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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 1995 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

F-8426. F-8426, a new foliar herbicide, was applied with X-77 surfactant at three stages of rice and weed growth, three rates and two water depths. At the 4-5 leaf stage of rice (first timing) the water depths were

1) completely drained, or 2) lowered to 0.5 inches exposing 70% of the weed foliage. At the 6 leaf-1 tiller rice (second timing), the water was 1) drained or 2) lowered to 1 inches and at the full-tiller rice stage (third timing), the water was lowered to 4 inches. Applications of F-8426 + X-77 at all rates and timings caused some brown spotting on the rice leaf, but the rice recovered (Table 1a). Applications made to drained rice at the 4-5 leaf stage controlled weeds better than treatments made with 0.5 inches of water; presumably due to more exposed weed foliage and better coverage by the herbicide. Weed control at the 6 leaf-1 tiller growth stage of rice was also better in drained than in shallowly flooded plots. At full tillering, F-8426 adequately controlled ricefield bulrush but controlled Monochorea poorly. Weeds remaining uncontrolled at this application timing delayed rice heading (Table 1b) and rice yield was reduced.

Grandstand (trichlopyr), MCPA, and 2,4-D Formulations. Various treatments of HI-DEP (2,4-D), Solution (2,4-D), MCP Amine, or 2,4-D Amine and Grandstand were applied alone, or in combinations at the different rates and timings shown in Table 2a. HI-DEP was applied at a spray volume of 10 GPA and all other treatments in 25 GPA. All treatments of Grandstand alone, were with X-77 surfactant (0.25% v/v). MCPA and Grandstand were applied at the 1-2 and 3-4 leaf stages of rice to assess weed control and rice injury at these early stages. All 2,4-D treatments were delayed until tillering to avoid the well-documented injury caused by 2,4-D at early rice growth stages. Grandstand and MCPA were first applied at 14 days after seeding (DAS) to drained plots exposing the weed foliage. Four- to 6 inches flood water was reestablished 48 hours after the application. At 2-3 leaf rice and 20 DAS (second application), the water was lowered to 1-2 inches to expose 70% of the weed foliage, and reestablished at 4-6 inches deep 48 hours after the applications. All 2,4-D formulations, Grandstand, MCPA and combinations were applied at the 1-2 tiller stage of rice (30 DAS). Additionally, Grandstand was applied at the 3-tiller (37 DAS) and early boot stages of rice (68 DAS).

All early (2-3 leaf stage) treatments of MCPA or Grandstand caused severe rice injury; rice did not recover and died (Table 2a). At the 4-5 leaf stage of rice (20 DAS), MCPA and Grandstand controlled ricefield bulrush and ducksalad and caused minimal injury to rice. Although rice injury decreased at later applications, ricefield bulrush became too large for Grandstand to control. At 6 leaf-1 tiller rice (30 DAS), 2,4-D Amine, HI-DEP, Solution or MCPA controlled ricefield bulrush and monochorea. Arrowhead and redstem, present in much lower populations, were also controlled with these treatments. Rice injury, although acceptable, appeared early as stunting and leaf tip burn. At heading, some malformed rice heads were observed in the HI-DEP and Solution treatments. The combinations of 2,4-D Amine + MCPA controlled 70% of the ricefield bulrush at the lowest rates; higher rates gave 100% control. The combination of 2,4-D Amine + Grandstand gave excellent control at all rates. In a separate experiment, Grandstand, MCPA and 2,4-D Amine were compared at the 3 tiller stage of rice (Table 3ab). Control of the sedges, smallflower umbrella sedge and ricefield bulrush, was excellent, but control of the broadleaf weeds was more erratic due to uneven weed emergence. Rice was injured most by MCPA, followed by 2,4-D and Grandstand.

KIH 2023 alone, or in combination with Abolish, F-8426 and Prowl. KIH 2023 alone, and the combinations listed in Table 4a were applied to drained rice (M202) at the 2 leaf stage (June 16, 1996). All treatments included F-77 surfactant. The flood water was reestablished to a depth of 6 inches 48 hr after application. KIH 2023 alone, did not control watergrass or ricefield bulrush at either rate. Combinations of KIH 2023 + Abolish 8E gave excellent season-long control of watergrass and ricefield bulrush (Table 4a), especially at the higher rate of KIH 2023 (24 g ai/A) and also gave the highest rice yield (Table 4b). The combination of F-8426 and KIH 2023 increased early rice injury and did not adequately control watergrass over KIH 2023 alone,. The combination of Prowl + KIH 2023 caused permanent injury to rice.

Bolero and Ordram alone, or in combination. Ordram or Bolero was applied to 2-3 leaf stage rice and 2 leaf watergrass at two rates (2 or 4 lb ai/A) into the floodwater. At the 4-5 leaf stage of rice, Bolero was applied to the previous Ordram treatments and Ordram was applied to the previous Bolero treatments (Table 5a). Londax was uniformly applied at this time to control the broadleaf and sedge weeds. No rice injury was observed with any treatment. Ordram alone, or all combinations with Ordram at the high rate, or Bolero at the high rate followed by Ordram, controlled watergrass (97%). Bolero alone, or applied late in any combination did not adequately control watergrass. The late biotype of watergrass was the major weed not controlled in this experiment.

Whip 1 EC or Whip 360 for Watergrass and Sprangletop Control. Whip and Whip 360 were applied to rice (M202) at several stages and rates and as split treatments as shown in Table 6a. The first treatment (June 27) was applied to 4-5 leaf stage rice with the flood water lowered to 3 inches to expose the weed foliage. All later treatments were applied to normal water depths (6 inches). Watergrass was in the 4 leaf stage and sprangletop in the 3 leaf stage at the first treatment date. Londax at 1 oz ai/Awas applied to the entire plot area for broadleaf and sedge weed control.

Whip 1 EC or Whip 360 alone at the low rates on the first two application timings did not control watergrass season-long (especially late watergrass). The higher rate controlled watergrass season-long, but caused early season leaf burn and stunting from which the rice recovered (Table 6a). The split applications of Whip 1EC at 0.07 lb ai/A or Whip 360 at 0.02 lb ai/A gave some satisfactory watergrass control at all timings with less rice injury than the single application. Whip 1 EC at 0.075 lb ai/A alone, or with L-77 or crop oil concentrate (COC) applied at the second timing, controlled early watergrass but not late watergrass. The addition of L-77 caused more rice injury than COC. Later applications (3-4 tiller) of Whip 1EC or Whip 360 controlled weeds season-long, especially at the higher rates.

V-10029 alone or in combination with MCPA or Londax. V-10029 (+ Kenitic 0.25% v/v) was applied alone or in combination with MCPA or Londax at the rates shown in Table 7a. V-10029 alone was effective in controlling watergrass and ricefield bulrush. Combinations with MCPA or Londax gave broad spectrum weed control of watergrass, ricefield bulrush and ducksalad with only slight injury to rice. The combination of V-10029 + Londax was as effective as Ordram + Londax but rice showed early symptoms from the V-10029.

KIH 2023 rate and timing. KIH 2023 (+ L-77 at 0.25% v/v) was applied to rice at three stages of growth: 4-5 leaf, 1 tiller, and 2 tiller. The flood water was lowered but not removed completely at the 4-5 leaf and 1 tiller applications, to expose 70% of the weed foliage, but was not lowered for the 2 tiller treatments. Watergrass was controlled at the 4-5 leaf and 1 tiller stages, but control was poorer at the 2 tiller stage. Better ricefield bulrush control was obtained at the two later stages than at the early timing. The 1 tiller application controlled weeds best overall, but caused the most rice injury. A second study was established at the 5 leaf-1 tiller stage of rice to evaluate how nitrogen application would affect the performance of KIH 2023. Thirty lbs/A nitrogen was applied to plots 1 week prior, at the time, and 1 week following the application of KIH 2023. Nitrogen fertilizer had no affect on rice injury or weed control compared to the non-fertilized treatments.

Combinations of Grandstand and Whip or KIH 2023. Grandstand was tank-mixed with Whip 1 EC or KIH 2023 and applied to rice in the 5 leaf-1 tiller stage at 23 DAS (June 30) at the rates listed in Table 9a. The flood water was lowered to 2 inches to expose rice weeds and returned to a depth of 5-6 inches 48 hours after the herbicide application. All treatments contained the surfactant X-77 (0.25% v/v). The high rate of Whip (0.15 lb ai/A) in combination with Grandstand controlled watergrass but caused more rice injury than the other treatments. The same combination with the low rate of Whip controlled watergrass poorly, but was safer to the rice. Combinations of Grandstand with KIH 2023 gave overall better weed control with less rice injury. Although ricefield bulrush was controlled up to 97% with combinations of Grandstand and Whip, combinations of Grandstand with KIH 2023 consistently provided almost 100% control.

Rodeo for rice levee weed management. Rodeo was applied on July 25, and sequentially July 25 and August 10, on established rice levees with a Honda shielded levee sprayer at the rates shown in Table 10. The applications were made in 10 GPA of spray solution with X-77 surfactant (0.5% v/v) to barnyard grass, sprangletop and swamp smartweed. The initial applications of Rodeo partially controlled these weeds (about 70%), but swamp smartweed, a perennial broadleaf, reestablished as the dominant weed. Rodeo applied sequentially at one-half the original rate increased barnyard grass and swamp smartweed control.

OBJECTIVE II

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

Bolero. An experiment was conducted to evaluate mid-season Bolero (thiobencarb) injury. Soil was collected from fields showing mid-season Bolero injury and placed in greenhouse basins. Basins were divided into 2 groups, one received Bolero and one received no herbicide. Rice was planted, allowed to grow to the 2-leaf stage, and treated with Bolero. At heading the basins were dried and the plant residue chopped and mixed into the soil. After completing 4 cycles, typical Bolero symptoms were still apparent. Samples from these basins were analyzed in Dr. Crosby's laboratory, Department of Environmental Toxicology, UC Davis, and deschlorothiobencarb was found in both treatments but the treatment receiving repeated applications of Bolero had higher levels of deschlorothiobencarb than the group receiving no Bolero.

To verify that the Bolero symptoms associated with deschlorothiobencarb were actually a result of this metabolite, Bolero or deschlorothiobencarb (prepared in Dr. Crosby's laboratory) at rates of 0, 0.5, 1, 2 or 4 ppm were incorporated into Yolo Clay Loam soil, placed in basins, flooded, and planted to rice (variety M202 or L202). Both varieties showed slight injury at 0.5 ppm deschlorothiobencarb, but injury was severe in all basins treated with 1 ppm or above. Thiobencarb-treated soils showed only slight injury to both varieties at the 4 ppm rate (Table 11).

Command. Command was evaluated in the greenhouse as a potential herbicide for rice weed control applied preflood incorporated (PPI), preflood surface (PFS) and postemergence (Post). Rates of 0.25, 0.5, or 1.0 lb ai/A PPI or PFS were phytotoxic to rice at all rates. Watergrass control was excellent at all rates when applied PPI or PFS. Lower rates, 0.0625, 0.125 or 0.25 lb ai/A, applied Post to rice in the 3 leaf stage with and without flood water, showed less injury when the flood water was lowered but not completely removed, but watergrass was not controlled. Command was not active on smallflower umbrella sedge at any rate or method of application.

F-8426. F-8426 was evaluated in the greenhouse at rates of 0.015, 0.06 or 0.12 lb ai/A with and without surfactant. The herbicide was applied PPI, PFS or Post to rice in the 3 leaf or 1 tiller stage of growth. The Post treatments were made with the flood water lowered or completely removed. F-8426 showed no soil residual. Foliar activity was greatly enhanced when surfactant was added, but broadleaf or sedge weeds required at least 70% of their foliage exposed for the herbicide to be effective. F-8426 showed no activity on watergrass.

OBJECTIVE III

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

Field Studies:

A trial was established at the Rice Experiment Station, Biggs, where a Londax-resistant biotype of California arrowhead was present in the weed population. The field was water-seeded with rice, M202, on June 8. Ordram (4 lb ai/A) was applied to the entire area to control watergrass when the rice was in the 2 leaf stage. Applications of Londax, both as a spray and as the granular 90DF, were made to rice in the 3-4 leaf, 4-5 leaf, 5 leaf-1 tiller, or 3 tiller stage. Tank-mix or sequential applications of Londax plus MCPA, 2,4-D, Grandstand, F-8426 or Londax were made at several rice growth stages. A standard application of MCPA, 2,4-D Amine, or the experimental herbicide F-8426 was applied without Londax (Table 12).

Londax, whether applied as a granule into the flood water or as a foliar spray with L-77 surfactant or as a repeat application, did not control the resistant California arrowhead. MCPA or 2,4-D Amine applied in the 3-4 leaf growth stage or later effectively controlled the Londax-resistant California arrowhead, even if it had been treated with Londax. Rice injury was severe when MCPA or 2,4-D Amine were applied to rice in the 3 leaf stage but was reduced at later timings. Grandstand + X-77 provided the best weed control when applied to rice in the 5 leaf-1 tiller stage with little or no injury to rice. F-8426 + L-77 was very effective for the control of Londax-resistant California arrowhead.

Survey:

Bensulfuron methyl (Londax) is the primary means of sedge and broadleaf weed control in California rice. Since 1989, Londax was used on 80-95% of California rice fields. During the 1992 rice growing season biotypes of two aquatic weed species resistant to Londax were discovered: California arrowhead (*Sagittaria montevidensis*) and smallflower umbrellaplant (*Cyperus difformis*). Because an increase in the numbers of fields with Londax-resistant weeds was anticipated, a resistance monitoring program was instituted for the 1993 through 1995 rice growing seasons to identify if, and in what manner Londax resistance would increase from the initial four sites in 1992.

In 1993, a twice normal rate foliar application of Londax was applied to a 9m^2 plot in fields where failure could not be attributed to errant cultural practices. Plots were subsequently rated for control. In 1994 and 1995 a survey which solicited Londax resistance information was mailed to rice Pest Control Advisors (PCAs). The survey generated quantitative data similar to that obtained in 1993 as well as qualitative data on the performance of resistance management practices. The survey accounted for 87.9% and 88.3% of planted acres in 1994 and 1995 respectively.

In the three years subsequent to the initial 1992 discovery, substantial increase in number and distribution of fields containing Londax-resistant weed biotypes has been documented. In 1993, 72 of 93 overspray plots contained a Londax-resistant biotype. Two new species, ricefield bulrush (*Scirpus mucronatus*) and redstem (*Ammannia coccinea*), were among the 72 resistant biotype sites. Londax resistance in the ricefield bulrush and redstem biotypes was subsequently confirmed in laboratory enzyme assays. The 72 confirmed sites were comprised of resistant biotypes of California arrowhead (51 sites or 70% of 72 total sites), smallflower umbrellaplant (15 sites or 21%), ricefield bulrush (5 sites or 7%) and redstem (1 site or 1%). By 1994 the total number of species-fields (sites) with a resistant biotype had increased to 4,753 as reported via survey. Of 5,015 reported fields, 40.7% contained resistant California arrowhead, 21.8% smallflower umbrellaplant, 9.4% ricefield bulrush, and 22.7% redstem. In 1995, 4,118 fields were surveyed, of which 60.4% contained resistant California arrowhead, 36.2% smallflower umbrellaplant, 19.1% ricefield bulrush, and 33.9% redstem (Figure 1). The total number of species-fields in 1995 was 6,156 (Table 13) indicating that on average each field surveyed contained more than one resistant species. Geographic distribution of each species increased relative to the four 1992 locations. In 1994 and 1995, resistant weeds were observed in all rice growing counties of California.

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CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

The development of broadleaf herbicides has become critical with the advent of Londax-resistant weeds. In 1995, evaluation of the new herbicides, KIH 2023, F-8426 and Grandstand (trichlopyr), continued. KIH 2023 is primarily a barnyardgrass/watergrass herbicide, but shows reasonably good activity on ricefield bulrush. Both F-8426 and Grandstand are broadleaf herbicides. Grandstand is an old herbicide with current registration in southern U.S. rice and this research explores the possibility of extending its use to California rice. Both F-8426 and Grandstand successfully controlled ricefield bulrush, the predominant sedge on the Rice Experiment Station where they were evaluated, and one of two major sedge weeds of the rice industry. In timing studies with Grandstand and MCPA, severe injury occurred at early 2-3 leaf stage treatments, indicating that rice should have at least one tiller (5 leaf stage) before treatment. Several formulations of

2,4-D were tested (2,4-D Amine, HI-DEP, and Solution) and all were equally effective. Extensive testing of Whip showed that early applications (4-5 leaf to 1 tiller) controlled sprangletop and watergrass, but late-season watergrass reinfested the plots. Later applications (2-4 tiller) of Whip gave season-long control of these weeds. A few California rice fields have shown mid-season injury from Bolero or Abolish (thiobencarb) treatments, thought to be due to microbial conversion of thiobencarb to the highly toxic deschlorothiobencarb metabolite. In greenhouse studies, deschlorothiobencarb was isolated from soils collected from these fields, and treatment with the metabolite showed severe injury to rice. Control strategies for Londax-resistant weeds was tested in a resistant California arrowhead field at the Rice Experiment Station. Neither Londax granules or later foliar spray applications of Londax controlled these resistant weeds. Applications of MCPA, 2,4-D or F-8426 alone, or in combinations with Londax, controlled resistant California arrowhead. A survey of Londax resistance was continued in 1995 to determine how widespread and what weeds were resistant. Pest control advisors from the rice growing areas cooperated with the DuPont Company and the University of California in the survey. California arrowhead was determined to be the most widespread resistant weed, occurring in approximately 60% of all fields. Redstem and smallflower umbrella sedge were found in approximately 35% of the fields and ricefield bulrush in 19%. The problem is found in every rice growing county. About 20% of the fields in the areas where resistance was originally found are now beyond economic treatment with Londax but are still less than 10% of the total 1995 rice acreage.

Table 1a. F-8426 rate and timing.

Treatment	Rate	Water Depth	Timing[1]	Rice injury (7/12)	Rice injury (8/14)	Rice injury (9/14)	Weed Control[2] SCPMU (7/12)	SCPMU (8/14)	SCPMU (9/14)	MOOVA (7/12)	MOOVA (8/14)	MOOVA (9/14)
	(lb ai/A)	(inches)		%	%	%	%	%	%	%	%	#[3]
F-8426 + X-77	.031 + 0.25%	0	*4.4l*	1.7	1.7	0.0	10.0	10.0	10.0	6.7	9.0	0.0
F-8426 + X-77	.061 + 0.25%	0	*4.4l*	2.0	1.2	0.3	10.0	10.0	9.7	5.7	9.3	0.0
F-8426 + X-77	.126 + 0.25%	0	*4.4l*	2.7	1.0	0.2	10.0	9.8	10.0	9.3	10.0	0.0
F-8426 + X-77	.031 + 0.25%	0.5	*4.4l*	1.7	0.8	0.0	9.7	8.3	9.3	4.3	9.3	0.0
F-8426 + X-77	.061 + 0.25%	0.5	*4.4l*	1.0	0.8	0.0	10.0	9.3	10.0	3.3	8.3	0.0
F-8426 + X-77	.126 + 0.25%	0.5	*4.4l*	2.7	0.8	0.2	10.0	10.0	10.0	3.0	7.3	0.0
F-8426 + X-77	.031 + 0.25%	0	*6l - 1t*	2.3	0.7	0.3	9.7	8.8	10.0	2.0	8.0	0.0
F-8426 + X-77	.061 + 0.25%	0	*6l - 1t*	2.0	0.3	0.0	10.0	9.7	10.0	6.7	8.0	0.3
F-8426 + X-77	.126 + 0.25%	0	*6l - 1t*	2.3	0.5	0.2	10.0	10.0	10.0	5.7	8.3	0.0
F-8426 + X-77	.031 + 0.25%	1	*6l - 1t*	1.0	0.8	0.3	9.7	7.7	9.0	2.3	7.3	0.7
F-8426 + X-77	.061 + 0.25%	1	*6l - 1t*	2.3	0.8	0.3	10.0	9.8	10.0	1.3	7.7	1.7
F-8426 + X-77	.126 + 0.25%	1	*6l - 1t*	2.0	1.0	0.2	10.0	9.7	10.0	2.7	6.7	0.0
F-8426 + X-77	.031 + 0.25%	4	*tillering*		1.0	0.0		8.5	8.3		7.0	6.7
F-8426 + X-77	.061 + 0.25%	4	*tillering*		2.0	0.0		9.8	9.0		7.0	5.3
F-8426 + X-77	.126 + 0.25%	4	*tillering*		2.3	0.2		10.0	9.0		8.3	7.7
Untreated				0.0	0.2	0.5	5.3	5.3	7.3	0.0	5.0	4.0

[1] *l* = leaf stage rice, *t* = rice tillers, *tillering* = rice full tiller
[2] = SCPMU = ricefield bulrush, MOOVA = monochoria
[3] = average stand count of monochoria per plot.

Table 1b. Days to 50% heading and rice yield for F-8426 rate and timing study.

Treatment	Rate (lb ai/A)	Water Depth (inches)	Timing	Days to 50% heading (DAS)1	Yield at 14 % moisture (lb/A)
F -8426 + X-77	.031 + 0.25%	0	4.41	80	8240
F-8426 + X-77	.061 + 0.25%	0	4.41	79	8150
F-8426 + X-77	.126 + 0.25%	0	4.41	80	8710
F-8426 + X-77	.031 + 0.25%	0.5	4.41	79	9440
F-8426 + X-77	.061 + 0.25%	0.5	4.41	79	9140
F-8426 + X-77	.126 + 0.25%	0.5	4.41	79	8300
F-8426 + X-77	.031 + 0.25%	0	61 - 1t	80	8880
F-8426 + X-77	.061 + 0.25%	0	61 - 1t	80	8320
F-8426 + X-77	.126 + 0.25%	0	61 - 1t	81	8370
F-8426 + X-77	.031 + 0.25%	1	61 - 1t	80	8090
F-8426 + X-77	.061 + 0.25%	1	61 - 1t	80	8170
F-8426 + X-77	.126 + 0.25%	1	61 - 1t	80	8230
F-8426 + X-77	.031 + 0.25%	4	*tillering*	82	7370
F-8426 + X-77	.061 + 0.25%	4	*tillering*	82	7040
F-8426 + X-77	.126 + 0.25%	4	*tillering*	84	6640
Untreated		4		79	7390

[1] DAS = days after seeding

Table 2a. Evaluation of rates and timing of Hi-Dep (2,4-D) Solution (2,4-D), 2,4-D Amine, MCPA and Grandstand alone or combination at various rates and timings.

			Rice Injury		Weed Control[2]					
					SCPMU		HETLI		ARR	Rdstm
Treatment	Rate	Timing[1]	(7/10)	(9/14)	(7/26)	(9/14)	(7/26)	(9/14)	(7/26)	(7/26)
	(lb ai/A)		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Hi-Dep (2,4-D)	0.75	1-2 *t*	2.3	0.3	10.0	10.0	10.0	10.0	10.0	10.0
Hi-Dep (2,4-D)	1	1-2 *t*	3.3	0.8	10.0	10.0	10.0	10.0	10.0	10.0
Hi-Dep (2,4-D)	1.5	1-2 *t*	3.0	1.0	10.0	10.0	10.0	10.0	10.0	10.0
Solution(2,4-D)	0.75	1-2 *t*	1.3	0.3	9.7	10.0	9.0	10.0	10.0	10.0
Solution(2,4-D)	1	1-2 *t*	3.3	0.0	10.0	10.0	9.7	10.0	8.3	10.0
Solution(2,4-D)	1.5	1-2 *t*	2.0	0.3	10.0	10.0	9.0	10.0	9.0	9.0
2,4-D Amine	0.75	1-2 *t*	3.0	0.0	10.0	10.0	9.0	10.0	10.0	10.0
2,4-D Amine	1	1-2 *t*	1.7	0.8	10.0	10.0	9.7	10.0	10.0	10.0
2,4-D Amine	1.5	1-2 *t*	3.5	0.0	10.0	10.0	10.0	10.0	10.0	5.0
MCP Amine	0.75	2.8 *l*	8.7	8.3	7.7	5.7	7.7		10.0	
MCP Amine	1	2.8 *l*	10.0	10.0	7.3	9.0	7.7		10.0	
MCP Amine	0.75	4.8 *l*	3.7	2.2	10.0	10.0		10.0		
MCP Amine	1	4.8 *l*	3.3	2.3	10.0	10.0		10.0		
MCP Amine	1.5	4.8 *l*	5.0	0.8	10.0	10.0		10.0		
MCP Amine	0.75	1-2 *t*	2.3	0.2	10.0	10.0	9.3	10.0	10.0	10.0
MCP Amine	1	1-2 *t*	2.7	0.0	10.0	10.0	10.0	10.0	10.0	10.0
Grandstand + X-77	0.3 + 0.25%	2.8 *l*	10.0	10.0	2.3	3.3	3.3		5.0	
Grandstand + X-77	0.5 + 0.25%	2.8 *l*	10.0	10.0	2.3	0.0	3.7		6.7	
Grandstand + X-77	1.0 + 0.25%	2.8 *l*	10.0	10.0	2.7	0.0	2.0		4.0	
Grandstand + X-77	0.3 + 0.25%	4.8 *l*	2.3	1.0	10.0	10.0		10.0		
Grandstand + X-77	0.5 + 0.25%	4.8 *l*	3.0	0.3	10.0	10.0		10.0		
Grandstand + X-77	1.0 + 0.25%	4.8 *l*	4.7	2.7	10.0	10.0		9.3		
Grandstand + X-77	0.3 + 0.25 %	1-2 *t*	1.3	0.3	8.3	9.3	9.0	6.7	9.3	7.7

(Table 2a continued)

Grandstand + X-77	0.5 + 0.25 %	1-2 *t*	1.0	0.5	9.0	9.0	8.3	10.0	8.3	8.3
Grandstand + X-77	1.0 + 0.25%	1-2 *t*	1.3	0.8	10.0	10.0	9.0	6.7	10.0	10.0
Grandstand + X-77	0.3 + 0.25 %	3 *t*	0.3	0.0	8.7	9.0	8.3	6.0	6.7	8.3
Grandstand + X-77	0.5 + 0.25 %	3 *t*	0.3	0.2	8.0	8.3	7.3	5.0	6.7	10.0
Grandstand + X-77	1.0 + 0.25%	3 *t*	1.5	1.5	9.5	10.0	10.0	10.0	10.0	9.0
Grandstand + X-77	0.3 + 0.25 %	early *boot*	0.3	0.0	5.7	8.3	6.7	6.7	10.0	8.3
Grandstand + X-77	0.5 + 0.25 %	early *boot*	1.0	0.0	5.7	7.7	8.0	9.3	10.0	8.3
Grandstand + X-77	1.0 + 0.25%	early boot	0.0	2.5	2.0	3.5	10.0	10.0	10.0	5.0
2,4-D + MCPA	0.25 + 0.25	1-2 *t*	1.3	0.3	5.0	7.0	8.3	10.0	10.0	10.0
2,4-D + MCPA	0.375 + 0.375	1-2 *t*	3.0	0.2	10.0	10.0	9.0	9.3	10.0	10.0
2,4-D + MCPA	0.5 + 0.5	1-2 *t*	3.0	0.2	10.0	10.0	9.3	10.0	10.0	9.0
2,4-D + Grandstand	0.25 + 0.25	1-2 *t*	1.0	0.0	10.0	10.0	9.7	10.0	10.0	8.3
2,4-D + Grandstand	0.25 + 0.375	1-2 *t*	1.7	0.5	10.0	9.8	10.0	10.0	10.0	10.0
2,4-D + Grandstand	.025 + 0.5	1-2 *t*	1.0	0.2	9.7	9.3	7.3	6.0	10.0	10.0
2,4-D + Grandstand	05 + 0.25	1-2 *t*	2.7	0.2	10.0	10.0	8.3	10.0	10.0	10.0
2,4-D + Grandstand	.05 + 0.375	1-2 *t*	1.3	0.0	10.0	10.0	10.0	10.0	10.0	10.0
2,4-D + Grandstand	0.5 + 0.5	1-2 *t*	2.3	0.3	10.0	10.0	10.0	10.0	10.0	10.0

[1] *l* = leaf stage rice, *t* = rice tillers, early boot = rice growth stage

[2] SCPMU = ricefield bulrush, HETLI = ducksalad, SAGMO = California arrowhead, AMMCO= redstem

Table 2b. Days to 50% heading and rice yield of Hi-Dep (2,4-D), Solution (2,4-D), 2,4-D Amine, MCPA, Grandstand + X-77, alone or combination at various rates and timings.

Treatment	Rate	Timing[1]	Days to 50% Heading	Yield at 14% moisture
	(lb ai/A)		(DAS)2	(lbs)
Hi-Dep (2,4-D)	0.75	1- 2 *t*	79	7060
Hi-Dep (2,4-D)	1	1-2 *t*	82	5940
Hi-Dep (2,4-D)	1.5	1-2 *t*	82	5200
Solution(2,4-D)	0.75	1-2 *t*	79	6180
Solution(2,4-D)	1	1-2 *t*	80	6480
Solution(2,4-D)	1.5	1-2 *t*	81	6180
2,4-D Amine	0.75	1-2 *t*	79	7020
2,4-D Amine	1	1-2 *t*	80	7020
2,4-D Amine	1.5	1-2 *t*	82	6040
MCP Amine	0.75	2.8 *l*	86	4050
MCP Amine	1	2.8 *l*	85	0
MCP Amine	0.75	4.8 *l*	86	5030
MCP Amine	1	4.8 *l*	85	5620
MCP Amine	1.5	4.8 *l*	84	4170
MCP Amine	0.75	1-2 *t*	79	6420
MCP Amine	1	1-2 *t*	82	6550
Grandstand + X-77	0.3 + 0.25%	2.8 *l*	87	0
Grandstand + X-77	0.5 + 0.25%	2.8 *l*		0
Grandstand + X-77	1.0 + 0.25%	2.8 *l*		0
Grandstand + X-77	0.3 + 0.25%	4.8 *l*	82	5990
Grandstand + X-77	0.5 + 0.25%	4.8 *l*	83	5230
Grandstand + X-77	1.0 + 0.25%	4.8 *l*	86	4620
Grandstand + X-77	0.3 + 0.25 %	1-2 *t*	80	6310
Grandstand + X-77	0.5 + 0.25 %	1-2 *t*	81	6390
Grandstand + X-77	1.0 + 0.25%	1-2 *t*	80	5240
Grandstand + X-77	0.3 + 0.25 %	3 *t*	80	6630
Grandstand + X-77	0.5 + 0.25 %	3 *t*	80	6360
Grandstand + X-77	1.0 + 0.25%	3 *t*	80	6140

(Table 2b continued)

Grandstand + X-77	0.3 + 0.25 %	early boot	78	6030
Grandstand + X-77	0.5 + 0.25 %	early boot	78	5330
Grandstand + X-77	1.0 + 0.25%	early boot	84	5240
2,4-D + MCPA	0.25 + 0.25	1-2 *t*	79	5640
2,4-D + MCPA	0.375 + 0.375	1-2 *t*	79	7280
2,4-D + MCPA	0.5 + 0.5	1-2 *t*	78	6290
2,4-D + Grandstand	0.25 + 0.25	1-2 *t*	79	7170
2,4-D + Grandstand	0.25 + 0.375	1-2 *t*	79	5880
2,4-D + Grandstand	.025 + 0.5	1-2 *t*	79	6520
2,4-D + Grandstand	05 + 0.25	1-2 *t*	79	6440
2,4-D + Grandstand	.05 + 0.375	1-2 *t*	79	5970
2,4-D + Grandstand	0.5 + 0.5	1-2 *t*	82	4300
Untreated			81	5120

[1] *l* = leaf stage rice, *t* = rice tillers, early boot = growth stage rice.
[2] DAS = days after seeding

Table 3a. Evaluation of late applications (3 tillers) of Grandstand, MCPA or 2,4-D Amine with surfactants.

				Weed Control[1]						
		Rice Injury		CYPDI[1]		AMMCO[1]	HETLI[1]		SCPMU[1]	ECHOR[1,2]
Treatment	Rate	(7/25)	(9/7)	(7/25)	(9/7)	(7/25)	(7/25)	(9/7)	(9/7)	(9/7)
	(lb ai/A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(#)
Grandstand + X-77	0.375 + 0.25%	1.5	1.0	7.0	9.9	4.8	4.3	0.0	10.0	15.8
Grandstand + X-77	0.5 + 0.25%	1.5	1.3	7.8	9.6	7.8	5.0	2.5	10.0	6.8
Grandstand + X-77	0.75 + 0.25%	1.4	1.3	8.8	10.0	9.5	8.5	2.5	10.0	17.5
MCPA + X-77	0.375 + 0.25%	2.3	0.8	7.5	10.0	6.0	7.3	5.0	10.0	21.5
MCPA + X-77	0.5 + 0.25%	2.0	0.5	9.3	10.0	10.0	8.8	10.0	10.0	13.0
MCPA + X-77	0.75 + 0.25%	2.1	0.0	8.3	10.0	8.5	9.3	7.5	10.0	20.0
2,4-D Amine + X-77	0.375 + 0.25%	2.0	0.3	7.7	10.0	6.7	6.0	6.7	10.0	14.0
2,4-D Amine + X-77	0.5 + 0.25%	1.5	0.0	9.3	10.0	8.3	9.0	10.0	10.0	15.8
2,4-D Amine + X-77	0.75 + 0.25%	1.9	0.3	8.0	10.0	7.5	7.8	7.5	10.0	6.5
Untreated		0.0	0.5	0.0	6.3	3.8	0.0	0.0	10.0	16.0

[1] CYPDI = smallflower umbrella sedge, AMMCO = redstem, HETLI = ducksalad, SCPMU = ricefield bulrush, ECHOR = watergrass

[2] ECHOR = average plants per plot

Table 3b. Days to 50% heading and rice yield for Grandstand, MCPA or 2,4-D Amine when applied with surfactant to 3-tiller rice.

Treatment	Rate	Days to 50 % heading	Yield at 14% moisture
	(lb ai/A)	(DAS)1	(lb/A)
Grandstand + X-77	0.375 + 0.25%	82	5830
Grandstand + X-77	0.5 + 0.25%	80	5720
Grandstand + X-77	0.75 + 0.25%	81	5630
MCPA + X-77	0.375 + 0.25%	82	5970
MCPA + X-77	0.5 + 0.25%	80	7190
MCPA + X-77	0.75 + 0.25%	79	6520
2,4-D Amine + X-77	0.375 + 0.25%	83	6400
2,4-D Amine + X-77	0.5 + 0.25%	81	6730
2,4-D Amine + X-77	0.75 + 0.25%	82	6590
Untreated		81	7180

[1] DAS = days after seeding

Table 4a. Evaluation of KIH 2023 + L-77 applied alone or in combination with Abolish, F-8426, or Prowl.

Treatment	Rate	Rice Injury			Weed Control 1											
					ECHOR			SCPMU			LEFFA		CYPDI		MOOVA
	(ai/A)	(7/6)	(7/28)	(9/7)	(7/6)	(7/28)	(9/7)	(7/6)	(7/28)	(9/7)	(7/28)	(9/7)	(7/28)	(9/7)	(9/7)
Abolish + KIH 2023 + L-77	4 lb + 12g + 0.25%	0.0	0.3	0.3	10.0	8.7	8.3	8.3	6.7	7.7	10.0	10.0	10.0	10.0	10.0
Abolish + KIH 2023 + L-77	4 lb + 24g + 0.25%	1.3	0.3	0.7	10.0	10.0	9.5	8.0	8.3	9.5	10.0	10.0	10.0	10.0	10.0
F-8426 + KIH 2023 + L-77	.06 lb + 12g + 0.25%	2.7	1.3	0.0	2.7	2.3	3.7	6.3	4.7	6.0	1.3	6.7	8.0	9.7	10.0
F-8426 + KIH 2023 + L-77	.06 lb + 24g + 0.25%	4.7	1.7	1.0	10.0	4.3	4.7	6.7	2.7	5.7	1.3	6.0	3.3	10.0	6.7
Prowl + KIH 2023 + L-77	.75 lb + 12g + 0.25%	8.0	6.0	5.3	10.0	7.3	6.3	0.3	0.0	0.0	8.0	10.0	4.7	7.7	6.7
Prowl + KIH 2023 + L-77	.75 lb + 24g + 0.25%	7.7	4.3	3.7	10.0	7.3	7.0	4.0	2.7	3.0	8.0	8.7	6.7	8.7	10.0
KIH 2023 + L-77	12g + 0.25%	1.0	0.0	0.0	5.7	4.7	4.7	1.7	2.7	6.0	6.3	9.0	7.7	9.0	3.3
KIH 2023 + L-77	24g + 0.25%	1.7	0.0	0.3	6.7	2.7	4.7	5.3	5.3	7.3	4.7	9.3	8.3	9.7	10.0
Untreated		0.0	1.0	6.0	0.0	0.0	0.0	0.0	3.3	6.3	8.0	10.0	6.3	10.0	6.7

[1] ECHOR = watergrass, SCPMU = ricefield bulrush, LEFFA = sprangletop, CYPDI = smallflower umbrella sedge, MOOVA = monochoria

Table 4b. Days to 50% heading, yield and % lodged rice for KIH-2023 alone or in combination with Abolish, F-8426 or Prowl.

	Rate	Days to 50% heading	Yield at 14% moisture	Lodging at harvest
	(ai/A)	(DAS) [1]	(lb/A)	(%)
Abolish + KIH 2023 + L-77	4 lb + 12g + 0.25%	85	8890	1.67
Abolish + KIH 2023 + L-77	4 lb + 24g + 0.25%	82	9010	0
F-8426 + KIH 2023 + L-77	.06 lb + 12g + 0.25%	88	7050	3.33
F-8426 + KIH 2023 + L-77	.06 lb + 24g + 0.25%	87	7080	3.33
Prowl + KIH 2023 + L-77	.75 lb + 12g + 0.25%	91	2660	50
Prowl + KIH 2023 + L-77	.75 lb + 24g + 0.25%	88	4970	43.3
KIH 2023 + L-77	12g + 0.25%	85	6650	0
KIH 2023 + L-77	24g + 0.25%	85	7710	0
Untreated		90	2170	43.3

[1] DAS = days after seeding

Table 5a. Evaluation of Ordram and Bolero alone and in combination for grass control.

Treatment	Rate	Timing [1]	Rice injury		Weed Control [2]			Weed Count [3]	
					ECHOR		LEFFA	LWG	EWG
			(7/18)	(9/18)	(7/18)	(9/18)	(7/18)	(9/18)	(9/18)
	(lb ai/A)		(%)	(%)	(%)	(%)	(%)	(#)	(#)
Ordram 10G	4	2.3 *l*	0.0	0.0	9.7	9.8	10.0	0.7	0.0
Bolero 10G	4	2.3 *l*	0.0	0.0	9.0	6.7	10.0	15.3	0.0
Ordram 10G + Bolero 10G	2 + 2	2.3*l* + 4.8*l*	0.0	0.0	8.7	6.0	8.7	22.5	3.0
Ordram 10G + Bolero 10G	2 + 4	2.3*l* + 4.8*l*	0.0	0.0	9.0	7.0	8.7	14.0	1.3
Ordram 10G + Bolero 10G	4 + 2	2.3*l* + 4.8*l*	0.0	0.0	9.7	9.7	10.0	0.3	0.3
Bolero 10G + Ordram 10G	2 + 2	2.3*l* + 4.8*l*	0.0	0.2	9.0	6.7	10.0	19.7	0.7
Bolero 10G + Ordram 10G	2 + 4	2.3*l* + 4.8*l*	0.0	0.2	9.7	9.7	10.0	0.3	0.3
Bolero 10G + Ordram 10G	4 + 2	2.3*l* + 4.8*l*	0.0	0.0	10.0	9.7	10.0	0.7	0.0
Untreated			0.0	2.3	0.0	1.7	0.0		1.3

[1] l = leaf stage rice
[2] ECHOR = watergrass, LEFFA = sprangletop
[3] average number of plants per 200 sq. ft.

Table 5b. Days to 50% heading and rice yield for treatments of Ordram or Bolero applied alone or combinations.

Treatment	Rate	Timing [1]	Days to 50% heading	Rice yield at 14% moisture
	(lb ai/A)		(DAS)[2]	(lb/A)
Ordram 10G	4	2.3 *l*	78	8480
Bolero 10G	4	2.3 *l*	81	8660
Ordram 10G + Bolero 10G	2 + 2	2.3*l* + 4.8*l*	79	8080
Ordram 10G + Bolero 10G	2 + 4	2.3*l* + 4.8*l*	78	8630
Ordram 10G + Bolero 10G	4 + 2	2.3*l* + 4.8*l*	79	8370
Bolero 10G + Ordram 10G	2 + 2	2.3*l* + 4.8*l*	80	8360
Bolero 10G + Ordram 10G	2 + 4	2.3*l* + 4.8*l*	81	8680
Bolero 10G + Ordram 10G	4 + 2	2.3*l* + 4.8*l*	80	8870
Untreated			80	4640

[1] l = leaf stage rice
[2] DAS = days after seeding

Table 6a. The influence of Whip 1 EC or Whip 360 timing and rate on rice injury and grass control in rice

Treatment	Rate	Timing[1]	Rice Injury (7/10)	Rice Injury (7/18)	Rice Injury (9/18)	Weed Control[2] ECHOR (7/10)	ECHOR (7/18)	ECHOR (8/17)	(EWG) (8/17)	(LWG) (8/17)	(LWG) (9/18)	LEFFA (7/10)	LEFFA (7/18)	LEFFA (9/18)
	(Lb ai/A)													
Whip 1 EC	0.1	4.8 *l*	1.3	0.3	0.2	5.3	8.0	6.0	7.7	6.0	5.0	6.3	9.3	10.0
Whip 1 EC	0.15	4.8 *l*	7.0	2.7	1.7	7.3	9.0	8.7	9.3	9.0	7.3	10.0	9.7	10.0
Whip 1 EC	0.1	1*t*		1.3	0.0		3.7	3.7	6.3	3.7	3.7	3.0	9.7	10.0
Whip 1 EC	0.15	1*t*		2.0	0.0		6.7	6.7	8.0	6.7	6.0	10.0	9.7	10.0
Whip 1 EC	0.1	2.2*t*		0.3	0.2		5.7	8.7	9.3	9.0	6.7	5.0	6.7	10.0
Whip 1 EC	0.15	2.2*t*		1.0	0.5		5.3	9.3	10.0	9.3	8.7	6.7	8.0	9.7
Whip 1 EC + Whip 1 EC	0.07 + 0.07	4.8 *l* 2.2*t*	1.7	1.0	0.2	3.3	7.3	8.0	8.7	8.3	5.7	9.7	9.3	10.0
Whip 1 EC + Whip 1 EC	0.07 + 0.07	1 *t* 3.5*t*		0.7	0.2		4.3	9.0	9.0	10.0	7.7	5.3	9.7	10.0
Whip 1 EC + Whip 1 EC	0.07 + 0.07	2.2*t* 4*t*		0.0	0.0		6.7	8.7	9.3	8.7	7.3	2.7	9.7	10.0
Whip 360	0.04	4.8 *l*	2.3	0.3	0.0	6.7	7.3	7.0	8.0	7.0	6.7	8.3	9.7	10.0
Whip 360	0.06	4.8 *l*	5.0	2.0	0.7	6.7	9.0	8.0	8.7	8.3	7.0	9.7	9.7	10.0
Whip 360	0.04	1*t*		0.7	0.0		6.0	6.0	7.7	6.0	5.7	3.7	7.7	10.0
Whip 360	0.06	1*t*		2.3	0.7		9.0	8.7	9.3	8.7	7.3	10.0	8.7	10.0
Whip 360	0.04	2.2*t*		0.7	0.0		10.0	8.7	9.3	9.3	7.7	7.7	7.7	10.0
Whip 360	0.06	2.2*t*		1.3	0.3		8.0	8.3	9.0	8.3	8.5	9.0	8.3	10.0
Whip 360 + Whip 360	0.02 + 0.02	4.8 *l* 2.2*t*	0.0	0.3	0.0	4.7	7.7	7.0	7.3	7.3	6.0	6.7	8.7	10.0
Whip 360 + Whip 360	0.02 + 0.02	1 *t* 3.5*t*		0.3	0.0		0.0	8.3	9.7	8.3	6.3	0.0	7.3	10.0
Whip 360 + Whip 360	0.02 + 0.02	2.2*t* 4*t*		0.3	0.2		7.7	9.3	10.0	9.3	7.0	6.3	8.7	10.0
Whip 1 EC + L-77	0.075 + 0.5%	1*t*		2.3	0.3		6.3	6.0	9.3	6.0	6.0	8.0	8.3	10.0
Whip 1 EC + COC	0.075 + 1 qt	1*t*		0.7	0.2		6.0	7.3	9.0	7.7	5.3	5.3	9.3	10.0
Whip 1 EC	0.075	1*t*		0.0	0.2		3.0	5.3	7.0	5.3	5.0	8.7	9.7	10.0
Untreated				0.0	0.0		0.0	1.3	3.7	1.3	4.3	1.3	8.7	10.0

[1] *l* = leaf stage rice, *t* = rice tillers

[2] ECHOR = watergrass, LEFFA = sprangletop, EWG = early watergrass, LWG = late watergrass

Table 6b. The influence of Whip 1 EC or Whip 360 timing and rate on days to 50% heading of rice, rice yield and rice height.

Treatment	Rate	Timing[1]	Days to 50% heading	Yield at 14 % moisture	Rice height
	(lb ai/A)		(DAS)[2]	(lb /A)	(cm)
Whip 1 EC	0.1	4.8 l	81	6780	85
Whip 1 EC	0.15	4.8 l	82	6680	79
Whip 1 EC	0.1	1t	81	5140	77
Whip 1 EC	0.15	1t	81	5800	76
Whip 1 EC	0.1	2.2t	81	6880	80
Whip 1 EC	0.15	2.2t	79	7410	80
Whip 1 EC + Whip 1 EC	0.07 + 0.07	4.8 l 2.2t	80	5890	81
Whip 1 EC + Whip 1 EC	0.07 + 0.07	1 t 3.5t	79	6790	78
Whip 1 EC + Whip 1 EC	0.07 + 0.07	2.2t 4t	79	6960	78
Whip 360	0.04	4.8 l	80	7600	84
Whip 360	0.06	4.8 l	81	6190	83
Whip 360	0.04	1t	81	6560	81
Whip 360	0.06	1t	82	5790	74
Whip 360	0.04	2.2t	80	7110	82
Whip 360	0.06	2.2t	79	6900	82
Whip 360 + Whip 360	0.02 + 0.02	4.8 l 2.2t	80	6620	79
Whip 360 + Whip 360	0.02 + 0.02	1 t 3.5t	80	6760	80
Whip 360 + Whip 360	0.02 + 0.02	2.2t 4t	79	6860	79
Whip 1 EC + L-77	0.075+0.5%	1t	82	6110	78
Whip 1 EC + COC	0.075 + 1 qt	1t	80	6390	78
Whip 1 EC	0.075	1t	80	6220	83
Untreated			79	6270	85

[1] l = leaf stage rice, t rice tillers
[2] DAS = days after seeding

Table 7a. Evaluation of V-10029, alone and in combination with MCPA or Londax for rice weed control.

Treatment[1]	Rate	Rice			Weed Control[2]								
		Injury		Stand	ECHOR			LEFFA	SCPMU			HETLI	
		(7/12	(8/10)	(9/19)	(7/12)	(8/10)	(9/19)	8/10)	(7/12)	(8/10)	(9/19)	(8/10)	(9/19)
	(ai/A)	(%)	(%)	#/plot	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
V-10029	15 g	1.8	0.3	0.8	10.0	6.8	9.3	7.8	8.8	7.0	9.5	9.5	8.8
V-10029	20 g	1.5	0.3	0.4	10.0	9.5	8.5	8.8	7.0	6.0	8.0	9.0	5.0
V-10029 + MCPA	15 g + 1.0 lb	2.0	0.8	0.5	9.9	9.0	8.5	9.3	9.8	9.8	10.0	10.0	10.0
V-10029 + MCPA	20 g + 1.0 lb	2.3	0.5	0.1	10.0	9.8	9.5	10.0	9.5	8.5	9.5	10.0	10.0
Ordram + Londax	4.0 lb + 1.0 oz	0.0	0.1	0.0	10.0	10.0	9.6	9.8	10.0	10.0	10.0	10.0	10.0
V-10029 + Londax	20 g + 1.0 oz	2.3	0.0	0.8	10.0	10.0	9.9	7.5	9.9	10.0	10.0	10.0	10.0
Untreated		0.0	0.0	4.8	0.0	2.5	0.5	9.5	5.0	3.3	5.5	9.8	10.0

[1] Kinetic at 0.25% v/v added to all V-10029 treatments.
[2] ECHOR = watergrass, LEFFA = sprangletop, SCPMU = ricefield bulrush, HETLI = ducksalad

Table 7b. Rice yield and height for V-10029 alone or in combination with MCPA or Londax

Treatment [1]	Rate	Yield at 14% moisture	Rice height
	(ai/A)	(lb/A)	(cm)
V-10029	15 g	6610	76
V-10029	20 g	5420	80
V-10029 + MCPA	15 g + 1.0 lb	6380	81
V-10029 + MCPA	20 g + 1.0 lb	6670	77
Ordram + Londax	4.0 lb + 1.0 oz	8080	78
V-10029 + Londax	20 g + 1.0 oz	5900	78
Untreated		3380	80

[1] Kinetic at 0.25% v/v applied to all V-10029 treatments

Table 8a. KIH 2023 rate and timing with three fertilizer applications.

Treatment	Rate	Timing [1]	Rice injury			Weed Control [2]											
						ECHOR			LEFFA			SCPMU			HETLI		
	(g ai/A)		(7/17)	(8/9)	(9/19)	(7/17)	(8/9)	(9/19)	(7/17)	(8/9)	(9/19)	(7/17)	(8/9)	(9/19)	(7/17)	(8/9)	(9/19)
KIH 2023 + L-77	12 + 0.25%	4.8 l	1.0	0.7	0.0	9.7	9.7	8.3	1.7	3.0	6.5	0.0	0.3	4.7	3.3	4.5	6.7
KIH 2023 + L-77	16 + 0.25%	4.8 l	1.0	1.2	0.3	10.0	10.0	7.3	1.3	3.0	7.3	2.0	2.3	5.0	6.7	6.7	6.7
KIH 2023 + L-77	24 + 0.25%	4.8 l	2.0	1.5	0.3	9.7	10.0	8.7	0.0	0.0	4.7	2.3	3.3	5.7	5.7	10.0	10.0
KIH 2023 + L-77	12 + 0.25%	5l - 1t	0.3	1.7	0.5	10.0	8.0	7.3	3.3	3.0	10.0	6.3	5.7	9.0	6.7	1.5	6.7
KIH 2023 + L-77	16 + 0.25%	5l - 1t	1.7	2.5	0.5	9.7	8.7	8.0	0.7	4.3	6.3	6.0	6.7	8.3	6.7	5.0	6.7
KIH 2023 + L-77	24 + 0.25%	5l - 1t	2.7	2.0	1.0	10.0	10.0	9.5	1.0	4.7	5.0	4.7	7.0	8.7	5.0	4.3	3.3
KIH 2023 + L-77	12 + 0.25%	2t	0.3	0.0	1.3	3.0	5.0	2.7	7.7	6.3	10.0	1.3	9.5	10.0	6.7	8.0	10.0
KIH 2023 + L-77	16 + 0.25%	2t	0.0	0.5	0.8	3.0		5.0	8.3	0.0	9.3	1.0	9.0	9.7	7.3	10.0	8.3
KIH 2023 + L-77	24 + 0.25%	2t	0.3	0.3	0.7	3.0	8.0	5.7	8.0	8.0	9.3	2.7	10.0	10.0	8.3	10.0	10.0
KIH 2023 + L-77	12 + 0.25%	5l - 1t	0.3	1.2	0.0	9.3	10.0	9.2	3.0	8.0	9.3	6.0	8.7	9.7	6.7	4.5	6.7
KIH 2023 + L-77	16 + 0.25%	Fertilizer 1 wk	2.3	1.3	0.0	10.0	9.3	8.3	3.0	6.3	8.3	6.3	6.3	8.0	4.0	4.3	3.3
KIH 2023 + L-77	24 + 0.25%	before	2.7	1.2	0.8	10.0	10.0	9.3	8.0	8.3	9.7	6.3	7.7	9.0	6.7	5.3	6.7
KIH 2023 + L-77	12 + 0.25%	5l - 1t	1.3	1.0	0.0	8.7	6.7	8.7	1.7	2.0	7.0	3.0	5.0	7.0	3.3	4.0	6.7
KIH 2023 + L-77	16 + 0.25%	Fertilizer at	2.0	1.0	0.3	10.0	10.0	9.5	1.0	6.7	7.7	5.7	7.0	8.8	5.3	5.7	6.7
KIH 2023 + L-77	24 + 0.25%	application	3.3	1.7	0.5	10.0	10.0	9.5	1.7	3.7	4.7	7.3	7.3	9.3	10.0	10.0	6.7
KIH 2023 + L-77	12 + 0.25%	5l - 1t	0.0	0.8	0.0	10.0	10.0	7.7	3.0	6.3	9.3	6.3	5.7	9.3	8.0	7.5	10.0
KIH 2023 + L-77	16 + 0.25%	Fertilizer 1 wk	1.5	2.0	0.8	10.0	10.0	8.0	2.7	4.5	8.0	5.7	6.5	9.3	3.3	8.5	5.0
KIH 2023 + L-77	24 + 0.25%	after	2.0	1.7	0.5	10.0	10.0	9.3	2.0	4.3	6.7	5.0	6.3	8.3	7.7	4.5	2.0
untreated			0.0	0.3	6.0	0.0	0.0	0.0	0.0	7.3	10.0	0.0	1.7	7.7	3.3	6.7	10.0

[1] l = leaf stage rice, t = rice tillers, fertilizer was applied 1 week before treatment, applied to rice at time of treatment but not with KIH 2023, applied 1 week after herbicide treatments.
[2] ECHOR = watergrass, LEFFA = sprangletop, SCPMU = ricefield bulrush, HETLI = ducksalad

Table 8b. KIH 2023 + L-77 timing in relation to rice growth stage or fertilizer application on days to 50% heading, rice yield and rice height.

Treatment	Rate	Timing	Days to 50% heading	Yield at 14% moisture	Rice height
	(g ai/A)		(DAS)[1]	(lb/A)	(cm)
KIH 2023 + L-77	12 + 0.25%	4.8 l	78	5980	85
KIH 2023 + L-77	16 + 0.25%	4.8 l	79	6660	85
KIH 2023 + L-77	24 + 0.25%	4.8 l	79	6790	88
KIH 2023 + L-77	12 + 0.25%	5l - 1t	79	5820	81
KIH 2023 + L-77	16 + 0.25%	5l - 1t	79	7180	83
KIH 2023 + L-77	24 + 0.25%	5l - 1t	78	6240	85
KIH 2023 + L-77	12 + 0.25%	2t	78	4520	80
KIH 2023 + L-77	16 + 0.25%	2t	78	4720	81
KIH 2023 + L-77	24 + 0.25%	2t	77	4420	83
KIH 2023 + L-77	12 + 0.25%	5l - 1t	78	7340	82
KIH 2023 + L-77	16 + 0.25%	Fertilizer 1 wk	79	7270	91
KIH 2023 + L-77	24 + 0.25%	before application	78	8970	88
KIH 2023 + L-77	12 + 0.25%	5l - 1t	81	6600	86
KIH 2023 + L-77	16 + 0.25%	Fertilizer at	79	8220	86
KIH 2023 + L-77	24 + 0.25%	application	79	8060	90
KIH 2023 + L-77	12 + 0.25%	5l - 1t	78	8550	81
KIH 2023 + L-77	16 + 0.25%	Fertilizer 1 wk	80	6690	82
KIH 2023 + L-77	24 + 0.25%	after application	79	7220	83
Untreated			79	2730	86

[1] DAS = days after seeding

Table 9a. Combinations of Grandstand + Whip 1EC or KIH 2023 for weed control.

Treatment[2]	Rate	Rice Injury			Weed Control[1]									
					HOR lwg				SCPMU		HETLI			LEFFA
		(7/12)	(8/14	(9/13)	(7/12	8/10)	(9/13)	(7/12)	(8/10)	(9/13)	(7/12)	(8/10)	(9/13)	(8/10)
	(ai/A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Grandstand + Whip 1 EC	.25 lb + .10 lb	0.7	0.8	0.8	7.3	4.7	4.7	9.3	6.0	8.3	7.0	5.7	0.0	10.0
Grandstand + Whip 1 EC	.37 lb + .10 lb	2.3	0.8	0.5	8.7	7.5	3.5	10.0	10.0	10.0	7.0	7.5	6.0	10.0
Grandstand + Whip 1 EC	.50 lb + .10 lb	1.0	1.7	0.5	7.7	5.0	3.7	8.7	7.7	9.3	7.7	7.0	4.0	10.0
Grandstand + Whip 1 EC	.25 lb + .15 lb	2.7	1.3	1.3	9.7	7.3	7.7	10.0	7.7	8.0	7.3	5.7	1.0	10.0
Grandstand + Whip 1 EC	.35 lb + .15 lb	3.0	1.0	0.5	9.3	8.0	6.0	9.3	8.7	10.0	6.7	3.0	1.3	10.0
Grandstand + Whip 1 EC	.50 lb + .15 lb	2.0	2.0	1.3	9.0	8s.0	6.3	10.0	9.3	9.8	8.3	6.7	1.3	10.0
Grandstand + KIH 2023	.25 lb + 12 g	1.0	1.2	0.5	10.0	8.0	7.7	9.7	9.7	10.0	9.3	8.0	6.0	9.0
Grandstand + KIH 2023	.37 lb + 12 g	1.3	1.3	0.3	9.7	7.0	6.0	10.0	9.7	10.0	7.3	8.0	5.0	9.7
Grandstand + KIH 2023	.50 lb + 12 g	1.3	1.0	0.2	8.7	6.3	6.0	10.0	9.3	1.0.0	9.7	8.0	7.7	8.0
Grandstand + KIH 2023	.25 lb + 24 g	1.0	0.8	1.0	10.0	8.3	8.8	10.0	8.3	9.3	8.0	8.0	5.0	7.0
Grandstand + KIH 2023	.37 lb + 24 g	1.0	1.3	0.2	10.0	9.3	8.7	9.7	10.0	10.0	9.0	8.7	4.7	9.7
Grandstand + KIH 2023	.50 lb + 24 g	1.3	1.0	0.5	10.0	8.3	8.6	10.0	9.7	10.0	9.7	8.7	6.3	8.3
Untreated		0.0	0.5	1.0	0.0	0.0	0.0	0.0	0.3	6.0	6.3	9.0	9.7	10.0

[1] ECHOR = watergrass, lwg = late watergrass, SCPMU = ricefield bulrush, HETLI = ducksalad, LEFFA = sprangletop

[2] X-77 added to all Grandstand treatments at the rate of 0.25% v/v

Table 9b. Evaluation of rates of Grandstand + Whip or KIH 2023 when applied to rice at the 5-leaf to 1-tiller on days to 50% heading and rice yield.

Treatment[1]	Rate	Days to 50 % heading	Yield at 14 % moisture
	(ai/A)	(DAS[2])	(lb/A)
Grandstand + Whip 1 EC	.25 lb + .10 lb	78	5630
Grandstand + Whip 1 EC	.37 lb + .10 lb	80	4670
Grandstand + Whip 1 EC	.50 lb + .10 lb	79	5580
Grandstand + Whip 1 EC	.25 lb + .15 lb	79	5470
Grandstand + Whip 1 EC	.35 lb + .15 lb	79	5660
Grandstand + Whip 1 EC	.50 lb + .15 lb	78	6110
Grandstand + KIH 2023	.25 lb + 12 g	78	6150
Grandstand + KIH 2023	.37 lb + 12 g	78	5880
Grandstand + KIH 2023	.50 lb + 12 g	78	6470
Grandstand + KIH 2023	.25 lb + 24 g	77	6460
Grandstand + KIH 2023	.37 lb + 24 g	78	6820
Grandstand + KIH 2023	.50 lb + 24 g	78	6720
Untreated		80	4230

[1] X-77 applied to all Grandstand treatments at 0.25% v/v

[2] DAS = days after seeding

Table 10. Rice levee weed control with Rodeo.

Treatment	Rate	Timing	Weed Control[1] ECHOR	POLCC	LEFFA	ECHOR	POLCC
			8/10			9/12	
	(lb ai/A)		(%)	(%)	(%)	(%)	(%)
Rodeo + X-77	0.125 + 0.5%	July 25	1.0	1.0	5.0	0.0	0.0
Rodeo + X-77	0.25 + 0.5%	July 25	3.3	3.0	9.0	2.0	3.3
Rodeo + X-77	0.5 + 0.5%	July 25	3.7	1.0	4.3	7.0	4.0
Rodeo + X-77	1.0 + 0.5%	July 25	4.3	4.0	9.0	5.3	7.0
Rodeo + X-77	1.5 + 0.5%	July 25	4.3	2.5	6.5	8.0	8.3
Rodeo + X-77	2.0 + 0.5%	July 25	5.0	4.0	3.0	4.3	7.7
Rodeo + X-77	0.125 + 0.5%	July 25	2.0	1.0	3.3		
Rodeo + X-77	0.125 + 0.5%	Aug 10				4.0	10.0
Rodeo + X-77	0.25 + 0.5 %	July 25	2.0	1.5	2.5		
Rodeo + X-77	0.25 + 0.5%	Aug 10				8.3	8.0
Rodeo + X-77	0.5 + 0.5 %	July 25	4.3	1.5	3.0		
Rodeo + X-77	0.5 + 0.5	Aug 10				9.3	9.3
Rodeo + X-77	1.0 + 0.5%	July 25	6.0	2.5	4.0		
Rodeo + X-77	1.0 + 0.5%	Aug 10				10.0	10.0
Rodeo + X-77	.125 + 0.5%	July 25	1.3	0.0	8.0		
Rodeo + X-77	.25 + 0.5%	Aug 10				6.3	6.7
Rodeo + X-77	.25 + 0.5%	July 25	1.7	2.0	4.0		
Rodeo + X-77	.125 + 0.5%	Aug 10				5.7	7.0

[1] ECHOR = barnyardgrass, POLCC = swamp smartweed, LEFFA = sprangletop

Table 11. Phytotoxicity of deschlorothiobencarb and thiobencarb to rice in the greenhouse

Treatment	Rate	Rice Variety	Rice Plants[1]	Rice Height	Rice Injury
	(ppm)		(number)	(inch)	(%)
Deschlorothiobencarb	0	M202	19	10	0
	0.5		21	9	10
	1		17	5	70
	2		6	3	80
	4		3	1	90
Deschlorothiobencarb	0	L202	17	10	0
	0.5		15	8	20
	1		10	4	80
	2		3	2	90
	4		3	1	100
Thiobencarb	0	M202	14	10	0
	0.5		13	10	0
	1		16	10	0
	2		17	10	0
	4		15	9	10
Thiobencarb	0	L202	15	10	0
	0.5		16	10	0
	1		11	10	0
	2		11	10	0
	4		12	9	20

[1] Average of 3 basins, 21 rice seeds planted per basin

Table 12. Evaluation of timing of Londax, MCPA, 2,4-D Amine, F8426 alone or combinations of Londax + Grandstand + X-77, MCPA, 2,4-D Amine or F8426 for the control of Londax-resistant California arrowhead.

Treatment	Rate	Timing[1]		Water Depth	Rice Injury		Weed Control[2] SAGMO			SCPMU	Days to 50% heading	Rice Yield
					(7/1)	(9/11)	(7/1)	(8/9)	(9/11)	(7/1)		
	(oz ai/A)	(DAS)	(Rice)	(inch)	(%)	(%)	(%)	(%)	#/plot	(%)	(DAS)	(lb/Acre)
Londax + L-77	1 + .25%	17	3 - 4 l	0	0.0	0.2	1.3	8.3	0.0	10.0	85	8310
Londax + L-77	1 + .25%	19	4 - 5 l	0	0.0	0.2	0.0	7.7	0.3	10.0	84	8110
Londax + L-77	1 + .25%	23	5l - 1t	0	0.3	0.2	1.7	7.7	0.3	10.0	84	7900
Londax + L-77	1 + .25%	27	3t	1	0.0	0.2	0.7	8.0	0.0	10.0	82	7830
Londax Granular	1	17	3 - 4 l	3	0.0	0.8	0.0	5.3	1.3	10.0	82	6670
Londax Granular	1	19	4 - 5 l	3	0.0	0.7	0.7	7.0	0.7	10.0	84	7350
Londax Granular	1	23	5l - 1t	3	0.0	1.0	0.7	8.7	0.0	10.0	85	6790
Londax Granular	1	27	3t	3	0.0	0.0	0.7	7.7	0.0	0.0	82	7900
Londax + MCPA	1 + 12	17	3 - 4 l	0	5.7	0.5	10.0	10.0	0.3	10.0	84	7110
Londax + 2,4-D	1 + 12	17	3 - 4 l	0	6.3	1.0	9.8	7.3	0.7	10.0	84	7570
Londax + Grandstand + X-77	1 + 4 + .25%	17	3 - 4 l	0	2.7	0.0	5.0	7.0	0.3	10.0	86	7270
Londax + Grandstand + X-77	1 + 6 + .25%	17	3 - 4 l	0	4.7	1.3	8.7	8.7	0.7	10.0	90	6740
Londax + MCPA	1 + 16	23	5l - 1t	0	3.3	0.5	10.0	10.0	0.0	10.0	84	7690
Londax + 2,4-D	1 + 16	23	5l - 1t	0	4.3	1.2	10.0	10.0	0.3	10.0	87	7080
Londax + Grandstand + X-77	1 + 4 + .25%	23	5l - 1t	0	2.7	0.5	5.3	9.0	2.0	10.0	86	7670
Londax + Grandstand + X-77	1 + 6 + .25%	23	5l - 1t	0	3.0	0.7	7.3	8.7	1.0	10.0	89	7420
Londax + MCPA	1 + 16	16 + 34	3l + 4t	2	0.0	1.3	2.0	10.0	0.0	6.7	83	6330
Londax + 2,4-D	1 + 16	16 + 34	3l + 4t	2	0.0	1.3	0.0	10.0	0.3	6.7	85	6960
Londax + Grandstand + X-77	1 + 4 + .25%	16 + 23	3l + 5l	0	3.0	0.3	5.7	7.3	1.0	10.0	89	8000
Londax + Grandstand + X-77	1 + 6 + .25%	16 + 23	3l + 5l	0	3.3	0.0	6.0	7.0	0.0	10.0	86	7780
Londax + Grandstand + X-77	1 + 4 + .25%	16 + 34	3l + 4t	2	0.0	1.2	1.0	9.3	2.3	10.0	85	6650
Londax + Grandstand + X-77	1 + 6 + .25%	16 + 34	3l + 4t	2	0.0	1.0	0.0	8.0	0.0	8.0	84	5830
MCPA	16	23	5l - 1t	0	4.0	0.3	10.0	10.0	0.0	10.0	83	7930
MCPA	16	34	4t	2	0.0	2.8	0.7	9.8	0.7	0.0	84	4630
2,4-D	16	23	5l - 1t	0	4.7	1.2	6.6	9.8	0.0	6.7	82	7120
2,4-D	16	34	4t	2	0.0	0.8	0.0	10.0	0.0	0.0	84	7140
Londax + Londax	1 + 1	16 + 23	3l + 5l	0	0.0	0.0	2.7	8.3	0.0	10.0	85	8430
F8426 + L-77	1 + .25%	19	4 - 5 l	0	1.3	0.0	7.0	9.8	0.0	9.3	84	7800
F8426 + L-77	1 + .25%	27	3t	1	3.0	0.0	5.3	9.8	0.0	10.0	86	7730
Londax + F8426 + L-77	1 + 1 + .25%	16	3 - 4 l	0	1.7	0.0	10.0	10.0	0.0	10.0	83	7780
Londax + F8426 + L-77	1 + 1 + .25%	23	5l - 1t	0	1.7	0.8	10.0	10.0	0.0	10.0	83	7680
Untreated					0.0	2.0	0.0	3.7	7.0	6.7	88	6450

[1] DAS = days after seeding, l = leaf stage rice, t = rice tillers
[2] SAGMO = California arrowhead, SCPMU = ricefield bulrush

Table 13. Londax resistance development 1992-1995.

County	No. of resistant sites			
	1992	1993	1994	1995
Butte	0	13	336	644
Colusa	0	7	1314	2053
Fresno	0	0	3	47
Glenn	0	9	519	821
Merced	0	0	0	26
Placer	0	3	418	358
Sacramento	0	5	271	240
San Joaquin	0	1	56	94
Stanislaus	0	0	48	40
Sutter	2	25	1059	1298
Tehama	0	0	2	11
Yolo	0	0	109	144
Yuba	2	9	618	380
Total	4	72	4753	6156

Figure 1: LONDAX RESISTANCE 1992-1995