COMPREHENSIVE RESEARCH ON RICE
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PROJECT TITLE: Weed Control in Rice

PROJECT LEADER AND PRINCIPAL UC INVESTIGATORS:

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

I. To develop new chemical methods of weed control in rice and to improve the efficacy and safety of herbicides now in use.

II. To continue the development of integrated rice management systems for weed control.

III. To study the biology and physiology of rice weeds in the field, greenhouse and laboratory.

SUMMARY OF 1991 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVES:

Objective I

Develop New Chemical Methods of Weed Control and Improve the Use of Existing Herbicides

New Herbicides

KIH 2023, a product of Kumiai Corporation, was evaluated for postemergence barnyardgrass and watergrass control at five growth stages of rice, barnyardgrass and watergrass. Applications were made to the rice at the 3- to 3.5-leaf stage, 5- to 5.5-leaf, early tillering (2.5 tillers), 4- to 5-tillers and boot stage. The floodwater was maintained at a 4- to 6- in depth and was not lowered. A nonionic surfactant was added to the treatments. Applications made before the boot stage of watergrass gave good to excellent control (Table 1). Combinations of KIH 2023 and Londax, applied at the early growth stages of rice, gave excellent broad spectrum weed control. Grain yields were higher when watergrass competition was removed from rice during the vegetative phase prior to panicle initiation.

KIH 6127, a product of Kumiai Corporation, was applied at 24.3, 36.4 and 48.6 gm ai/A as preflood incorporated, preflood surface and early postemergence for grass control in rice. Preflood applications gave excellent watergrass, barnyardgrass and ricefield bulrush control (Table 2). The floodwater was removed to expose the foliage for the postemergence treatments and only the combination with Londax gave satisfactory control at the 2.5- leaf timing. No treatment gave satisfactory control at the later timing. Sprangletop was not controlled by any treatment.

BASF 9133, a product from BASF, was applied as a preflood and postflood treatment. Preflood surface and preflood incorporated treatments at the rates of .045, .06 and .09 lb ai/A were evaluated. BASF 9133 gave complete control of ricefield bulrush, smallflower umbrellaplant and Monchoria at all three rates with both preflood application methods (Table 3). Watergrass and sprangletop were not controlled with this herbicide. The later timing of BASF 9133 at the early tillering stage of the rice had a severe stand of watergrass and the rice yields were greatly reduced.

AC 322,140, a product of American Cyanamid similar to Londax, was tested at several rates to determine an appropriate level of application for weed control in rice. The spectrum of weed control for this herbicide was similar to Londax, but 1.5 oz ai/A were required to reach an approximately equivalent level of control as 1.0 oz ai/A of Londax (Table 4). As with Londax, AC 322,140 partially controlled watergrass. The next step in testing AC 322,140 will be to examine combinations with grass control herbicides.

Improved Uses for Existing Herbicides

Facet combinations with Ordram and Londax: Combinations of Ordram with Facet were applied to rice in the 2- to 2.5-leaf stage of the rice. At the time of the Facet application the floodwater was low (1 to 2 inches). Twelve hours after the Facet application the floodwater was raised to 4 to 6 inches in depth and the Ordram granule was applied one day later. The addition of Crop Oil Concentrate at the rate of 2 pt/A or Silwet surfactant at .5 percent gave excellent watergrass control (Table 5) at both the .25 lb ai/A and .5 lb ai/A rates. The addition of Ordram at low rates increased watergrass control as well as increased ricefield bulrush control. Combinations of Facet + Londax were applied one week later when the rice was at the 3.5- to 4-leaf stage and the ricefield bulrush and smallflowered umbrellaplant was completely controlled. Watergrass control was not as effective at the .25 lb ai/A rate as the earlier 2-leaf application but the .5 lb ai/A rate did give satisfactory control (Table 6).

Comparison of Poast and Whip when applied at three different growth stages of rice and watergrass. Poast and Whip were applied to rice at early tillering (2 to 2.5 tillers), mid tillering (4 to 5 tillers) and in the boot stages of growth. For the first treatment the water was lowered to 1 to 2 inches to expose the foliage of the rice and watergrass, four days after this treatment the water was raised to 6 to 8 inches and maintained at that level for the growing season. A late application of Londax at 1 oz ai/A was applied after the first treatment date to suppress ricefield bulrush. All applications of Poast + Crop Oil Concentrate or Silwet caused injury to the rice. The early application caused stunting of the rice especially with the addition of Silwet (Table 7). The watergrass was also stunted but was not completely controlled. The maximum air temperature at this timing reached 110 F. The mid tillering application gave less rice injury but also a decrease in watergrass control (Table 8). The application made when the rice was in the boot stage of growth gave the best watergrass control but also caused the most rice injury which was reflected in the decreased rice yield (Table 9). Applications of Whip and Crop Oil Concentrate or Silwet gave very satisfactory watergrass control at all rates and additives. Increased rice injury was reflected in the higher rate .14 lb ai/A or in increased COC from 1 pt/A to 1 qt/A. At the last timing a new .75 lb ai/gallon formulation was also tested. This formulation caused stunting of the rice but did not show the visual injury symptoms of leaf discoloration or tip burn as did the other formulation of Whip. Watergrass control was not as good with this new formulation at the .065 lb ai/A and .101 lb ai/A rates.

Londax rate and timing: This experiment was designed to determine the effectiveness of Londax at lower than label rates and later stages of application. Watergrass was controlled by Ordram at all rates and timings (Londax and Ordram only, and untreated plots were included for reference). Londax controlled ricefield bulrush at 2-, 4-, and 6-leaf stage of rice (lsr), and unlike in 1990, at 30 days after seeding. In 1991, Ordram alone gave much higher than normal control of ricefield bulrush (53 percent as compared to 18 percent in 1990) and may account for the increase in effectiveness of Londax applied late in this experiment. There were no differences in ricefield bulrush control when the rate of Londax was lowered to 3/4 oz ai/A (Table 10). Thus full label rates and early timings of Londax may not always be necessary for successful ricefield bulrush control.

Londax combinations with preplant incorporated Ordram: Postemergence (post) applications of Ordram are more popular than preplant incorporated (PPI) treatments because the latter often give erratic watergrass control. Postemergence Ordram applications, however, greatly increase the potential for residues to escape in rice field drain water. We have established from previous experiments that Londax controls 40 percent to 60 percent watergrass. This experiment was designed similar to the 1990 experiment to continue testing of the effectiveness of Londax in controlling watergrass missed by PPI applications of Ordram. Ordram applied PPI at 3 lb/A controlled 78 percent late watergrass whereas the same treatment followed by Londax at 1 oz/A controlled 92 percent. Weed control, yield and moisture at harvest were the same whether Ordram was applied PPI or post when followed by Londax (Table 11).

Objective II

Integrated Rice Weed Management Systems

Modeling and experimental analysis of weed/rice competition. Progress in modeling activities. Previously, we developed CARICE, a rice management oriented growth model for California. One of the major benefits of the phenological, degree-day driven structure of CARICE is that it can be expanded to include the effects of rice productivity in competition with weeds. In 1991, the CARICE model was translated into three computer simulation languages to obtain working versions that will be made user friendly so they can easily be used by anyone.

The first version of CANWR (Canopy Weed-Rice), an extension of CARICE, has been programmed, and is also being debugged. CANWR is designed to predict rice yield according to rice and weed density and environment. Light, shading and heat drive the model. Its value as a management tool is that it runs on data supplied by growth analysis, that is, from plants grown and measured individually in greenhouse pots or small field plots. This type of weed data is much easier to obtain than species mixture (competition) studies. New as well as existing competition studies will be used to test CANWR's predictions. Thus, a critical advantage of this model is that it is built and tested with different kinds of data sets, potentially increasing its robustness. Although it is too early to tell how successful this model will be, we anticipate that the model will be working shortly after the new year. Testing and sensitivity analysis will begin immediately after the model is running properly. The following two sections discuss experiments undertaken to build and test the CANWR model.

Growth analysis: Individual plants of ricefield bulrush and annual arrowhead were grown in the field without significant water, light or nutrient stress. Previous data of this nature exist for rice and watergrass. Plant height, leaf number, biomass, leaf area, and maximum net photosynthetic rate were measured temporally. These results are presented in Table 12.

It is not surprising that watergrass grows so quickly, but it is interesting that ricefield bulrush outperforms annual arrowhead, which if not controlled is often thought to be a strong competitor with rice. However, the ricefield bulrush location had a somewhat warmer season than the arrowhead location. Next year, this comparison will be made directly under identical environmental conditions.

Competition studies: In order to validate the predictions of the CANWR model for rice yields in competition with grasses, sedges and broadleafs, data for controlled density experiments are needed. Unfortunately, we were only able to establish such a field experiment with rice vs. watergrass, as neither the bulrush nor arrowhead established properly in the field. In the greenhouse, we completed a rice/annual arrowhead competition experiment. These results (Table 13) do not support the idea that arrowhead is a strong competitor with rice, even at relatively high densities. Both of the above will be among those used to test the predictions of the CANWR model.

Objective III

Rice Weed Biology

Greenhouse, growth chamber and laboratory studies were conducted at UC Davis on the physiology of rice, treated with herbicides, redstem and perennial arrowhead. The purpose of the greenhouse and laboratory studies on rice treated with herbicides was 1) to evaluate techniques to enhance herbicide activity and minimize injury to the rice and 2) to evaluate the influence of Londax on root development of rice. The purpose of the research on redstem and perennial arrowhead was to learn how these weeds germinate and establish in rice fields.

Herbicide activity of KIH 2023. Several adjuvants were evaluated under greenhouse conditions for their ability to enhance the foliar activity of KIH 2023. Several families of adjuvants are being evaluated. So far it is very evident that an adjuvant is necessary to enhance the foliar uptake and that Triton X-100 and Silwet are highly efficient. Rates of 0.2 to 0.5 percent by volume appear to be necessary.

Herbicidal activity of KIH 6127. In greenhouse tests KIH 6127 applied preemergence into the flood water or when the rice is in the 2- to 3-leaf stage will provide excellent watergrass control with no visible injury to the rice. Watergrass control was reduced when flood water was removed prior to spraying or if the watergrass was beyond the 3-leaf stage.

Influence of Londax on rice roots. When germinating rice seed or young rice seedlings were exposed to Londax root growth was inhibited. If the seedlings were removed from the Londax-treated medium root growth would resume. Light microscope studies are underway to determine exactly the sequence of events.

Redstem. Germination studies suggest that germination of redstem seeds will benefit from periods of light but that germination is not dependent on light. Seed dormancy is readily broken by exposure to cold moist conditions.

Perennial arrowhead. Germination of perennial arrowhead seed has not been highly successful. The reason why only 50 percent or less of the seed germinate is unknown. Vegetative propagation in the greenhouse has not been successful.

PUBLICATIONS OR REPORTS

Bayer, D. E., J. E. Hill and E. Roncoroni. 1991. Studies on rice weed control. Rice Field Day Program. p. 28-29.

Bayer, D. E., J. E. Hill, S. R. Roberts, E. Roncoroni, S. C. Scardaci, J. Brandon, N. Itchizen and J. Breen. 1990. Weed control in rice. Annual Report, Comprehensive Rice Research. University of California and USDA. p. 61-75.

Hill, James E., Stacey R. Roberts, D. E. Bayer and J. F. Williams. 1990. Crop response and weed control from new herbicide combinations in water-seeded rice (*Oryza sativa*). Weed Technol. 4:838-842.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

In 1991 a limited number of new herbicides were tested for their possibility of controlling weeds in water-seeded rice. Two new experimental herbicides, KIH 2023 and KIH 6127 from Kumiai Chemical Co., Japan, looked extremely promising for watergrass control at rates well below those of the currently used grass control herbicides. A new herbicide from American Cyanamid, AC 322,140, controlled broadleaf weeds similar to Londax. Combinations of Facet (BAS 514) with Ordram and Bolero for watergrass control also looked promising, especially in view of the erratic results of Facet alone in previous studies. Continuing studies with Londax rate and timing indicated, as in previous years, that lower than label rates and later times of application may control broadleaf weeds and sedges when preferred or necessary. Studies with postemergence grass herbicides showed more injury with Poast than with Whip.

Table 1. Effect of KIH2023 alone and in combination with Londax on rice and rice weeds applied at five different stages of growth.

Treatment	Rate	Growth stage	Rice injury	% Weed Control		Yield
				ECHOR	SCPMU	
	(gm ai/A)					(lb/A)
KIH2023	12.1	Rice 3-3.5 ℓ	0	37	33	3309
KIH2023	18.2	BYG 3.5 ℓ	0	86	57	4992
KIH2023	24.2		0	90	77	5540
KIH2023 + Londax	12.1 + 1 oz		3	96	100	5805
KIH2023 + Londax	12.1 + 0.5 oz		3	100	100	5622
KIH2023 + Londax	18.2 + 1 oz		17	93	100	5095
KIH2023 + Londax	18.2 + 0.5 oz		0	100	100	5491
KIH2023	12.1	Rice 5-5.5 ℓ	0	80	70	3633
KIH2023	18.2	BYG 5-6.5 ℓ	0	96	70	3542
KIH2023	24.2		0	100	80	3519
KIH2023 + Londax	12.1 + 1 oz		0	100	100	4343
KIH2023 + Londax	12.1 + 0.5 oz		0	100	100	4715
KIH2023 + Londax	18.2 + 1 oz		0	100	100	4589
KIH2023 + Londax	18.2 + 0.5 oz		0	100	100	4104
Untreated	—		0	40	0	3086
KIH2023	18.2	Rice 2.5 tiller	0	100	—	4636
KIH2023	24.2	BYG 3 tiller	0	100	—	4562
Untreated	—		0	15	—	3817
KIH2023	18.2	Rice 4 tiller	3	48	—	3569
KIH2023	24.2	BYG boot	5	53	—	3387
Untreated	—		0	25	—	4001
KIH2023	18.2	Rice boot	0	30	—	3100
KIH2023	24.2	BYG heading	0	45	—	3072
Untreated	—		0	10	—	3875

ECHOR = watergrass; SCPMU = ricefield bulrush
ℓ = leaf

Table 2. Evaluation of KIH6127 for weed control and injury to rice.

Treatment	Rate	Timing	Rice injury	% Weed Control ECHOR	LEFFA	SCPMU	Yield
	(gm ai/A)						(lb/A)
Untreated	---		0	60	37	37	3807
KIH6127	24.3	PFI	0	96	43	87	4974
KIH6127	36.4	PFI	0	100	43	90	5259
KIH6127	48.6	PFI	0	97	60	93	5981
KIH6127	24.3	PFS	0	97	50	90	5452
KIH6127	36.3	PFS	0	100	47	90	5533
KIH6127	48.6	PFS	0	97	37	90	5172
Ordram	3 (lb)	PFI	7	90	66	67	5325
KIH6127	12.1	Rice 2.5 ℓ	0	7	63	40	2667
KIH6127	18.2	WG 2-2.5 ℓ	0	27	60	57	3743
KIH6127 + Londax	18.2 + 1 oz		0	87	60	97	5146
KIH6127	24.3		0	43	63	53	4018
KIH6127	36.3		0	37	63	63	3103
Untreated	---		0	7	57	47	2057
KIH6127	12.1	Rice 4 ℓ	0	16	77	80	1790
KIH6127	18.2	WG 5 ℓ	0	26	70	70	1858
KIH6127 + Londax	18.2		3	50	70	100	2485
KIH6127	24.3		0	47	67	53	2191
KIH6127	36.3		6	58	80	63	2694
Untreated	---		0	10	56	47	2057

ECHOR = watergrass; LEFFA = sprangletop; SCPMU = ricefield bulrush
PFI = Preflood incorporated; PFS = Preflood surface
ℓ = leaf

Table 3. Preflood treatments of BASF 9133 for weed control in rice.

Treatment	Rate	Timing	Rice injury	% Weed Control ECHOR	SCPMU	CYPDI	MOOVA	Yield
	(lb ai/A)							(lb/A)
Untreated	---		0	60	37	33	40	3807
BASF 9133	.045	PFI	0	53	100	100	100	4137
BASF 9133	.06	PFI	0	60	100	100	100	4714
BASF 9133	.09	PFI	0	57	100	100	100	4420
BASF 9133	.045	PFS	0	40	100	100	97	4044
BASF 9133	.06	PFS	0	63	100	100	100	5301
BASF 9133	.09	PFS	0	67	100	100	100	4903

ECHOR = watergrass; SCPMU = ricefield bulrush; CYPDI = smallflower umbrellaplant; MOOVA = Monchoria
PFI = Preflood incorporated; PFS = Preflood surface

Table 4. A comparison of AC 322,140 at different application rates with Londax and Ordram, 1991. All applications made at 2-leaf stage rice.

Treatment	Rate	% Weed Control[1] ECHOR	SCPMU	HETLI	LEFFA	Yield @ 14% moisture	% Moisture at harvest
	(oz ai/A)					(lb/A)	
Untreated	---	25	0	0	43	5980	18.5
AC 322,140	0.25	16	48	13	33	4970	21.4
AC 322,140	0.5	27	77	21	0	6060	20.3
AC 322,140	0.75	40	83	75	30	6740	18.9
AC 322,140	1.0	38	96	67	20	6470	18.9
AC 322,140	1.5	73	95	90	33	7080	19.0
Londax	0.5	43	99	90	0	6680	20.3
Londax	1.0	68	100	99	40	7460	18.9
Londax + Ordram	1.0 + 4.0 (lb)	99	100	100	97	8010	18.0
CV %		35.8	8.6	18.3	67.1	13.4	8.0
LSD (.05)		30	12	20	38	1540	NS

[1] Weed control ratings: ECHOR = watergrass; SCPMU = ricefield bulrush; HETLI = ducksalad; LEFFA = sprangletop

Table 5. Combinations of Facet + Ordram on weed control in rice.

Treatment	Rate	Rice injury	% Weed Control				Yield
			ECHOR	LEFFA	SCPMU	CYPDI	
	(lb ai/A)						(lb/A)
Untreated	---	0	30	37	10	40	3663
Ordram	5.0	0	70	60	67	70	6163
Facet + COC	0.25 + 2 pt	0	83	60	63	57	6153
Facet + COC	0.5 + 2 pt	0	90	76	73	66	7076
Facet + Silwet	0.25 + .5%	0	87	63	60	43	6057
Facet + Silwet	0.5 + .5%	0	90	63	73	73	6329
Facet + COC + Ordram	0.25 + 2 pt + 1.0	0	93	80	67	63	5672
Facet + COC + Ordram	0.25 + 2 pt + 2.0	0	100	73	90	47	6118
Facet + COC + Ordram	0.25 + 2 pt + 2.5	0	100	77	80	50	6718
Facet + COC + Ordram	0.25 + 2 pt + 3.0	0	100	87	83	73	6378
Facet + COC + Ordram	0.5 + 2 pt + 1.0	0	100	77	77	73	6248
Facet + COC + Ordram	0.5 + 2 pt + 2.0	0	100	73	87	57	6248

ECHOR = watergrass; LEFFA = sprangletop; SCPMU = ricefield bulrush; CYPDI = smallflower umbrellaplant

Table 6. Combinations of Facet + Londax on weed control in rice.

Treatment	Rate	Rice injury	% Weed Control ECHOR	LEFFA	SCPMU	CYPDI	Yield
	(lb ai/A)						(lb/A)
Untreated	---	0	30	37	10	40	3663
Londax	1 oz	0	70	73	100	100	5103
Facet + COC + Londax	0.25 + 2 pt + .5 oz	0	60	77	100	100	5976
Facet + COC + Londax	0.25 + 2 pt + 1 oz	0	70	53	100	100	6586
Facet + COC + Londax	0.5 + 2 pt + .5 oz	0	87	73	100	100	6096
Facet +COC + Londax	0.5 + 2 pt + 1 oz	0	80	53	100	100	6808
Ordram + Londax	3.0 + 1 oz	0	80	76	100	100	5207

ECHOR = watergrass; LEFFA = sprangletop; SCPMU = ricefield bulrush; CYPDI = smallflower umbrellaplant

Table 7. Effect of Poast or Whip on watergrass control when applied to rice with 2 to 2.5 tillers.

Treatment	Rate	% Rice injury	% ECHOR Control	Rice height	Yield
	(lb ai/A)			(cm)	(lb/A)
Poast + OC	.09 + 1 pt	2	70	74	3921
Poast + OC	.09 + 1 qt	3	80	76	4346
Poast + OC	.14 + 1 pt	3.5	80	74	3511
Poast + Silwet	.09 + 0.5%	4	90	71	3570
Whip + OC	.09 + 1 pt	1.5	100	75	3841
Whip + OC	.09 + 1 qt	1	100	73	3728
Whip + OC	.14 + 1 pt	2	100	74	3251
Whip + Silwet	.09 + 0.5%	1	100	76	3983
Control	---	0	20	77	4562
Control	---	1	15	79	3817

ECHOR = watergrass

Table 8. Effect of Poast or Whip on watergrass control when applied to rice with 4 tillers.

Treatment	Rate	% Rice injury	% ECHOR control	Rice height	Yield
	(lb ai/A)			(cm)	(lb/A)
Poast + OC	.09 + 1 pt	13	53	80	4105
Poast + OC	.09 + 1 qt	18	50	80	4346
Poast + OC	.14 + 1 pt	43	63	78	3446
Poast + Silwet	.09 + 0.5%	35	55	78	3682
Whip + OC	.09 + 1 pt	8	93	80	4169
Whip + OC	.09 + 1 qt	40	100	72	3495
Whip + OC	.14 + 1 pt	38	100	77	3691
Whip + Silwet	.09 + 0.5%	10	100	81	4602
Control	---	8	30	77	4001
Control	---	0	25	82	4113

ECHOR = watergrass

Table 9. Effect of Poast or Whip on watergrass control when applied to rice in the boot stage of growth.

Treatment	Rate	% Rice injury	% ECHOR control	Rice height	Yield
	(lb ai/A)			(cm)	(lb/A)
Poast + OC	.09 + 1 pt	33	90	77	2271
Poast + OC	.09 + 1 qt	50	100	77	1907
Poast + OC	.14 + 1 pt	50	95	67	1658
Poast + Silwet	.09 + 0.5%	37	100	79	2870
Whip + OC	.09 + 1 pt	20	80	78	3402
Whip + OC	.09 + 1 qt	26	100	71	3350
Whip + OC	.14 + 1 pt	23	100	74	3690
Whip + Silwet	.09 + 0.5%	23	100	69	3506
new Whip	.065	10	68	70	3707
new Whip + OC	.065 + 1 pt	13	68	73	3533
new Whip + OC	.065 + 1 qt	20	75	72	3400
new Whip + OC	.101 + 1 pt	10	90	70	3615
new Whip + Silwet	.065 + 0.5%	13	85	69	3611
Control	---	0	10	81	3875

ECHOR = watergrass

Table 10. The effects of Londax rate and application time on rice weed control, 1991.

Treatment	Rate[1]	Timing[2]	% Weed Control[3]			Yield @ 14% moisture	% Moisture at harvest
			ECHOR	SCPMU	HETLI		
	(oz/lb ai/A)					(lb/A)	
Untreated	---	---	12	8	5	6320	19.6
Londax	1.0	2 lsr	86	100	100	8510	18.4
Ordram	4.0	2 lsr	95	52	2	8050	17.6
Londax + Ordram	0.75 + 4.0	2 lsr	95	100	99	8580	17.6
Londax + Ordram	1.0+ 4.0	2 lsr	95	100	72	8480	17.1
Londax + Ordram	0.75 + 4.0	4 lsr	96	100	68	8050	18.9
Londax + Ordram	1.0 + 4.0	4 lsr	92	100	62	8010	18.4
Londax + Ordram	0.75 + 4.0	6 lsr	99	100	100	8280	18.3
Londax + Ordram	1.0 + 4.0	6 lsr	90	100	77	8090	18.1
Londax + Ordram	0.75 + 4.0	30 DAS	96	100	60	8530	17.7
Londax + Ordram	1.0 + 4.0	30 DAS	92	100	50	8160	18.5
CV %			8.4	12.1	23.6	6.7	4.0
LSD (.05)			10	15	22	780	1.1

[1] Application rates: Londax (oz ai/A), Ordram (ai lb/A)
[2] Timing: lsr = leaf stage rice; DAS = days after seeding
[3] Weed control: ECHOR = watergrass; SCPMU = ricefield bulrush; HETLI = ducksalad

Table 11. A comparison of postemergence and PPI Ordram in combination with Londax, 1991.

Treatment	Rate[1]	Timing	Weed Control[2]			Yield @ 14% moisture	% Moisture at harvest
			ECHOR	SCPMU	HETLI		
	(oz/lb ai/A)					(lb/A)	
Untreated	---	---	12	8	5	6310	19.6
Ordram	3.0	PPI	71	30	12	7370	19.1
Ordram	4.0	PPI	65	30	22	7170	18.4
Ordram	4.0	Post	82	35	22	8100	18.3
Londax	1.0 (oz)	Post	86	100	100	8510	18.4
Londax + Ordram	1.0 + 3.0 (lb)	Post + PPI	94	100	100	8460	18.1
Londax + Ordram	1.0 + 4.0 (lb)	Post + PPI	94	100	100	8930	17.9
Londax + Ordram	1.0 + 4.0 (lb)	Post + Post	94	100	100	8710	18.4
CV %			19.7	21.5	16.3	8.6	3.5
LSD (.05)			21	19	14	1010	1.0

[1] Application rates: Londax (oz ai/A), Ordram (lb ai/A)
[2] Weed control: ECHOR = watergrass; SCPMU = ricefield bulrush; HETLI = ducksalad

Table 12. Rice and weed growth characteristics at maturity.

Species	Height	Biomass per plant	No. Leaves	Leaf area per plant	Maximum net photosynthetic rate
	(cm)	(g)		(cm^2)	($\mu mol\ CO_2\ m^{-2}s^{-1}$)
Rice (a)	78.3	14.5	53	960	24.9
Early watergrass (a)	147.8	67.5	86	2006	35.1
Ricefield bulrush	63.1	8.4	45	820	30.8
Annual arrowhead	27.2	2.5	8	121	40.1

(a) from previous work by other researchers

Table 13. Rice vs. early watergrass and rice vs. annual arrowhead results.

Experiment	Treatment	Rice density	Weed density	Mean rice biomass yield (1)
		(plants/m^2)	(plants/m^2)	(g/m^2)
Watergrass	1	35	0	598.1 c
	2	35	1	523.7 bc
	3	35	5	312.3 b
	4	70	0	824.6 d
	5	70	1	672.7 cd
	6	70	5	473.3 bc
Arrowhead (2)	1	200	0	129.1 a
	2	200	45	104.1 a
	3	200	90	135.1 a

(1) Means followed by different letters are different at the 5% level of significance.
(2) Rice harvested before maturity.