ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
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PROJECT TITLE: Weed Control in Rice

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

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

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

III. To study Londax-resistant weeds and develop a strategy for their control.

SUMMARY OF 1993 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVES:

Objective I

Develop new chemical methods of weed control in rice and improve the efficacy and safety of herbicides now in use.

New Herbicides

MON-0139. MON-0139 was applied at the rate of 0.14, 0.28, 0.38 and 0.56 lb ai/acre plus X-77 surfactant at the rate 0.5% v/v for weed control in rice. The rice plots were drained to expose the rice and weed foliage for the 2-leaf growth stage treatment on June 8. The plots were reflooded three days following the treatment and maintained at a water depth of 4 to 6 inches for the remainder of the season. After the rice had reached the 4-leaf growth stage, the flood water was lowered in selected plots to expose

50% of the weed foliage for the second treatment (June 15). A third treatment was made on June 25, when the rice was in the 1-tiller growth stage. The fourth application was made July 6, when the rice had reached the 2.5- to 3-tiller growth stage. The final timing was made July 21 when the rice had reached the internode elongation stage of growth. At this time there was a heavy watergrass population that was beginning to head. Only the application of Ordram + Londax at 4 ai/acre + 1 oz ai/acre used as a standard treatment gave satisfactory weed control without causing injury to the rice. All application of MON-0139 caused severe injury to the rice (Table 1).

KIH-2023. KIH-2023 was tested for weed control and injury to rice at the Rice Experiment Station, Biggs, CA. Foliar applications at 0.228 and 0.456 oz ai/acre with R-11 surfactant at 0.25% v/v were made to watergrass in the 4-leaf or 6-leaf growth stage. Prior to the application made at the 4-leaf growth stage the flood water was lowered to expose at least 2/3 of the watergrass foliage. The flood water was returned to the treated area 48 hours following the treatment. The later application made at the 6-leaf growth stage gave significantly greater rice yield (Table 3) and increased ricefield bulrush weed control over the earlier treatment at the 4-leaf growth stage. The reduction in the yield of rice was due to the emergence of late watergrass following the treatment at the 4-leaf growth stage.

R-104992. R-104992 alone or in combination with Londax was applied to watergrass in the 4-leaf growth stage or 6-leaf growth stage and compared to KIH-2023, Ordram, Londax and combinations of Ordram and Londax or Bolero and Londax. Prior to the first application made at the 4-leaf growth stage, made June 15, the flood water was lowered to exposed the rice weeds. Flood water was returned to the plots 48 hours following the treatment. The second application, was made June 24, to rice in the 6-leaf growth stage. The early applications of R-104992 + R-11 without Londax gave adequate early watergrass control (Table 2) but did not control ricefield bulrush. The addition of 0.728 oz ai/acre of Londax provided season long watergrass control and complete ricefield bulrush control. The 0.913 oz ai/acre of R-104992 caused slight stunting of the rice plants. The application made at the 6-leaf growth stage gave 88% or better control of watergrass with or without the addition of Londax. Ricefield bulrush control was greatly increased over the earlier application of R-104992 was applied alone. The Ordram + Londax and Bolero + Londax combinations were equally effective for the control of the rice weeds. All applications of R-104992 and KIH-2023 alone or in combination with Londax made at the 6-leaf growth stage gave higher rice yields (Table 3) than treatments of R-104992 or KIH-2023 made at the 4-leaf growth stage because of the late emergence of late watergrass in these plots.

KIH-6127. Applications of KIH-6127 were made preflood surface and postemergence at the 2-leaf and 4-leaf growth stage of the rice.

The preflood treatments of KIH-6127 at 12, 24, 36 and 48 g ai/acre were made to a moist soil surface. The preflood surface treatments were applied in a spray volume of 25 gallons of spray per acre. Flooding started immediately after the application. The preflood application of KIH-6127 at the 36 and 48 g ai/acre gave excellent early watergrass control but soil residual was not sufficiently long to allow for season long control because of heavy pressure from late emerging late watergrass (Table 4). Ricefield bulrush was controlled with these rates. The 12 and 24 g ai/acre rates gave partial control of watergrass and ricefield bulrush but did not provide season long control.

Postflood treatments. Two water management regimes were established for the postemergence treatments in separate basins. The water depths were 1 to 2 inches of water for the shallow water management basin and 4 to 6 inches of water for the deep water management basin. Each plot was

isolated by an eight foot diameter aluminum ring. Soaked rice seed was hand-seeded into each ring. The first postemergence application was made at the 2-leaf growth stage of the rice using the granular formulations of KIH-6127, Ordram and Bolero in both the shallow and deep water management plots. At the 4 leaf growth stage of the rice only the 4 to 6 inches water depth plots were treated using both the 0.1% G and 10 DF formulations of KIH-6127. All granular treatments were mixed with sand for an even distribution. The 4-leaf postemergence treatments were applied at the spray volume of 25 gallons of spray solution per acre.

The postemergence treatments of KIH-6127, Ordram and Bolero applied to 2-leaf rice in the 1 to 2 in water depth basin did not control the rice weeds. The same treatments applied into the 4 to 6 inches water depth basin at the 2-leaf growth stage gave partial control of the watergrass and ricefield bulrush. At the 4-leaf growth stage the 48 g ai/acre of the 0.1% G formulation of KIH-6127 gave satisfactory season long watergrass and ricefield bulrush control (Table 5). The 12, 24 and 36 g ai/acre KIH-6127 granular treatments provided only partial control of both watergrass and ricefield bulrush. The 10% DF formulation of KIH-6127 also gave satisfactory early watergrass control at the 90 and 120 g ai/acre rates and all rates showed activity on ricefield bulrush.

Grandstand (triclopyr). Grandstand with the addition of X-77 surfactant was applied to rice 35 days after flooding for broadleaf weed and sedge control. A preplant incorporated application of Ordram at 5 lb ai/acre was made for watergrass control. Once the rice had reached the 1- to 1.5- tiller growth stage the flood water was lowered to expose 70% of the foliage of the ricefield bulrush for application of the herbicide and was returned 48 hours following the treatments and maintained at 5 to 6 inches for the remainder of the season. The application of Londax was made into ringed plots to confine the treatment. The Londax application gave 98% control of the ricefield bulrush and was the highest yielding treatment (Table 6). Grandstand + X-77 provided good control of the broadleaf weeds but was weak on ricefield bulrush.

Whip 1EC or Whip 360 Timing for Watergrass Control. The first application of Whip 1EC at rates of 0.08, 0.1 or 0.125 lb ai/acre or Whip 360 at rates of 0.034, 0.042 or 0.05 lb ai/acre were made June 26 to rice that had reached the 1.3-tiller stage of growth and watergrass that had 1.5- to 2-tillers. All spray applications were made using 25 gallons of spray solution per acre. The second application timing of Whip 1EC at 0.15 lb ai/acre or Whip 360 at 0.059 lb ai/acre was made July 6 to rice in the 2.5- to 3-tiller growth stage. The watergrass population at this time was made up of early watergrass in the 5-tiller growth stage and starting to head and a high population of late watergrass that was in the 2- to 2.5-tiller growth stage. The late application was made on July 21 to watergrass that was starting to head and beginning to lodge over the rice and younger watergrass plants. Whip 1EC at 0.15 or 0.2 lb ai/acre or Whip 360 at 0.059 or 0.067 lb ai/acre was applied. At this time a second application of a split treatment of Whip 1EC at 0.1 lb ai/acre was made to plots previously treated on June 26 with either 0.08 lb ai/acre or 0.10 lb ai/acre of Whip 1EC. A split application of Whip 360 at 0.042 lb ai/acre was applied to plots that had received 0.034 or 0.042 lb ai/acre of Whip 360. Ordram at 4 lb ai/acre was applied on June 26 when the rice and watergrass was in the 1- to 2-tiller growth stage.

The early single application of Whip 1EC at 0.125 lb ai/acre or Whip 360 at 0.5 lb ai/acre gave early watergrass control of 88% to 90% control (Table 7) but a late invasion of late watergrass in these plots was not controlled because Whip does not have any soil residual activity. The split applications of Whip 1EC or Whip 360 provided equivalent watergrass control to a late single application and better control than the earlier treatments. Because of the high watergrass stand, later applications were made

under severe competition, and although the treatments controlled watergrass, rice did not recover from weed interference. The Ordram application made June 26 gave early watergrass control but even these plots were re-invaded by a heavy infestation of late emerging late watergrass and thus did not give season long grass control.

Influence of Water Management on Whip 1EC. After the rice stand was established the flood water was maintained at 1 to 2 inches, 2 to 4 inches, 4 to 6 inches and 6 to 8 inches in each of four basins. Whip 1EC at rates of 0.08, 0.1, 0.125 or 0.15 lb ai/acre or Ordram 10 G at 4 lb ai/acre was applied to rice and watergrass growing in each water management basin. The watergrass was treated on June 28 at which time the rice was in the 1.5- to 2-tiller stage of growth. Applications of Whip 1EC were made in 25 gallons of spray solution per acre. Fourteen days after the applications had been completed the water depths were raised to 6 to 8 inches in all water management basins and maintained at this depth for the remainder of the season.

Because of the late emergence of a heavy stand of late emerging watergrass in these plots the season long watergrass control was below acceptable levels (Table 8). Rice yields were generally higher in the water management plots with 6 to 8 inches water depth because of a delay in emergence and suppressed vigor of late watergrass. Ordram at 4 lb ai/acre did not give adequate control when applied at this late treatment date. Rice yield was reduced because of the severe watergrass interference that also resulted in severe lodging.

Ordram Formulation. Two 15G Ordram formulations, WF 1600 and WF 1148, were compared at the RES, Biggs, CA, at 3 and 4 lb/acre and at three times of application; preplant incorporated (PPI), 2-leaf and 4-leaf stages of rice. Both formulations were similar in weed control. The experimental area had very high pressure from late watergrass (Table 9), see untreated yield), thus no formulation or application timing provided 100% control. Highest watergrass control for either formulation was 99% (WF 1148) and 96% (WF 1600) at the 4 lb/acre rate at the 2-leaf stage of rice. Control at PPI or the 4-leaf stage was significantly less, but still exceeded 80%. Sprangletop was also effectively controlled at 4 lb/acre at the 2-leaf stage of rice, but dropped significantly by the 4-leaf stage of rice. Only slight rice injury was observed and was higher at PPI and the 2-leaf stage than at the 4-leaf stage of rice. Yields were significantly higher in all treatments than in the untreated check, but differences between treatments showed no definite pattern.

Preplant/Preflood Abolish and Molinate. Early experiments with Preflood treatments of Bolero and Ordram failed to adequately control the watergrass. More recently, however, the partial control of watergrass from Londax and smoother seedbeds from the rice roller, have made preflood treatments worth reexamining. Both preflood surface (PFS) Abolish (thiobencarb) and preplant incorporated (PPI) Ordram were compared to conventional postflood applications of 10G Bolero (thiobencarb) and 10G Ordram, with and without Londax. In general, PFS and PPI treatments without Londax controlled watergrass about equally, excepting for the postflood 10G Bolero (Table 10). Failure of postflood Bolero to control watergrass was due to pregermination in the wet (rainy) planting season in 1993, making the grass too large at the time rice reached the safe 2-leaf stage. Of the single herbicide treatments, 10G Ordram provided the best control. Nearly all combinations with Londax controlled weeds effectively. The exception was Londax plus 10G Bolero at the 2-leaf stage of rice which failed to control grass weeds for the reasons noted above. All PFS or PPI treatments increased rice injury, with PFS Abolish averaging about 25% injury at the 4 lb/acre rate, but the rice was able to recover from early stand thinning and injury. Due to a very heavy watergrass infestation, rice yields from all treated plots were significantly

greater than in the untreated plot. Among all treated plots, postflood 10G Bolero yields were lowest due to the large watergrass at the time of application combined with the lack of control on ricefield bulrush.

Timing of MCPA or 2,4-D Alone or in Combination for Broadleaf Weed Control in Flooded Rice. MCPA or 2,4-D at rates of 0.75 and 1.0 lb ai/acre or combinations of MCPA + 2,4-D at rates of 0.375 + 0.375 or 0.5 + 0.5 lb ai/acre were applied to rice 30, 40, 50 and 60 days after flooding. Prior to the first treatment on June 27, (30 days after flooding) the flood water was lowered to expose the rice weeds. At this time the rice was 40 cm tall with 1 to 1.5 tillers and the ricefield bulrush was 49 to 52 cm tall with 1 tiller. Forty days after flooding when the second treatment was made, the rice was 50 cm tall and in the 1.5- to 2-tiller growth stage and the ricefield bulrush was 73 cm tall with 2 to 2.5 tillers and starting to head. On July 21, when the third treatment was made 50 days after flooding, the rice was 56 cm tall and had 2 tillers. The ricefield bulrush was 83 cm tall and had 3 tillers. The fourth and last treatment was made on July 31, 60 days after flooding when the rice was 64 cm tall and averaged 2.5 tillers. The ricefield bulrush was 75 to 80 cm tall with 3 flowering tillers. All herbicide applications were made in 25 gallons of spray solution per acre.

All treatments made June 27 gave excellent ricefield bulrush control (Table 11). Both MCPA and 2,4-D provided better ricefield bulrush control when applied to younger plants and control decreased as age of the ricefield bulrush increased. 2,4-D was more phytotoxic to ricefield bulrush when applied 50 days after flooding than MCPA but by 60 days after flooding control by either was unsatisfactory. Applications made June 27 caused stunting of the rice plants but height measurements taken at harvest showed that the rice had recovered. The early application of MCPA at 0.75 lb ai/acre provided excellent ricefield bulrush control and was the highest yielding treatment.

Objective II

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

Effects of Drill- vs Water-seeded Rice on Weed Abundance and Rice Yield. 1993 was the third year of comparing drill- and water-seeded rice to evaluate the impact of flooded and non-flooded seedling establishment on weed abundance and competition. Rice yields were higher on average in the water-seeded plots (Fig. 1), probably due to denser rice stands. Broadleaf and sedge populations were higher in the water-seeded plots (Fig. 2). In the water-seeded plots not treated with Londax significant broadleaf and sedge populations depressed rice stand and yield. Drill-seeded plots not treated with Londax for broadleaf and sedge control had low populations of these weeds and showed no significant decrease in yield (Fig. 1). Grass control proved to be the primary concern in drill-seeded rice, with significant levels of barnyardgrass, watergrass and sprangletop present even in the treatments receiving both Ordram and Londax. Drill-seeded plots not treated with Ordram were overrun by grass weeds and had minimal yields. In the water-seeded plots the continuous flood at seedling establishment suppressed the large population of grasses seen in the drilled plots. The control treatments consisted of smaller ringed plots and the results were confounded by herbicide seepage from the surrounding treatments.

Greenhouse Studies:

Experiment 1: Different formulations of R-104992 or KIH-2023 were evaluated in the greenhouse on rice and watergrass. No differences in weed control or rice injury was observed between the 80% WP, 30% WG or 30% DF formulation of either herbicide.

Experiment 2: MON-0139 plus X-77 was evaluated at 0.28, 0.38, 0.56 and 0.75 lb ai/acre + 0.5% surfactant X-77 for watergrass control and rice injury at the 2-leaf or 1-tiller growth stages. All rates of MON-0139 controlled watergrass and all rates caused severe rice injury except the 0.28 lb ai/acre applied at the 2 leaf growth stage of the rice.

Experiment 3: Whip 1EC and Whip 360 were evaluated in the greenhouse for rice injury and watergrass control. No differences in watergrass control or in rice injury was observed between the two herbicides at comparable rates. When either surfactant Triton X-100 or X-77 were added to the spray solution both formulations of whip were more injurious to the rice than when sprayed without surfactant.

Experiment 4: Rough Jointvetch seeds were planted into trays containing Stockton Clay soil. One set of trays was sprinkled and the soil was allowed to dry before watering again, the second set of trays was placed under 4 in of continuous flooding. Rough Jointvetch germinated in the trays that were allowed to dry out between watering but no germination occurred in the continuously flooded trays.

Experiment 5: Rough Jointvetch seedlings were planted into 1 gallon containers and allowed to grow until the plants flowered and were setting seed, at this time Roundup, 2,4-D, MCPA, or Grandstand at 0.25, 0.5, or 1.0 lb ai/acre was applied in 20 gallons per acre spray solution. All treatments caused initial injury to the leaves but all plants treated with Roundup, 2,4-D or MCPA regrew. Plants treated with Grandstand did not regrow at either the 0.5 or 1.0 lb ai/acre rate.

Experiment 6: Tomato 'UC-204C' were grown in the greenhouse in 6-inches pots and treated with Ordram, Bolero or Londax to determine injury. The tomatoes were treated when they had reached the 2-leaf growth stage. Ordram and Bolero granular and liquid treatments were applied at the rate of 4 lb ai/acre and Londax was applied at 1 oz ai/acre. The granular formulations of Ordram and Bolero and the

Dry flowable formulation of Londax were mixed with sand and hand dispersed over the tomato. One set of tomato plants were sprinkled from overhead to wet the leaves prior to treatment and the other set of tomatoes leaves were left dry. Vermiculite was placed on the surface of the soil to prevent movement of the herbicide into the soil. The spray treatment was applied in 10 gallons of spray solution per acre. The Londax application applied as a liquid spray killed the tomato plants. Liquid treatments of Bolero and Ordram treatments caused severe injury to the new growth and leaf burn on the treated leaves. The dry formulations applied to wet leaves caused necrotic spots on the leaves and reduced growth of the tomato plants. Londax applied dry to wet foliage was especially injurious. The dry formulations of Londax, Ordram or Bolero applied to dry leaves did not cause any injury symptoms to the tomatoes.

Objective III
To study Londax-resistant weeds and develop a strategy for their control.

1993 Londax Resistance Monitoring Efforts: In 1993 the University of California, DuPont and many PCAs cooperated to determine how widespread was Londax resistance and on what species. Londax-treated fields were monitored by DuPont and PCAs and where unexplained weed escapes occurred, the herbicide was over-sprayed in small plots at twice (2x) the label rate. Weeds not controlled after the 2x treatment were considered suspect for resistance. From Fresno county to Butte county 72 sites were considered to be Londax resistant. Some 68% were California arrowhead, 18% smallflower umbrellaplant, 9% ricefield bulrush, and the remaining were redstem and waterhysop. Samples obtained from selected fields have undergone laboratory analysis by DuPont. 1993 laboratory tests have confirmed that suspected ricefield bulrush and redstem sites were also resistant to Londax. It is quite clear that weed resistance is an emerging problem for California rice growers and will require a carefully planned strategy to prevent the obsolescence of Londax.

1993 "Londax" In-Field Resistance Monitoring Program. County by species of the 72 sites rated as "resistant" or "Intermediate."

County	California Arrowhead	Smallflower Umbrellaplant	Ricefield Bulrush	Redstem	Total
Butte	11	1	1	0	13
Colusa	5	1	1	0	7
Fresno	0	0	0	0	0
Glenn	8	1	0	0	9
Placer	1	0	1	1	3
Sacramento	3	1	0	1	5
San Joaquin	1	0	0	0	1
Sutter	13	8	2	2	25
Yuba	7	2	0	0	9
Total	49	14	5	4	72

PUBLICATIONS OR REPORTS:

1992 Bayer, D. E., and J. E. Hill. Weed control in rice. Annual Report, Comprehensive Rice Research. Univ. of Calif. and USDA. p.58-76

1993 Hill, J. E., S. C. Scardaci, J. F. Williams and S. R. Roberts. Management strategies to reduce herbicides in rice field tail water of the Sacramento Valley. Abstract, 14th Asian Pacific Weed Science Society Conference. Sept. 6-10, 1993. Brisbane, Australia. p.83

1993 Bayer, D. E., J. E. Hill, E. J. Roncoroni, J. R. Webster, and M. D. Carriere. New herbicide developments in rice weed control. Abstract, 1993 Rice Field Day, Biggs, Calif. p.39-42

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CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

Two sets of trials were conducted in aluminum rings on the Biggs Rice Experiment Station by private companies to evaluate new experimental herbicides for rice. Four other experimental herbicides, MON-0139, KIH-2023, R-104992, and KIH-6127 were evaluated for weed control. MON-0139 provided good watergrass control when applied at the first tiller stage. Ricefield bulrush control was excellent when MON-0139 was applied at the late tillering or panicle initiation of rice. However all treatments severely injured the rice. KIH-2023 provided acceptable watergrass control at the 4- to 6-leaf stage, but plots treated in the earlier stages of growth were invaded with late watergrass following the treatments because KIH-2023 does not have any soil residual. R-104992 showed similar results to KIH-2023 in that applications made when watergrass was in the 4- to 6-leaf stage was controlled but invasion with late

watergrass occurred in the earlier treatments. KIH-6127 Provided early watergrass control when applied preemergence but postemergence treatments were unsuccessful whether applied in shallow water (1 to 2 inches) or deeper water (4 to 6 inches).

Grandstand provided good broadleaf rice weed control but provided poorer control of sedges. Smallflower umbrellaplant appeared to be more susceptible to Grandstand than ricefield bulrush. Grandstand did not appear to injure the rice at these timings of applications. Two formulations of Whip were evaluated for watergrass control. Both formulations provided equivalent control with little or no injury to the rice when applied at the 5-leaf to 1-tiller growth stage of the rice. Two formulations of Ordram were tested for efficacy. Both formulations provided approximately equal grass control. The application of preflood treatments of Ordram in combinations with Londax was successful for the forth consecutive year. Both PPI Ordram and preflood surface with Abolish 8E provided good watergrass control. Both MCPA and 2,4-D provided the best ricefield bulrush control with least effect on rice yield when applied 30 days after seeding. Later applications of these herbicides provided less ricefield bulrush control and yields were lower.

For the third year, stand establishment methods were compared with respect to weed type and abundance in waterseeded and drilled rice. Grass weeds were shown to be highest in drill-seeded rice and aquatic weeds were highest in water-seeded rice. In drill-seeded rice competition from grass weeds was very intense requiring a grass herbicide to achieve a reasonable yield.

Londax resistance was noted to occur in 72 sites from Fresno County to Butte County. Sixty-eight percent were California arrowhead, 19 percent smallflower umbrellaplant, 7 percent ricefield bulrush and 2 percent redstem. It is clear that weed resistance is an emerging problem for California rice growers and will require a carefully planned strategy to prevent the obsolescence of Londax.

Table 1. MON-0139 rates and timing of application for weed control and rice injury.

	Rate	Timing[2]	Rice injury	Weed Control[1] ECHOR (7/27)	Weed Control[1] SCPMU (7/27)	Rice height	Yield @ 14% moisture	Lodging
	(lb ai/acre)		(%)	(%)	(%)	(inches)	(lb/acre)	(%)
MON-0139	.14	2*l*	100	0	66	0	0	100
MON-0139	.24	2*l*	87	10	33	7.0	135	100
MON-0139	.38	2*l*	80	20	37	19.0	687	92
MON-0139	.56	2*l*	73	7	27	20.5	563	78
ORDRAM + LONDAX	4.0 + 1 oz	2*l*	23	47	100	20.5	4060	76
MON-0139	.14	4*l*	97	3	20	0	0	100
MON-0139	.28	4*l*	83	10	63	9.0	155	100
MON-0139	.38	4*l*	100	33	20	0	0	100
MON-0139	.56	4*l*	100	57	33	0	0	67
MON-0139	.14	1*t*	70	23	16	18.0	851	97
MON-0139	.28	1*t*	50	83	73	29.5	1907	20
MON-0139	.38	1*t*	87	100	16	7.5	193	33
MON-0139	.56	1*t*	93	100	20	8.0	174	0
MON-0139	.14	2.5*t*	77	17	93	0	0	100
MON-0139	.28	2.5*t*	57	67	100	26.0	1113	87
MON-0139	.38	2.5*t*	63	57	100	24.5	697	33
MON-0139	.56	2.5*t*	67	67	97	23.0	793	31
MON-0139	.14	*l t*	100	0	100	0	0	100
MON-0139	.28	*l t*	100	0	100	0	0	100
MON-0139	.38	*l t*	100	0	100	0	0	100
MON-0139	.56	*l t*	100	0	100	0	0	100
MON-0139	.14	*pi*	100	0	100	0	0	100
MON-0139	.28	*pi*	100	0	100	0	0	100
MON-0139	.38	*pi*	100	0	100	0	0	100
MON-0139	.56	*pi*	100	0	100	0	0	100
Untreated			70	0	50	0	0	100

[1]ECHOR = watergrass, SCPMU = ricefield bulrush
[2]*l* = leaf stage rice, *t* = tillers, *pi* = panicle initiation

Table 2. Effect of R-104992 + R11 and KIH-2023 + R11 alone and in combination with Londax on rice weeds applied at the 4-leaf and 6-leaf growth stages of watergrass, Biggs RES.

			Weed Control[1]				
			ECHOR		SCPMU		LEFFA
	Rate	Timing[2]	(7/8)	(8/24)	(7/8)	(8/24)	(8/24)
	(oz ai/acre)		(%)	(%)	(%)	(%)	(%)
R-104992 + R-11	.228+.25%	4*l*	75	48	0	0	68
KIH-2023+R-11	.228+.25%	4*l*	80	49	0	0.5	65
R-104992+R-11	.456+.25%	4*l*	73	38	0	0	63
KIH-2023+R-11	.456+.25%	4*l*	85	45	0	0.5	75
R-104992+R-11	.456+.25%	4*l*	83	50	0	0	53
R-104992+R-11	.913+.25%	4*l*	88	59	13	0.8	23
R-104992+R-11 + Londax	.228+.25%+.728	4*l*	85	82	100	100	93
R-104992+R-11 + Londax	.456+.25%+.728	4*l*	100	87	100	100	45
Ordram+Londax	48.5+.728	4*l*	98	65	100	98	88
Bolero+Londax	48.5+.728	4*l*	83	38	100	100	90
Ordram	48.5	4*l*	90	73	48	65	90
Londax	.728	4*l*	65	18	100	98	88
Untreated		4*l*	25	13	0	28	83
R-104992+R-11	.228+.25%	6*l*		88		95	93
KIH-2023+R-11	.228+.25%	6*l*		90		85	85
R-104992+R-11	.456+.25%	6*l*		97		85	67
KIH-2023+R-11	.456+.25%	6*l*		92		80	80
R-104992+R-11	.456+.25%	6*l*		95		75	75
R-104992+R-11	.913+.25%	6*l*		100		85	75
R-104992+R-11 + Londax	.228+.25%+.728	6*l*		100		100	85
R+104992+R-11 + Londax	.456+.25%+.728	6*l*		100		100	78
Ordram+Londax	48.5+.728	6*l*		25		100	95
Bolero+Londax	48.5+.728	6*l*		10		100	100
Ordram	48.5	6*l*		20		90	100
Londax	.728	6*l*		12		100	98

[1] ECHOR = watergrass, SCPMU = ricefield bulrush, LEFFA = sprangletop
[2] *l* = leaf stage watergrass

Table 3. Effect of R-104992 + R11 and KIH-2023 + R11 alone and in combination with Londax on rice when applied at the 4-leaf and 6-leaf growth stages of watergrass, Biggs RES.

	Rate	Timing[1]	Rice injury	Root wt	Rice ht	Yield @ 14% moisture
	(oz ai/acre)		(%)	(g)	(inches)	(lb/A)
R-104992+R-11	.228+.25%	4l	0.0	6.9	33.5	4301
KIH-2023+R-11	.228+.25%	4l	0.0	6.9	33.0	4185
R-104992+R-11	.456+.25%	4l	3.0	4.6	33.0	4024
KIH-2023+R-11	.456+.25%	4l	8.0	6.9	33.0	4047
R-104992+R-11	.456+.25%	4l	0.0	5.5	33.0	3808
R-104992+R-11	.913+.25%	4l	20.0	5.6	32.0	3118
R-104992+R-11 + Londax	.228+.25%+.728	4l	10.0	7.7	31.5	3225
R-104992+R-11 + Londax	.456+.25%+.728	4l	8.0	12.1	33.5	6475
Ordram+Londax	48.5+.728	4l	0.0	12.1	35.0	6989
Bolero+Londax	48.5+.728	4l	0.0	3.9	33.5	3634
Ordram	48.5	4l	0.0	7.4	34.0	6404
Londax	.728	4l	0.0	5.9	31.5	2553
Untreated		4l	0.0	4.6	30.0	1175
R-104992+R-11	.228+.25%	6l	0.0	7.9	34.5	8104
KIH-2023+R-11	.228+.25%	6l	0.0	6.2	32.5	7793
R-104992+R-11	.456+.25%	6l	0.0	7.7	33.5	8010
KIH-2023+R-11	.456+.25%	6l	0.0	6.7	34.0	7859
R-104992+R-11	.456+.25%	6l	0.0	5.7	33.0	8003
R-104992+R-11	.913+.25%	6l	10.0	6.0	33.5	8093
R-104992+R-11 + Londax	.228+.25%+.728	6l	0.0	5.3	34.0	7974
R-104992+R-11 +Londax	.456+.25%+.728	6l	0.0	5.4	34.0	8444
Ordram+Londax	48.5+.728	6l	0.0	6.4	32.5	2672
Bolero+Londax	48.5+.728	6l	0.0	5.0	32.5	3248
Ordram	48.5	6l	0.0	9.4	30.0	696
Londax	.728	6l	0.0	6.5	32.0	2813

[1] *l* = leaf stage watergrass

Table 4. Preflood surface applications of KIH-6127 10 DF formulation for weed control in rice.

			Weed Control[1]						
		Rice	ECHOR		SCPMU		Rice	Yield @	
	Rate	injury	(6/21)	(7/31)	(6/21)	(7/31)	ht	14% moisture	Lodging
	(g ai/acre)	(%)	(%)	(%)	(%)	(%)	(inches)	(lb/acre)	(%)
KIH-6127	12	0	33	15	58	40	33.5	4050	30
KIH-6127	24	0	45	30	70	53	33.5	4385	18
KIH-6127	36	0	78	53	95	83	33.0	5225	25
KIH-6127	48	0	90	68	100	95	33.5	6375	10
Untreated	—	0	0	0	20	10	30.5	1579	100

[1]ECHOR = watergrass, SCPMU = ricefield bulrush

Table 5. Evaluation of KIH-6127 formulations, rates, timing of application and influence of water depth on rice weed control.

						Weed Control[1]				
				Water		ECHOR		SCPMU	Rice	Yield @ 14%
	Rate		Formulation	depth	Timing[2]	(6/21)	(7/31)	(7/31)	ht	moisture
	(g	lb/acre)	(% ai)	(inches)		(%)	(%)	(%)	(inches)	(lb/acre)
KIH-6127	12		0.1 G	1-2	2l	0	0	0	29.0	2532
KIH-6127	24		0.1 G	1-2	2l	0	0	0	29.0	2685
KIH-6127	36		0.1 G	1-2	2l	0	0	0	29.0	2554
KIH-6127	48		0.1 G	1-2	2l	0	0	0	28.5	2283
Ordram		4.0	10 G	1-2	2l	0	0	0	28.5	2023
Bolero		4.0	10 G	1-2	2l	0	0	0	28.5	2312
Untreated				1-2	2l	0	0	0	28.5	2186
KIH-6127	12		0.1 G	4-6	2l	8	0	43	30.0	2789
KIH-6127	24		0.1 G	4-6	2l	20	0	70	29.5	2523
KIH-6127	36		0.1 G	4-6	2l	23	0	43	30.5	3372
KIH-6127	48		0.1 G	4-6	2l	33	0	25	31.5	3495
Ordram		4.0	10 G	4-6	2l	38	0	8	30.0	3326
Bolero		4.0	10 G	4-6	2l	40	8	43	30.5	3771
Untreated				4-6	2l	28	0	32	30.5	2488
KIH-6127	12		0.1 G	4-6	4l	18	0	50	31.0	3138
KIH-6127	24		0.1 G	4-6	4l	45	15	63	31.0	4975
KIH-6127	36		0.1 G	4-6	4l	63	43	70	31.0	4995
KIH-6127	48		0.1 G	4-6	4l	97	80	93	31.0	7344
Untreated				4-6	4l	0	0	58	30.0	3099
KIH-6127	12		10 DF	4-6	4l	0	0	48	31.0	3315
KIH-6127	24		10 DF	4-6	4l	63	24	63	31.0	4607
KIH-6127	36		10 DF	4-6	4l	73	45	63	31.0	6276
KIH-6127	48		10 DF	4-6	4l	83	58	75	31.0	6197
Untreated				4-6	4l	0	0	50	29.0	2986

[1]ECHOR = watergrass, SCPMU = ricefield bulrush
[2]*l* = leaf stage

Table 6. Grandstand efficacy and tolerance to rice when applied at the 1- to 1.5-tiller growth stage of rice.

		Weed Control[1]					
	Rate	SCPMU	CYPDI	MOOHA	Rice injury	Rice ht	Yield @ 14% moisture
	(lb ai/acre)	(%)	(%)	(%)	(%)	(inches)	(lb/acre)
Grandstand + X-77	0.25+.25%	33	85	83	0	30.0	5416
Grandstand + X-77	0.25+.5%	30	93	73	0	31.0	5136
Grandstand + X-77	0.375+.25%	50	100	80	0	32.5	5210
Grandstand + X-77	0.375+.5%	45	98	73	0	32.0	5390
Grandstand + X-77	0.5+.25%	53	98	75	0	31.0	5845
Grandstand + X-77	0.5+.5%	40	88	93	0	33.0	5068
Grandstand + X-77	0.75+.25%	48	93	78	0	32.0	4793
Grandstand + X-77	1.0+.25%	55	93	90	0	31.5	5034
Londax	0.0625	98	100	94	0	31.0	7166
MCPA	1.0	55	100	95	0	31.0	5387
Untreated	—	0	100	38	0	32.0	5950

[1] SCPMU = ricefield bulrush, CYPDI = smallflower umbrellaplant, MOOHA = monochoria
Weed Control ratings were made 8/4/93

Table 7. Evaluation of Whip 1EC and Whip 360 rates and timing of application for watergrass control in rice, Biggs RES.

	Rate	Timing[2]	ECHOR[1] (6/21)	ECHOR[1] (8/24)	Rice injury	Rice ht	Yield @ 14% moisture	Lodging
	(lb ai/acre)		(%)	(%)	(%)	(inches)	(lb/acre)	(%)
Whip 1EC + Whip 1EC	0.08 + 0.1	1*t* + 4*t*	53	82	10	29.0	2231	8
Whip 1EC + Whip 1EC	0.1 + 0.1	1*t* + 4*t*	67	77	10	29.5	2111	20
Whip 1EC	0.1	1*t*	70	33	0	21.0	1723	67
Whip 1EC	0.125	1*t*	87	53	0	31.0	3724	17
Whip 1EC	0.15	3*t*		53	0	30.5	1625	43
Whip 1EC	0.15	4*t*		73	15	20.5	290	70
Whip 1EC	0.2	4*t*		83	20	21.0	328	100
Ordram	4.0	5*l*	40	10	0	23.0	602	83
Untreated			0	0	0	20.5	290	100
Whip 360 + Whip 360	0.034+ 0.042	1*t* + 4*t*	67	87	10	29.5	2220	36
Whip 360 + Whip 360	0.042+ 0.042	1*t* + 4*t*	80	90	15	29.5	2872	0
Whip 360	0.042	1*t*	83	47	0	31.0	1788	40
Whip 360	0.050	1*t*	90	53	0	33.0	2551	3
Whip 360	0.059	3*t*		57	0	29.0	1389	46
Whip 360	0.059	4*t*		77	15	21.0	290	100
Whip 360	0.067	4*t*		90	10	20.5	290	93

[1]ECHOR = watergrass
[2]*l* = leaf, *t* = tiller

Table 8. Influence of water management and rate of whip 1EC on watergrass control when applied to rice at the 1.5- to 2-tiller growth stage, Biggs, ES.

	Rate	Water depth	ECHOR[1] (8/24)	Rice height	Yield @ 14% moisture	Lodging
	(lb ai/acre)	(inches)	(%)	(inches)	(lb/acre)	(%)
Whip	0.08	1-2	33	31.0	1211	53
Whip	0.1	1-2	60	31.0	2049	40
Whip	0.125	1-2	50	30.5	1919	52
Whip	0.15	1-2	60	31.0	2052	77
Ordram	4.0	1-2	7	27.0	513	100
Untreated	—	1-2	4	28.5	396	93
Whip	0.08	2-4	23	30.0	1390	55
Whip	0.1	2-4	47	30.5	1969	65
Whip	0.125	2-4	47	31.5	1818	67
Whip	0.15	2-4	60	30.0	2083	77
Ordram	4.0	2-4	10	28.5	551	96
Untreated	—	2-4	9	29.0	571	93
Whip	0.08	4-6	17	31.5	813	70
Whip	0.1	4-6	53	32.0	1903	40
Whip	0.125	4-6	40	31.0	1864	80
Whip	0.5	4-6	47	31.5	2085	53
Ordram	4.0	4-6	10	30.5	756	100
Untreated	—	4-6	7	31.1	725	100
Whip	0.08	6-8	20	32.0	1507	87
Whip	0.1	6-8	63	33.5	2526	30
Whip	0.125	6-8	50	32.5	2344	83
Whip	0.15	6-8	53	32.0	2570	80
Ordram	4.0	6-8	17	32.5	1039	93
Untreated	—	6-8	15	31.5	802	100

[1]ECHOR = watergrass

Table 9. 1993 Molinate formulation study, Biggs RES.

Treatment	Rate	Timing[2]	Rice Injury	Weed Control[1]			Yield	Moisture
				SCPMU (7/9)	LEFFA (7/9)	ECHOR (8/30)		
	(lb/acre)			(%)	(%)	(%)	(lb/acre)	(%)
Ordram 15GR WF1600	4.0	PPI	1.5	62	95	85	6680	17.6
Ordram 15GR WF1148	4.0	PPI	0.9	58	100	85	7370	16.4
Ordram 15GR WF1600	3.0	*2l*	1.5	63	90	91	7260	16.2
Ordram 15GR WF1148	3.0	*2l*	0.6	45	58	89	6160	16.0
Ordram 15GR WF1600	4.0	*2l*	1.4	71	100	96	7800	15.6
Ordram 15GR WF1148	4.0	*2l*	1.2	65	100	99	7040	16.8
Ordram 15GR WF1600	4.0	*4l*	0.0	65	10	85	6300	16.9
Ordram 15GR WF1148	4.0	*4l*	0.2	40	22	82	6750	17.2
Untreated	—	—	0.1	10	8	0	880	14.0
CV %			55.8	34.8	26.6	9.7	9.2	9.2
LSD (0.05)			0.7	27	25	11	900	2.2

[1]SCPMU = ricefield bulrush, HETLI = ducksalad, LEFFA = sprangletop, ECHOR = watergrass
[2]PPI = Pre-plant incorporated; *l* = leaf stage rice

Table 10. 1993 Pre-plant molinate/thiobencarb study, Biggs, RES.

Treatment	Rate	Timing[2]	Rice Injury	Weed Control[1]				Yield	Moisture
				SCPMU (7/9)	LEFFA (7/9)	ECHOR (7/9)	ECHOR (8/30)		
	(lb oz/acre)			(%)	(%)	(%)	(%)	(lb/acre)	(%)
Abolish 8E	4.0	PFS	2.7	72	90	94	90	7790	15.3
Abolish 8E + Londax	4.0 + 1.0	PFS + 2*l*	2.2	100	100	100	100	7520	15.3
Bolero 10G + Londax	4.0 + 1.0	2*l* + 2*l*	0.9	100	92	81	91	7690	16.2
Ordram 10G	4.0	PPI	1.2	55	100	85	90	6470	16.8
Ordram 10G	4.0	2*l*	1.5	40	100	100	96	6310	17.9
Ordram 10G + Londax	4.0 + 1.0	PPI + 2*l*	1.6	100	98	100	100	8410	15.4
Ordram 10G + Londax	4.0 + 1.0	2*l* + 2*l*	0.8	100	100	100	100	7340	16.5
Londax	1.0	2*l*	1.2	100	0	80	88	6760	16.4
Bolero 10G	4.0	2*l*	0.1	22	100	75	65	3840	20.0
Untreated	—	—	0.0	0	5	0	0	780	14.0
CV %			54.0	27.3	10.2	6.8	4.9	12.1	8.1
LSD (0.05)			1.1	27	12	8	6	1120	1.9

[1]SCPMU = ricefield bulrush, LEFFA = sprangletop, ECHOR = watergrass
[2]PFS = Pre-flood surface applied; PPI = Pre-plant incorporated; *l* = leaf stage rice

Table 11. Effect of timing of MCPA and 2,4-D amine alone and in combination on rice and ricefield bulrush control.

	Rate	DAS[2]	SCPMU[1] (8/24)	Rice injury	Rice ht	Moisture
	(lb ai/acre)		(%)	(%)	(inches)	(lb/acre)
MCPA	.75	30	100	0	32.0	7835
MCPA	1.0	30	100	0	30.5	6162
2,4-D	.75	30	100	0	32.5	6313
2,4-D	1.0	30	96	3	31.0	5889
MCPA + 2,4-D	.375 +.375	30	100	0	32.0	6561
MCPA + 2,4-D	.5 +.5	30	100	0	31.0	5763
MCPA	.75	40	93	0	31.5	5945
MCPA	1.0	40	97	0	34.0	4929
2,4-D	.75	40	100	7	33.0	5901
2,4-D	1.0	40	97	0	32.5	5621
MCPA + 2,4-D	.375 +.375	40	73	3	32.5	6673
MCPA + 2,4-D	.5 +.5	40	87	0	34.0	4977
MCPA	.75	50	67	3	34.0	5202
MCPA	1.0	50	57	0	35.5	4902
2,4-D	.75	50	90	0	33.5	5291
2,4-D	1.0	50	80	0	33.5	5868
MCPA + 2,4-D	.375 +.375	50	83	0	32.5	5576
MCPA + 2,4-D	.5 +.5	50	83	3	34.0	6827
MCPA	.75	60	73	10	32.0	4332
MCPA	1.0	60	50	3	31.0	4716
2,4-D	.75	60	37	3	35.0	6094
2,4-D	1.0	60	37	0	34.0	5742
MCPA + 2,4-D	.375 +.375	60	57	0	33.0	5234
MCPA + 2,4-D	.5 +.5	60	50	0	33.5	5071
Untreated	—	—	20	0	32.5	5142

[1]SCPMU = ricefield bulrush
[2]DAS = days after seeding