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COMPREHENSIVE RESEARCH ON RICE

10-12

PROGRAM AREA: Rice Management #3

PROJECT NUMBER AND TITLE:

Improvement of Stand Establishment Practices and Systems of Rice Culture.

PROJECT LEADER: D. S. Mikkelsen

PERSONNEL: D. S. Mikkelsen, D. E. Seaman, D. E. Bayer, M. D. Miller, J. Hardy.

OBJECTIVES:

1) Determine how to manage rice seed germination and seedling growth to insure an adequate plant population under various cropping systems.

2) Evaluate stand establishment practices, including seedbed preparation, seed performance, fertilizer use and water management as they influence seedling development, rice growth and yield.

3) Investigate the possibilities of establishing new systems of rice culture which have fewer management problems and lower costs per unit of production.

4) Examine the causes of stand failure and poor growth of rice as related to agronomic practices and environmental factors.

WORK IN PROGRESS:

1) To determine the influence of environmental factors such as temperature, light, oxygen supply and mineral nutrition on seedling establishment and growth.

2) To determine which methods of planting, other than direct water-sowing, such as drilling, broadcast on puddled soil, and flood and drain systems provide best stand establishment conditions for commercial use.

3) To obtain further information on the effects of water management on the micro-climate and micro-chemical effects in flooded soils and how these affect stand establishment.

EXPERIMENTS COMPLETED:

1) Seven systems of stand establishment and rice management were evaluated at two locations, namely Davis and Richvale for germination, seedling vigor, plant growth and rice yields. Herbicide variables were included since the development of any new system of rice culture must deal effectively with weeds.

2) Some field and greenhouse experiments have been completed to evaluate the effect of oxygen supply in the seed micro environment on the germination and seedling establishment of rice.

3) The effects of enhanced oxygen supply to germinating rice seeds and seedlings provided by seed coating chemicals, has been evaluated with very promising results. Several oxygen supplying chemicals, particularly calcium peroxide has been found to be effective.

4) The effects of various chemicals on the rate of germination and seedling growth of rice have been examined. Applied as seed coated treatments the desired effects obtained are enhanced germination, shoot growth and root anchorage.

WORK PLANNED:

1) Stand establishment practices, identified in 1971 research as having commercial possibilities, will be studied in relation to seedling development, rice growth and yield potential.

2) The investigation of environmental factors influencing the germination and seedling growth of rice will be elaborated upon with special attention given to temperature, oxygen and light effects.

3) The possibilities of coating seeds with calcium peroxide to supply oxygen to germinating rice seeds will be examined under greenhouse and field conditions.

4) Causes of stand failure and poor growth of seedling rice will be examined under field conditions to identify problem areas.

5) Several promising germination and seedling growth promoting chemicals will be examined under field and greenhouse conditions.

MAJOR ACCOMPLISHMENTS:

1) Seven systems of stand establishment and rice management were examined at two locations during the 1971 crop year. The systems treatments included a) Water-sown-continuously flooded rice, b) Dry sown-continuously flooded rice, c) Mud-sown on puddled soil-flooded 4" after germination, d) Drilled rice-Commercial Grain Drill-Flush-Drain followed by continuous flood, e) Same as d, except seed was drilled on beds, f) Rice seed broadcast on beds, Flush-Drain-followed by continuous flood, g) Sprinkler irrigation to allow seedling development, followed by continuous flood. At Davis, treatments b, c and a above, were superior to others, producing 8469, 7921, and 7227 pounds of rice per acre, respectively. The differences among these treatments were not statistically significant. Treatments e, g, h and f produced significantly lower yields than the others, with 6632, 6213, 5146 and 4211 pounds per acre, respectively.

2) The control of weed growth, with systems other than continuous flooding, is one of the major factors influencing rice stand establishment practices. Data collected by Dr. D. E. Seaman (Tables 1 and 2) summarize the effects of weed control chemicals under different systems of rice culture conducted at Richvale-Butte Co., California

3) Seed coating of rice with calcium peroxide prior to planting exerts a highly significant effect on germination percentage, seedling emergence and the

COMPREHENSIVE RESEARCH ON RICE

10-12

PROGRAM AREA: Rice Biology

PROJECT NUMBER AND TITLE:

Fertilization of rice and diagnosis of nutritional problems.

PROJECT LEADER: D. S. Mikkelsen

PERSONNEL: D. S. Mikkelsen, M. D. Miller, D. M. Brandon, C. M. Wick, J. Williams, R. S. Baskett and J. Hardy.

OBJECTIVES:

1) To determine the fertilizer requirements and management practices best suited to new rice varieties leading to full expression of yield capacity and quality.

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. Avoiding excessive use reduces production costs and minimizes environmental pollution. Special emphasis is given to nitrogen and micro-nutrient fertilization.

3) Determine the best systems of fertilizer management for use with different methods of rice culture and residue management. Evaluate the physiological disorders which occur and develop ameliorative practices.

4) Improve systems of diagnosing the nutritional status of rice, by both soil and plant testing methods.

WORK IN PROGRESS:

1) Evaluation of the physiological response of the rice plant to fertilizer applications made at different stages of plant development as they influence plant growth, yield components and nutrient uptake.

2) Studies on the micronutrient fertilization of rice, with special emphasis on zinc and iron nutrition. Experiments are in progress concerning micro-nutrient carriers, placement, movement and availability in the soil.

3) Studies of chemical changes occurring in flooded soils which have an adverse effect on subsequent crops. Iron, manganese and phosphorus systems are being studied in some detail.

4) Examination of toxic products developing in flooded soils as a consequence of the anaerobic decomposition of rice straw residues.

EXPERIMENTS COMPLETED:

1) Identification of zinc deficiency as the cause of a major seedling nutrient disorder in rice. Zinc impurities in commercial iron compounds responsible for beneficial effects of these materials.

2) Response of rice to rates, sources and placement of zinc materials under various soil types.

3) Evaluation of various nitrogen fertilizer materials as carriers for zinc fertilizers.

4) Calibration of soil test procedures for evaluating the zinc status of rice soils.

5) Continuing evaluation of the effect of time of nitrogen application on the growth and yield components in rice.

WORK PLANNED:

1) Measure the growth and yield response of new and existing varieties to both macro- and micronutrient fertilization under different soil and climatic conditions.

2) Examine new quick-test methods for the field test evaluation of the nitrogen status of rice.

3) Micronutrient materials vary widely in their efficiency factors in correcting micronutrient deficiencies. Natural and chemical chelated materials will be examined for nutrient supplying characteristics.

4) Examination of the causes of toxicities developing in flooded soils which limit the growth of rice and develop ameliorative practices.

MAJOR ACCOMPLISHMENTS AND IMMEDIATELY APPLICABLE RESULTS:

1) The so-called "alkali disease" problem observed widely in California rice, causing chlorosis in seedlings and partial to complete loss of stand, has been positively identified as zinc deficiency.

2) Commercial iron materials, used previously to correct the "alkali disease", are effective because they contain from .24 to 1.28 percent zinc. The application of large amounts of these materials supply sufficient zinc for plant growth, but at a much greater cost than commercial zinc materials.

3) Zinc deficiency can be corrected on most soils with 2 to 8 pounds of actual zinc per acre. The zinc ligno sulfonates, zinc sulfate and zinc oxide are effective in the order mentioned.

4) Zinc deficiency can be identified by soil test, using DTPA [(carboxymethyl) imid] bis(ethylenenitrild) tetra acetic acid extraction. Soil zinc levels below 0.5 ppm have given excellent correlation with plant responses. r=.94.

5) Surface placement of zinc is superior to incorporation when minimal zinc rates (2 pounds per acre) are used. At higher rates of application (8 pounds per acre) the effect is not significant.

6) Nitrogen fertilizers which are physiologically acid in the soil are superior carriers of zinc for rice. Ammonium sulfate and ammonium chloride are superior to urea, which is better than calcium cyanamid, a physiologically alkaline fertilizer. Physiological acidity of the nitrogen sources enhances soil zinc availability as measured by plant uptake.

7) Treatment of rice seed with up to 2 pounds of zinc per 100 pounds of seed and an appropriate sticker is effective in correcting zinc deficiency under most soil and water conditions.

8) Non-uniform applications of fertilizer from air craft and commercial ground application equipment is a major problem in obtaining high yields of quality rice. Yield differences within an application swath may vary by a factor of 4 or greater.

9) Time of nitrogen application experiments show that supplementary nitrogen, top-dressed on rice at the stage of panicle initiation has a favorable effect on rice yield. It produces a larger number of spikelets per panicle, heavier seeds and higher total grain yields.

10) A plant analysis survey of the nutritional status of California rice showed that 23% of the representative 424 fields sampled were deficient in nitrogen, 11% deficient in phosphorus and about 1% deficient in potassium.

11) Plant analysis is an effective means of evaluating the nutrient deficiencies and determining the fertilizer needs of rice.

EVALUATION OF PROJECT:

Significant contributions have been made in the identification of nutrient deficiencies limiting the growth and yield of rice in California. As an example, the direct use of zinc materials to correct the "alkali disease" problem will enable a significant reduction in fertilizer costs. Zinc deficiency can be positively identified by soil test and corrective materials, rates, sources, time and method of application recommended.

Nitrogen fertilization is a major production resource affecting the yield of rice, yet about 1/4 of the rice fields are deficient in this element. Topdressing applications made as late as the panicle initiation stage will significantly improve yield. Plant analysis can be used to effectively identify when deficiencies occur.

PUBLICATIONS OR REPORTS:

1) Mikkelsen, D. S. and Hunziker, H. R. A plant analysis survey of California rice. Agrichemical Age. June, 1971.

2) Mikkelsen, D. S., Brandon, D. M. and Miller, M. D. Zinc deficiency in California rice. Rice Field Day Program. Sept. 1971.

3) Mikkelsen, D. S. and Evatt, N. S. Fertilizer use on rice in the United States. Rice Committee for the Americas. International Rice Commission. Nov. 1971.

seedling development of water sown rice. The greatest effect was observed where the rice seed was either partially or completely covered with soil. Germination failed to occur when untreated seed was covered with soil, whereas 97 percent germination was obtained with treated seed. Currently, the best results are obtained with the application of 50 pounds of calcium peroxide per 100 pounds of seed, although beneficial effects are obtained at half this application rate. The benefits of peroxide treatment were evident over a temperature range of 15^{o} to $25^{o}C$. Peroxide enhancement of seedling growth was not evident above $25^{o}C$.

4) Various fungicides and insecticides have been observed to have a stimulatory effect on the germination and seedling growth of rice. A compound labelled Dowco 263, applied to rice seed, gave a highly significant stimulatory effect on the growth of seedling rice. Dry matter seedling growth was increased 23 percent over the control, but no differences were observed in rice yields at harvest.

IMMEDIATELY APPLICABLE RESEARCH RESULTS:

Experiments conducted during 1971 were the first of this kind to be conducted under California conditions. Guidelines were established for future research, with promising possibilities, but additional work is required before these results are applicable to commercial rice culture.

Results of subsidiary experiments indicate that greater care in selection of high density seeds, enhanced oxygen supply in the seed microenvironment, higher water temperatures and better seedbed conditions will improve rice stand establishment.

EVALUATION OF THE PROJECT:

Stand establishment is one of the high risk factors in the production of rice in California. It involves proper managment of such factors as seedbed conditions, seed size and quality, water management in respect to several environmental factors and pest control. This project is making excellent progress towards the objectives stated earlier, but it will require time to integrate these varied production factors into a new management system for California rice.

PUBLICATIONS OR REPORTS:

None to date.

4) Patrick, W. H., Jr. and Mikkelsen, D. S. "Fertilizer Interactions with Submerged Soils." Fertilizer Technology and Use. Feb. 1971.

5) Brandon, D. M., Mikkelsen, D. S. and Miller, M. D. Iron and zinc deficiencies in rice. Dec. 1969.

Table 1. Chemical weed control in rice under different planting and irrigation systems. I. Dry seed broadcast and harrowed, sprinkler irrigated 22 days followed by continuous flooding. LaMalfa Ranch, Butte County, 1971.

Herbicide formulation	Application rate	Application time[1/]	Rice stand	Weed control ratings[2/] (0 - 10) at 57 DAF					Grain yield[3/]
	(lb ai/A)		(0-10)	E.c.	L.f.	S.c.	S.m.	E.m.	(Cwt/A)
Butachlor (E)	2.0	PFAS	7	8	8	9	7	7	41.35 a
RP-17623 (E)	1.5	PFAS	7	9	8	9	6	6	44.72 a
IMC-3950 (E)	3.0	PFAS	9	3	9	10	9	9	- -
Fluorodiphen (E)	3.0	PFAS	8	3	2	7	7	7	- -
Propanil (E) + butachlor (E)	3.0 +2.0	21 DAF	9	4	4	10	10	10	28.35 a
Untreated control	- -	- - -	7	0	0	7	9	9	11.16 b

1/ PFAS = preflush after seeding; DAF = days after initial flushing.

2/ Mean visual ratings of prevalent weed species: Echinochloa crusgalli (E.c.), Leptochloa fascicularis (L.f.), Sagittaria calycina (S.c.), Scirpus mucronatus (S.m.) and Eleocharis macrostachya (E.m.).

3/ Mean grain yields (14% moisture) of 32 sq ft hand-harvested quadrats from quadruplicate 12 by 30-ft plots. Values followed by the same letter are not significantly different at the 5% level (LSD = 16.65 cwt/A).

Table 2. Chemical weed control in rice under different planting and irrigation systems. II. Dry seed broadcast and harrowed, flush-irrigated 22 days followed by continuous flooding. LaMalfa Ranch, Butte County, 1971.

Herbicide formulation	Application rate	Application time[1/]	Rice stand	Weed control ratings[2/] (0 - 10) at 57 DAF					Grain yield[3/]
	(lb ai/A)		(0-10)	E.c.	L.f.	S.c.	S.m.	E.m.	(Cwt/A)
A-820 (E)	2.0	PFAS	7	7	7	10	10	9	34.57 a
DCPA (W)	8.0	PFAS	7	7	7	10	8	4	26.35 bc
OCS-21693 (E)	6.0	PFAS	7	7	6	9	7	7	25.05 c
Linuron (W)	1.5	14 DAF	8	1	0	10	9	9	- -
Propanil (E) + bromoxynil (E)	2.0 +0.25	21 DAF	7	4	0	10	10	10	32.93 ab
Untreated control	- -	- - -	7	0	0	10	10	10	10.00 d

1/ PFAS = preflush after seeding; DAF = days after initial flushing.

2/ Mean visual ratings of prevalent weed species: Echinochloa crusgalli (E.c.), Leptochloa fascicularis (L.f.), Sagittaria calycina (S.c.), Scirpus mucronatus (S.m.) and Eleocharis macrostachya (E.m.).

3/ Mean grain yields (14% moisture) of 32 sq-ft hand-harvested quadrats from triplicate 12 by 30-ft plots. Values followed by the same letter are not significantly different at the 5% level (LSD = 6.87 cwt/A).

1971 REPORT
COMPREHENSIVE RESEARCH ON RICE

PROGRAM AREA(S) Rice Crop Management and Crop Protection

PROJECT NUMBER & TITLE A&RS 1818: Agronomic Components of Improved Rice Production Systems

PROJECT LEADER D. E. Seaman

PERSONNEL D. E. Seaman, M. D. Morse, B. W. Brandon and cooperating UCD and Agricultural Extension Service staff as indicated

OBJECTIVES Development of alternative seed-treatment, planting, crop-management and crop-protection practices, or combinations of them, that may become components of improved rice production systems and provide bases for systems-analysis applications.

WORK IN PROGRESS

Studies initiated under Comprehensive Rice Research Project No. 69-28, "Analysis and Improvement of Rice Production Systems," are being continued under this new Agricultural Experiment Station project as a means of fulfilling the original agronomic objectives of Project 69-28 after Rice Research Board support was withdrawn from the Agronomy & Range Science Department cooperator in 1970. The continuing studies include: preparation and evaluation of new kinds of weighted and protective seed coatings, evaluation of crop-protection methods for alternative planting and water-management systems, evaluation of submersed aquatic weed control methods, formulation and evaluation of granular combinations of molinate and chlorophenoxyacetic acid esters, and evaluation of liquid fertilizer-herbicide-insecticide-microelement combinations. Preliminary and advanced evaluations of experimental herbicides have been continued in cooperation with Dr. Bayer under Project No. 70-11. New work in progress under the present project includes a study of genotypical, cultural, and environmental factors affecting herbicide selectivity in rice, and the evaluation of growth regulators for improvement of grain yield or quality.

EXPERIMENTS COMPLETED

Weighted fungicidal seed coatings. Thirty batches of CS-M3 rice seed, each coated with a different combination of inert weighting materials, adhesives, and the fungicide thiram, were prepared by methods developed in 1970 and compared with presoaked-uncoated and presoaked-thiram-treated-uncoated seed in a field trial at seeding rates equivalent to 50 lb/A of uncoated seed. All kinds of coated seed gave higher mean grain yields than presoaked-uncoated seed (58.85 cwt/A), and 4 kinds gave higher yields than presoaked-thiram-treated-uncoated seed (67.47 cwt/A). The highest yield (70.71 cwt/A) was given by seed coated with a blend of bentonite and talc using a lignosulfonate dispersant-adhesive containing flowable thiram. The coatings of 2 other high-yielding batches contained a similar dispersant, so it appears that more dispersive coatings may enhance the fungicide's activity perhaps by increasing its "sphere of influence" around the germinating seed.

Activated-carbon seed coatings. No significant differences in grain yield were given by Colusa seed with 5 different weighted coatings containing activated carbon when water-seeded at rates equivalent to 100 lb/A of uncoated seed 7 days after flooding a field to which RP-17623 was applied before flooding at 2.5 lb ai/A. The herbicide gave excellent weed control in all plots, but it was not toxic, as expected, to presoaked uncoated seed, so no protective effects of the activated carbon coatings could be observed. Apparently the delay of seeding was long enough for the herbicide to dissipate below toxic levels, which suggests that delayed seeding might be a useful way to increase preflood herbicide selectivity.

Alternative planting and irrigation systems. The weed-control requirements of several alternative planting systems were compared with those of the California water-sowing and continuous-flooding system, in a cooperative trial with Dr. Mikkelsen. Dry-seeding systems involving initial flush- or sprinkler-irrigation followed by continuous flooding gave good stands, which were remarkably free of sedges and broadleaf weeds, but annual grasses were much more serious under these conditions than in water-sown continuously flooded rice. Butachlor and RP-17623, applied after planting and before the initial flush irrigation at 3 and 1.5 lb ai/A, respectively, gave the best weed control of 18 herbicides evaluated in drilled or broadcast-and-harrowed rice.

Early season drainage and weed control. Granular formulations of molinate and benthiocarb (formerly IMC-3950) were each applied without incorporation before flooding at 3 and 6 lb ai/A in an experiment designed to compare their performances as affected by early "panic" drainage, as practiced by growers to increase rice stands during cool weather. Early drainage of untreated plots for 1 or 2 weeks caused barnyardgrass populations to increase from about 6 plants/sq ft, (continuously flooded plots) to more than 10 plants/sq ft, with corresponding severe reductions in grain yield from 32.42 cwt/A (continuously flooded) to as low as 12.42 cwt/A (plots drained for 2 weeks and reflooded). In terms of grass control and rice yield, benthiocarb was about half as effective as molinate at similar rates in drained plots, but only slightly less effective in continuously flooded plots. The carry-over of weed control in treated plots after drainage seemed mainly the result of initial kill rather than herbicide persistence, since generally better weed control and rice yields were obtained in plots drained for 2 weeks than in those drained for only a week. So stimulated weed growth and retarded rice growth resulting from mineralization losses of nitrogen fertilizer probably are more important drawbacks of early drainage than losses of herbicides applied before flooding.

Control of submersed aquatic weeds in rice. Field trials of 1970 and 1971, in cooperation with R. S. Baskett, D. M. Brandon and B. B. Fischer, confirmed the efficacy of granular Hydrothol 191 for control of American pondweed, but the inexplicable failure of the herbicide to control southern naiad in 3 of the trials raised new doubts as to its versatility. Granular Hydrothol 191 gave good control of American pondweed, with corresponding increases in rice stand, at 2 and 4 lb ai/A in 2 trials in 1960, and, in one of the trials, carry-over of pondweed control from 1970 treatments was observed in 1971 in spite of intervening land preparation. The carry-over was probably the result of prevention of winter bud formation rather than herbicide persistence, since Hydrothol 191 degrades very rapidly after application. Similar effects will be looked for next year in a 15-A Glenn-County field, where an aerial application of granular Hydrothol 191 at 2 lb ae/A gave nearly 100% control of a uniform infestation of American pondweed and saved the rice crop. The field yielded 45 cwt/A of dry rice, although none was expected to be harvested before the application.

Granular molinate combinations. New granular formulations of molinate + MCPA-isopropyl ester (IPE) and molinate + 2,4-D-IPE were prepared using technical chemicals and 16/30-mesh clay granules. Applied 18, 21 or 24 days after seeding (DAS) at rates of 3 + 0.75 or 6 + 1.5 lb ai or ae/A, these combinations gave excellent control of annual grasses, sedges and broadleaf weeds without serious injury to rice in 50-sq ft aluminum-ringed plots. At all application times, molinate + MCPA-IPE was the safer and more effective combination, especially on California arrowhead, and it also performed as well with no rice injury at all in 300-sq ft unconfined plots of another trial where it was applied 20 DAS at 3 + 0.75 lb ai or ae/A.

Liquid fertilizer combinations. Trials were initiated in growers' fields in Butte County, Colusa County (with D. M. Brandon) and Sutter County (with Jack Williams), and at the Rice Experiment Station (with C. M. Wick), to evaluate mixtures of liquid fertilizers, herbicides, insecticides and microelements as single sprayboom applications to reduce costs of applying these materials separately. Unfortunately, it became necessary to abandon the 3 off-station trials, and the applications of the station trial were not incorporated deeply enough in the soil (by spiketooth harrow) for adequate rice nutrition and growth. Liquid molinate gave good initial control of barnyardgrass in liquid-suspension fertilizer mixtures at 3 or 6 lb ai/A, but control was not maintained, because rice growth was so retarded by poor nutrition. Where benthiocarb was substituted for molinate in the mixtures, there was no weed control at all, so it appears that incorporation destroys the herbicidal activity of benthiocarb, and this would make it useless.

Preliminary and advanced herbicide evaluation. The performances of 25 new herbicides and 10 promising ones from 1970 were evaluated in 5 trials at the Rice Experiment Station. This work is part of a cooperative effort with Dr. Bayer to develop alternative or improved systems of weed control for California water-seeded rice, and the results will be reported in more detail under Project No. 70-11.

AC-87528 and MON-0988 gave the best broad-spectrum and selective weed control of the 14 new herbicides applied before flooding, and 11 of the 17 new herbicides applied after flooding gave excellent selective control of barnyardgrass. Among the latter, BAS-3512H, DPX-6774, LN-68897, MON-0988, 06K and OCC-188-50 were of special interest, because of their broader spectra of control. Granular formulations of NTN-4725, DPX-6774, a combination of molinate + R-16938, and our combination of molinate + MCPA-IPE all were outstanding in an unconfined-plot yield trial. Advanced trials showed that benthiocarb was safe to rice when applied before flooding or

12 DAS at rates as high as 12 lb ai/A, or as early as 7 DAS at 2 or 4 lb ai/A. Preflood applications were not as effective as those made 10 or 12 DAS, but benthiocarb controlled sprangletop, ducksalad and barnyardgrass applied 12 DAS at only 3 lb ai/A. An aerial application of granular benthiocarb 12 DAS at 3 lb ai/A gave complete control of barnyardgrass and fair control of bulrush in a 6.5-A check of a 100-A field, but separate applications of liquid benthiocarb at 3 lb ai/A before flooding and of liquid and granular nitrofen at 2 lb ai/A 2 days before seeding failed to give satisfactory control in other checks of the same field. The 2 benthiocarb-treated checks yielded 5.1 cwt/A more than the average grain yield of the rest of the field.

Evaluation of new growth regulators. Applications of CL-84479, CL-84741, DPX-1840, TD-6265, TD-6266 and TD-6733, at rates and times suggested by their manufacturers, all failed to affect rice grain yield significantly.

WORK PLANNED

1. Further work with weighted seed coatings will include evaluation of other dispersive coating materials, studies of effects of coatings on seed viability during storage, engineering of scaled-up coating methods for evaluation of costs, convenience and performance of coated seed sown by aircraft, and publication of the results of this work.

2. Studies of alternative planting systems will be continued with emphasis on the stand-establishment advantages of dry-seeding methods.

3. Field trials to support our recommendations of Hydrothol 191 for control of American pondweed will be conducted with a terminal publication in mind. We also plan to test some hypotheses concerning the recent failures of Hydrothol 191 to control southern naiad and continue evaluation of herbicides that control chara and other submersed weeds in rice.

4. Larger-scale trials are planned for our granular molinate + MCPA-IPE combination compared with sequential applications of the 2 herbicides. Studies of other likely herbicide combinations are also planned.

5. Only 1 or 2 trials are planned with liquid fertilizer-herbicide mixtures (omitting insecticides and microelements), because we lack the resources and equipment for conducting meaningful research with these combinations.

6. Evaluation of new herbicides will be curtailed in favor of studies of crop-management systems for new rice varieties, varietal characteristics of rice with respect to weed competition, and factors affecting selectivity.

MAJOR ACCOMPLISHMENTS

1. Yield increases were obtained with new weighted seed coatings to justify their continued development for avoidance of soaking and reduced seeding cost.

2. An allotment-exempt facility was set up with a Butte County grower for continuing studies of alternative planting systems.

3. At least 12 new herbicides were found worthy of further development, and a granular molinate + MCPA-IPE combination was found highly promising as a better alternative to present sequential applications of molinate and MCPA.

IMMEDIATELY APPLICABLE RESEARCH RESULTS

Results of our developmental work with Hydrothol 191 and benthiocarb are being used to support petitions for Federal registration of these products, and experimental registration, at least, is expected for both in 1972. When registration is obtained, Hydrothol 191 will enable growers to avoid crop losses caused by American pondweed, and benthiocarb will be the first commercial herbicide capable of controlling sprangletop, ducksalad and barnyardgrass at reasonable rates. Since soil incorporation was found to inactivate benthiocarb, growers were cautioned about this at the 1971 Field Day at the Rice Experiment Station.

EVALUATION OF THE PROJECT

Excellent progress was made during the past year towards the fulfillment of this project's objectives. The results of the work with weighted seed coatings were especially encouraging. Other efforts were concentrated on herbicide evaluation and relationships between cultural practices and weed control, because improvements are urgently needed in these areas and are most likely to be of immediate benefit to rice growers. Another season's work should result in publications on weighted seed coatings, control of submersed weeds, the development of benthiocarb, and the performance of granular herbicide combinations. The continuing studies of alternative planting and crop-management systems, liquid fertilizer-herbicide combinations, and of interrelations of rice varieties and cultural practices should provide valuable background information for future systems-analysis programing of rice production systems towards which this project is aimed.

PUBLICATIONS OR REPORTS

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Seaman, D. E. 1971. Herbicide evaluation in water-seeded rice. Univ. of Calif. Intermural Weed Control Res. Prog. Rpt.

Seaman, D. E. 1971. Advanced evaluations of IMC-3950 in rice. Univ. of Calif. Intermural Weed Control Res. Prog. Rpt.

Seaman, D. E. 1971. Granular molinate + chlorophenoxy ester combinations for broad-spectrum weed control in water-seeded rice. Univ. of Calif. Intermural Weed Control Res. Prog. Rpt.

Seaman, D. E., R. S. Baskett, D. M. Brandon and B. B. Fischer. 1971. Control of submersed aquatic weeds in rice. Univ. of Calif. Intermural Weed Control Res. Prog. Rpt.