Comprehensive Research on Rice

Project Number and Title: Nutritional and Environmental Factors affecting High Yield Potential in California Rice (RB-1).

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General Objectives:

1. To develop a controlled-environment plant growth facility where individual nutritional and climatic variables occurring in commercial rice production can be evaluated as they influence the growth, development and yield capacity of California rice varieties.

2. To characterize the effects of nutritional cultural and climatic factors, namely nitrogen supply, constant, diurnal and seasonal temperature and wind variations, soil-plant water relations and herbicide applications on major aspects of the growth and development of the crop. Stages of plant development to receive special emphasis are: (1) on formation of vegetative organs for nutrient absorption and carbohydrate accumulation; (2) on the formation of floral organs and yield components; and (3) on the production, accumulation and translocation of organic substances and nutrient elements to the ripening grain. Single and interacting variables will be studied and plant response data collected and analyzed.

3. To consider rice plants in commercial field populations, their competitive relationships, and their relation as a unit to various nutritional, environmental and crop management practices. The environment community relationships will be used to determine the optimal climatic requirements of major varieties and cultural practices designed to meet any special situations.

4. To develop a computer model of a California rice management system enabling computer simulation of commercial rice production. The major controllable managerial and production inputs will be analyzed and boundary conditions established for each. A successful model would be useful to growers in determining the optimum combination of managerial operations consistent with optimum production and lowest unit production costs.

Work in Progress:

During the past year plans for utilization of controlled growth facilities for rice research has lagged because of delays in space procurement, development of a coordinated University project and material shortages encountered by the manufacturer. Installation is anticipated in December-January 1974-75 of eleven controlled environment research units, three of these will be permanently available for rice research. The use of other units will be possible on a space available basis.

Experiments Completed:

Experiments have been underway during the past program year to evaluate the effect of nitrogen fertilization on the growth habit and yield determinants in major rice varieties. Two Calrose genotypes differing in plant height have been studied to define growth and yield determinants.

The injury of rice from MCP applications, as related to the growth status of rice and the rate and timing of MCP application with nitrogen fertilization has been under study and will be continued in the next project year.

Work Planned:

The specific objectives are as follows:

1. To evaluate the effect of nitrogen nutrition on the growth habit and yield determinants in major rice varieties.

2. To conduct growth analysis studies of several climatic variables, particularly temperature under steady state, diurnal and seasonal conditions as they affect plant growth and grain yield components.

3. To evaluate the growth and yield effects of several crop cultural practices affected by soil-plant-water-root relationships.

4. To examine rice morphological factors influenced by nutritional and climatic variables and determine what cultural practices can be used to modify plant form for optimum crop performance.

5. To characterize the translocation of mineral nutrients and organic substances within the rice plant as influenced by nutritional and climatic factors.

6. To define the growth and grain yield component characteristics of rice grown in rice communities under nutritional and climatic variables. Growth and physiological processes occurring among plants in the community will be studied in respect to major components of nutrition, climate and crop cultural practices.

Major Accomplishments and Applicable Research Results:

1. Effect of nitrogen supply at various growth stages on the growth, yield components and yield of short and tall genotypes of the Calrose variety.

Nitrogen fertilization exerts a greater influence on California rice production than any other nutrient element. In relation to optimum grain yield at least three growth periods exist when the nitrogen effects are greatest, (1) at seeding to promote stand establishment, early growth and tillering, (2) at the stage preceding and during panicle formation to increase the number of ripened grain per panicle, and (3) at the panicle emergence stage to stimulate development and increase the weight of the ripened grain. This experiment was conducted to determine how growth and yield are influenced by the rate and timing of nitrogen fertilization and how yields are adversely affected. Two Calrose genotypes grown under strictly controlled nutrient conditions provided a means of adding and withdrawing nitrogen at nine different growth stages, ranging from the seedling stage to panicle formation.

Differences in green color and growth rate were observed between high and low nitrogen treatments within 2 weeks after planting and differences increased with time. Plants in high nitrogen tillered more, were taller and had better color during the entire experiment. While Calrose was taller than C-24, the genotypes gáve somewhat the same growth responses. At harvest factors affecting the yield were evaluated (Table 1).

Mature and immature panicles - The data show the importance of adequate N during the vegetative growth stage when tillering and panicle number per unit area are determined. The N status of the plants between the seedling stage to 10 days after maximum tillering influences the number of panicles per unit area. A high N supply only during the reproductive phase produced immature, imperfectly filled panicles at harvest. Plants supplied with high nitrogen between the stages of reduction-division and anthesis tended to have a large number of immature panicles.

Number of filled grains - Rates and timing of nitrogen produced highly significant effects on the numbers of filled grain. High nitrogen supplied at the time of anthesis significantly reduced grain filling and promoted renewed vegetative growth.

Weight of 1000 grains - In the low N series, plants which received low N for the first 74 days had lower grain weight than plants which were on low nitrogen for 130 days. Grain weight tended to increase in plants receiving high nitrogen after 88 days. In the hign N series, plants changed from high to low nitrogen at 46 days had a significantly higher seed weight.

Grain and straw yield - There was a close correlation between the yield of straw and grain and the total duration of nitrogen deficiency or adequacy. Adequate nitrogen during the vegetative phase encouraged tillering which had a bearing on the straw yield, numbers of panicles per plant and consequently grain yield. Excess nitrogen during the reproductive phase produced panicles with a higher percentage of blanks. Similar effects were observed when the nitrogen status of the plant was changed from a low to a high level at the stages of reduction division and anthesis. A decrease in yield was observed when plants grown at a low level of nitrogen were transferred to a high level of nitrogen at the end of the vegetative phase.

Nitrogen content of grain - High levels of nitrogen in the growth medium at heading time or after, significantly increases the nitrogen concentration (protein) in the grain. It was observed however that there occurred an inverse relationship between the weight of the filled grain and their nitrogen concentration. A close correlation also occurs between the concentration of nitrogen in the straw and in the grain. There was an inverse relationship between yield of filled grain and the nitrogen concentration in the grain.

2. Nitrogen and MCPA - Effect of rate and time of application on the growth and yield of rice.

Aerial applications of MCP are effectively used for the control of broadleaf aquatic weeds in ricefields, but on frequent occasions, depending upon environmental and management practices, foliar damage and root pruning occurs. This damage may reduce crop yields as much as 50 percent. Various factors influence the response of rice to MCP including rate and time of application, the density of stand and the amount of herbicide intercepted by the foliage, the stage of plant growth and its vegetative condition as influenced by the rate and timing of nitrogen fertilization. To better understand how the rate and timing of nitrogen fertilization affects plant growth and MCP damage, a factorial nitrogen rate x time x MCP rate x time experiment was established under greenhouse conditions. The following results briefly describe the results.

Highly significant yield reductions were observed with application rates of 3/4 and 1 1/2 pounds MCP applied per acre at three different levels of nitrogen fertilization. The largest yield depression occurred at the highest nitrogen fertilization rate with the smallest effect at the lowest nitrogen level. The injury from foliar MCP treatments increased in severity when applied at 5, 10, 15 and 20 days after N top-dressing. Nitrogen fertilization which stimulates new axillary leaf primordia, new leaf development and expansion, and increased adventitious root formation which increases plant damage.

On the basis of empirical field observations, injury from MCP decreases with plant age and declines to minimum damage during the late tillering stage, when aquatic weeds must be controlled. High air and water temperatures, usually over 100° F increase the incidence and severity of foliar damage and yield reduction. High temperatures together with rapidly growing, succulent tissues are a combination conducive to severe foliar damage. MCP introduced by intent or as it escapes interception by leaves during normal weed control operations can be potentially more damaging to rice than foliar materials. In sparse stands, where foliage does not intercept the MCP, water borne herbicide causes severe root pruning and subsequent yield reductions.

3. Colorimetric determination of nitrogen in rice tissue for diagnosing the nutritional status of rice and possibly grower field test evaluations.

There is a need for a rapid, simple routine method for determining the nitrogen content of rice leaves for use in evaluating the nitrogen status of the crop. The traditional Kjeldahl method, while highly reliable, is time consuming, expensive and is not adaptable to field test use. Orange G, a disulfonic acid dye is capable of finding itself to the basic groups on proteins to form an insoluble dye-protein complex which can be measured colorimetrically. This dye is used to determine milk protein and for the rapid determination of protein in wheat and flour. The amount of dye bound by the protein is quite linear and correlates well with the standard Kjeldahl method. Since crops differ in the kinds and amounts of protein present in plant tissues, it is essential to determine a protein-dye relationship for each crop. With rice leaf tissue, the protein changes also with time so that a regression relationship between dye color and plant nitrogen must be established.

Rice leaf samples, collected for tissue analysis at the mid-tillering stage, maximum tillering, panicle initiation and panicle emergence stage were analyzed for nitrogen by both standard Kjeldahl and the Orange G colorimetric method. Correlation coefficients were determined for each growth stage and regression equations were derived to define the nitrogen-dye binding relationships. Correlation coefficients observed improved with plant age: mid-tillering = .78; maximum tillering = .82; panicle initiation = .88 and panicle emergence = .95.

The Orange G dye-binding method gives satisfactory correlations with macro-Kjeldahl procedures and warrants further investigation for field test calorimetric evaluation of the nitrogen status of rice.

Evaluation of project:

This project has made excellent progress during 1974, but some original objectives had to be set aside until the environmentally controlled facilities became available. The original objectives are considered sound and when completed should add substantially to our knowledge of how environmental factors influence rice yields and how through better management practices, crop yields can be optimized.

Publications or Reports:

None.

Table 1 - Effect of nitrogen rate and time of application on rice yield components.

Low N Series days in Low N	High N	Mature panicles No.	Dry weight Panicles g.	Dry weight Straw g.	Weight of filled grain g.	Weight of unfilled grain g.	Weight of 1000 grains g.	Percent N in grain %
32	143	26.5	27.8	40.6	24.3	2.2	22.1	1.57
46	129	28.5	22.5	38.2	18.7	3.1	21.3	1.66
60	115	27.0	23.2	39.7	19.8	2.9	22.4	1.70
74	101	25.5	17.6	34.8	13.4	3.8	20.9	1.70
88	87	20.0	22.2	27.4	19.7	2.0	23.0	1.73
102	73	14.5	12.3	27.3	9.4	2.6	22.9	1.72
116	59	17.5	21.7	28.2	19.9	1.5	23.9	1.55
130	45	15.5	18.9	21.4	16.8	4.7	24.6	1.30
175	0	19.0	20.8	23.2	19.3	1.1	22.9	1.38

Cultivar - Calrose

High N Series

175	0	32.0	17.5	49.9	12.5	4.7	21.0	1.80
130	45	22.5	24.1	46.0	19.5	2.9	21.8	1.78
116	59	31.5	16.7	51.9	11.2	4.8	20.1	1.62
102	73	31.0	21.4	46.8	17.2	3.5	21.9	1.54
88	87	33.5	22.6	45.8	18.3	3.7	20.9	1.54
74	101	28.0	29.8	43.9	28.1	1.5	21.9	1.34
60	115	25.0	24.9	42.9	23.2	1.7	23.9	1.32
46	129	24.0	28.6	31.8	28.3	0.4	25.3	1.18
32	143	20.0	24.9	30.8	23.7	0.9	24.3	1.26

Cultivar - Calrose