. Other zinc sources compared, showed little movement.

Effect of Mid-Season Nitrogen Applications on Rice Yields, Protein Content and Milling Quality:

The potential yield of rice is determined at a comparatively early stage of plant development. The number of panicles produced per acre, the number of florets per panicle, and the potential size of the grain are all determined by the time of floret differentiation. Among the long term (150-155 day) California varieties, the number of potential panicles is determined about 6-14 days after the maximum tillering stage or about 45-60 days after planting. Some productive tillers do develop later but these new tillers do not contribute appreciably to the final yield. The number of florets per panicle is determined about 7-14 days before flowering or about 90 days after planting. Not all differentiated florets became filled grains however. The percent of mature florets at harvest is influenced not only by nutrition, but water and air temperatures, light conditions, carbohydrate accumulation, pests and other conditions which may occur after flowering.

Under most California conditions where near adequate pre-flood fertilization has been practiced, the optimum time of mid-season nitrogen top-dressing occurs at the panicle differentiation stage. Where nitrogen deficiencies occur earlier (as detected by plant analysis) applications made near the end of the grand period of tillering have given good yield benefits. Plants which are poor in nitrogen nutrition benefit from nitrogen applications at any period up through the late panicle initiation stage.

The protein composition of rice is increased when more nitrogen is assimilated than is required for plant growth needs. Grain protein is derived mainly from the breakdown and translocation of nitrogen already present in the leaves and culms at the time of flowering through grain maturation. Approximately 2/3 of the nitrogen in the rice plant is translocated to the mature grain. A correlation exists between the protein content of rice grain and milling yield in preliminary experiments. High grain protein appears to reduce breakage during milling with the consequent improvement of head yield.

Effects of Soil pH, Phosphorus and Bicarbonate Ions on the Iron Nutrition of Rice:

In thesis research with Mr. G. P. Offerman, studies were completed on factors which influence the iron nutrition of rice. Iron chlorosis has been found in California rice as has been identified to be a problem involving interrelationships between the soil, water and rice varieties. The soil-water complex has been investigated, and the varietal effects are under study. Soil pH has been shown to be the major factor affecting iron uptake with lesser affects attributable to the soil phosphorus and water-bicarbonate levels. Soil properties influence the kinetics of soil iron availability, while phosphorus and bicarbonate ion effects appear to primarily influence plant utilization and translocation of iron. Radio-iron experiments showed that iron accumulated in the basal culm

of chlorotic plants. Chlorotic plants had lower activity levels of the iron associated enzyme systems such as a aconitase, catalase and cytochrome oxidase. Chlorotic plants showed a marked increase in leaf organic acids, especially citric acid. It appears crucial that the metalloenzymes in rice receive adequate iron to enable them to function properly. The level of iron required is higher in rice than in many upland plants.

Prediction of the Phosphorus Requirement of Rice by Soil Test Value:

Over a period of years, trials have been conducted on growers fields to determine the phosphorus fertilizer requirements and to correlate soil test results with yield responses. Curves have been fitted to these values using equations of the form $y = a + bx + cx^2$ with c small and negative, soils giving different values for a, b and c, and y representing the yield of grain, and x the quantity of P_2O_5 applied per acre. By regression equation and establishing correlations it has been found that a close relationship exists between yield response, soil phosphorus values (extracted with 0.5M $NaHCO_3$ pH 8.5) and the economical optimum quantity of applied phosphate. The maximum yield responses and soil test values for available phosphorus are related by the equation $\log y = 9.953 - 2.241 \log x$. The correlation between log y and log x is - 0.9101 and is significant at the one percent level. The relationship between maximum yield and optimum phosphate fertilization for yield can be predicated from the same equation when maximum yield is at the point where the gradient dy/dx is equal to zero and the maximum quantity of P_2O_5 to be applied is at the point of maximum yield.

The $NaHCO_3$ test for available soil phosphorus is a reliable means of estimating the phosphorus needs of rice. The critical value to predict phosphorus needs is in the range of 5-6 ppm of soil phosphorus.

EVALUATION OF PROJECT:

Significant advances have been made towards a better understanding of fertilizer use to improve the economics of rice production, reduce potential environmental pollution and identify by soil and plant analysis where and when fertilizer materials can be used most effectively. Research has contributed to a better knowledge of the micronutrient needs of California rice crops, the sources , rates and methods of application for optimum use efficiency. The effects of mid-season nitrogen applicationss have been shown to be beneficial in improving yield and crop quality. Optimum times of application have been identified for rice as determined by the growth stages when deficiencies occur. The causes and correction of iron deficiency in rice is under study, and several soil factors contributing to iron deficiency have been identified. Soil test evaluation can be an effective means of diagnosing the phosphorus status of rice soils. Good correlations exist between crop response and initial soil test values.

PUBLICATIONS OR REPORTS:

1. Mikkelsen, D. S. and D. M. Brandon. Factors affecting zinc deficiency in California rice. U.S. Rice Technical Working Group 1972. June 21-22, 1972, Davis, California.

2. Mikkelsen, D. S. Plant Analysis--A technique for diagnosing the nutritional status of rice. Proc. California Plant and Soil Conference. January 11-13, 1972.

3. Mikkelsen, D. S. and D. M. Brandon. Zinc availability for water-sown rice as related to source, rate and method of application. Agronomy abstracts, 1972. American Society of Agronomy.

4. Mikkelsen, D. S. and N. S. Evatt. Fertilizer use on rice in the United States. U.S. Delegation to the Rice Committee for the Americas--International Rice Commission-FAO. December 6-11, 1971.

5. Mikkelsen, D. S. Zinc deficiency in California rice and factors affecting fertilizer zinc availability. TVA-USAID Project--"Tailoring Fertilizers for Rice". May, 1972.

6. Mikkelsen, D. S. Response of continuously flooded rice to slow-release urea fertilizers. TVA-USAID Project--Tailoring Fertilizers for Rice". May, 1972.