ANNUAL REPORT
January 1, 2022 - December 31, 2022

PROJECT TITLE: Weed Management in Rice

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LEVEL OF 2022 FUNDING: $ 169,676

OBJECTIVES OF PROPOSED RESEARCH:

1. Optimize and improve the efficacy of herbicide applied alone, in tank mixes, or/and in sequential treatments in different California rice production systems. Develop herbicide alternatives and programs that are efficacious, simple, adoptable, and cost effective.
2. Test new compounds that address critical weed control needs in rice cropping systems to ensure they are efficacious, compatible, and useful for California rice production.
3. Develop thermal model for growth and development of the weedy rice that can be used to predict emergence and growth of weedy rice.
4. Study mechanism of herbicide resistance in weeds and identify programs to manage resistant biotypes. Provide diagnosis services to growers and PCA to confirm cross/multiple resistance in rice fields, and mapping the spread of resistance in California rice production areas.

SUMMARY OF 2022 RESEARCH:

The UC Rice Weed Research Program seeks to assist the California rice industry in achieving sustainable weed control through research, demonstration, and other extension efforts. This year's program focuses on the performance and evaluation of new herbicides (including herbicides under development) in mixtures and/or sequential combinations with existing herbicides primarily for continuously-flooded rice system. We also are evaluating new formulations of existing rice herbicides, as well as refining full-season herbicide programs featuring common rice herbicides, with an emphasis on flexibility and herbicide rotation. Highlights of this year's program include studying florpyrauxifen-benzyl (Loyant), pyraclonil (Zembu), Roxy technology, Cliffhanger, Oxaziclomefone, GWN-10723, and Vantak weed control in water seeded rice when applied alone or incorporated into existing weed control programs. In addition, we have developed basic biological information to help managing weeds including weedy rice.

We have developed important data and knowledge to help growers managing weeds. Our program this year include advanced testing of five new herbicides, pyraclonil, Loyant, TVE29, Vantec, and Roxy technology. Pyraclonil is a PPO inhibitor, Loyant is auxin-type herbicides, TVE29 is a DHODH inhibitor which is a new mode of action not only for rice but also for other crops, and Vantec is a long chain lipid biosynthesis inhibitor. Research also was conducted to study the response of Roxy rice to different rates and combinations of ALB 2023 and ALB 2024 herbicide in Roxy cropping system. Additionally, we have continued our efforts to develop a thermal model to predict weedy rice emergence.

The dominant weed species in 2022 within our water-seeded field were watergrasses, bearded sprangletop, smallflower umbrella sedge, ricefield bulrush, and ducksalad. We also observed, to a lesser degree, redstems, arrowheads, and waterhyssops. Weed control efficacy of herbicide programs presented reflect the visual ratings (average of three or four replicates) 40 to 60 days after seeding. Rice injury (stand reduction, stunting, chlorosis, and necrosis) after herbicide application have also been noted wherever relevant.

Most of our 2022 weed management research was conducted in continuous flood system, which has been historically the most common rice growing system in California as this system promotes suppression of most competitive rice weeds such as barnyardgrass, watergrass, and sprangletop. In this system, a water depth of 4 inches is maintained throughout the season after seeding rice into a flooded field. When late post-emergence foliar applications are needed, water depth is lowered to expose about two-thirds of weed foliage to the herbicide spray, but fields are never completely drained.

This year, our planting dates were May 23, 24, and 26 with a seeding rate of 160 lb/A. We have used L-208, M206, M211, M209, M105, and CM203 rice varieties in our research, depending on the study. The rice harvest was conducted in early November. The dominant weed species in our water-seeded field have been barnyardgrass, early watergrass, smallflower umbrellasedge, and ricefield bulrush,

followed closely by bearded sprangletop, ducksalad, redstems, arrowheads, monochoria, and waterhyssop were also present in our water-seeded fields.

Objective 1. Optimize and improve the efficacy of herbicide applied alone, in tank mixes, or/and in sequential treatments. Develop herbicide alternatives and programs that are efficacious, simple, adoptable, and cost effective.

Due to variations in growing and irrigation methods utilized by farmers around the state of California, we continue to test herbicides in different settings, including continuous flood and pinpoint flood. Experiments were conducted at the Rice Experiment Station (RES) in Butte County at three fields. Experiments were planted on May 23 and 24 (M-209 rice variety) with seeding rate of 160 lb/A, and May 26 (M-209, L-208, M211, M105, and CM203 rice variety) with seeding rate of 160 lb/A. Continuously flooded plots were seeded into flooded fields, and water levels were maintained at approximately 4 inches throughout the season. The level of water, however, was lowered for certain late season herbicide treatment and water level brought back 48 h after treatment. Water was drained at about a month before harvest, to facilitate rice harvest. Weed control and rice injury were rated using 0 to 100 scale where 0 = no injury and 100 = mortality. Weed control and rice injury rating were conducted 20, 40, and 60 days after seeding (DAS). In all studies, weed control was also rated by species. Rice injury (stand reduction, stunting, chlorosis, etc.) was evaluated 20 and 40 DAS. All herbicide applications were made with a CO_2-pressurized (30 PSI) hand-held sprayer equipped with a ten-foot boom and 8003 nozzles, calibrated to apply 20 gallons/acre. Applications with solid formulations were made by evenly hand broadcasting the product over the plots. In this report, the trade name of herbicides was used and the herbicide rates appear as amounts of formulated product; a cross-reference between brands and active ingredients is presented in Table 1.

Table 1. Herbicides used and their active ingredient

Herbicide	Percentage ai
Bolero UltraMax (thiobencarb)	15
Butte (benzobicyclon + halosulfuron)	3 + 0.64
Cerano 5 MEG (clomazone)	5
Clincher CA (cyhalofop-butyl)	29.6
Grandstand (triclopyr)	44.4
Granite GR (penoxsulam)	0.24
Granite SC (penoxsulam)	24
Prowl H_2O (pendimethalin)	42.6
Regiment (bispyribac-sodium)	80
Sandea (halosulfuron)	75
Shark H_2O (carfentrazone)	40
SuperWham! CA (propanil)	41.2

a. Efficacy of Butte and Cliffhanger herbicides in water seeded rice

Butte is a relatively new herbicide that was introduced to the market in California in 2017. Butte is a granular formulation of benzobicyclon and halosulfuron active ingredients. The benzobicyclon component of Butte is HPPD-inhibitor whereas the halosulfuron component is ALS-inhibitor. Butte provides broad spectrum weed control and offers good crop safety when used according to the label. In 2023, the Butte registrant will market a formulation of benzobicyclon alone allowing more flexibility to farmers since Butte has some crop plant back restrictions because of the halosulfuron component that limited plant back of some crops. The objective of this study is to compare the efficacy of Cliffhanger with Butte and also to optimize the efficacy of Cliffhanger.

The study was planted on May 23, 2022. Cliffhanger was applied in liquid formulation and in combination with pyraclonil (Zembu), Cerano, RebelEX Granite, Grandstand, Regiment, and SuperWham. Nontreated control was included for comparison. Butte was applied at 0.5-1 rice leaf stage and Cliffhanger was applied at 0.5-1 or 3.5 to 4 rice leaf stage (Table 2). Cliffhanger applied alone had minimal crop injury, similar to Butte when applied alone. Plants recovered from injury and appeared normal 30 days after planting. There was an increase in watergrass control, approximately 80%, when Cliffhanger was applied alone compared to Butte alone, 66%, at both 40 and 60 days after treatment. Cerano followed by Cliffhanger as well as Cliffhanger followed by Regiment CA or SuperWham had greater than 90% control of watergrasses at both 40 and 60 days after treatment. Redstem control was poor with both Butte and Cliffhanger, however, the combination of Zembu, Regiment, SuperWham and Grandstand with Cliffhanger significantly increased redstem control. Sprangletop, ducksalad, ricefield bulrush and small flower control were near perfect with both Butte and Cliffhanger (Table 2). This study showed that Cliffhanger is safe on rice and slightly more efficacious than Butte.

b. Optimizing Loyant-based herbicide programs to control smallflower umbrellasedge

Loyant (florpyrauxifen-benzyl) is a new aryl picolinate herbicide developed by Corteva. Loyant is a synthetic auxin herbicide, the same mode of action of triclopyr herbicides that have been used on rice for more than 20 years; however, Loyant is a new structural class of synthetic auxin herbicides. Loyant will be used as postemergence herbicide in rice. It has broad window of application timing that range from 2-rice leaf-stage to 60 days before harvest. It is more effective, however, when it uses on small weeds when it is not covered by water. Loyant can be used in both dry direct-seeded and water-seeded.

Generally, Loyant has a broad-spectrum weed control activity. In rice, it controls selected grasses sedges, and broadleaf weed species. Our research showed while Loyant provide good control of barnyardgrass (*Echinochloa crus-galli*), it is less effective on other *Echinochloa* species. Loyant, however, provide good sedges and broadleaf weed control. Loyant usage rate may dependent upon the target weed species and geography.

A field study was conducted in the growing season of 2022 (This is a repeat of 2021 study), at California Rice Experiment Station in Biggs, CA to study the Efficacy of t 1.33 pt/acre Loyant to control of smallflower sedge when applied at full emergence, 4-, 6-, 8-, and 10-inch-tall weed stages.

This study has shown significant information in developing stewardship plans to use Loyant, recently registered rice herbicide in California. The treatments are listed in Table 3. Pre-germinated M-209 rice variety was planted at 160 lb/A rate by airplane on May 26, 2022, at California Rice Experiment Station in Biggs, CA. Clomazone at 12 lb/A was applied to all plots to control Echinochloa species on the day of seeding. Loyant at 1.33 pt/A were applied on June 7, June 13, June 15, June 17, and June 20, 2022, at full emergence (1 leaf), 4, 6, 8, and 10 inches weed stages, respectively. Water in the plots were pumped out to no standing water on the soil surface the day prior to application, and plots were reflooded to 4-inches 48 hours after application. A backpacked, CO2-pressurized six nozzle spray boom with XR8003VS(AI) nozzles at 30 PSI pressure delivers 20 GPA were used. Additionally, methylated seed oil at 0.5 pt/A was added to all treatments. The studies were conducted as randomized complete block design with four replicates. All plots were evaluated for weed control and crop injury ratings at 7, 14, 21, 28, and 42 days after treatments. Weeds were counted at 28 DAT within two randomly selected areas in each plot, and plots were harvested at the end of the season.

Table 2. Weed control as affected by Butte and Cliffhanger herbicide treatments applied on rice in 2022 at the Rice Experiment station In Biggs, California.

			CROP INJURY (%)								WEED CONTROL (%)											
			20 DAT				40 DAT				40 DAT						60 DAT					
HERBICIDE PROGRAM	RATE/ACRE	TIMING	BLEACHING	CHLOROSIS	STUNTING	STAND REDUCTION	BLEACHING	CHLOROSIS	STUNTING	STAND REDUCTION	WATERGRASSES	SPRANGLETOP	RICEFIELD BULRUSH	SMALLFLOWER	DUCKSALAD	REDSTEM	WATERGRASSES	SPRANGLETOP	RICEFIELD BULRUSH	SMALLFLOWER	DUCKSALAD	REDSTEM
Butte	9 lb	0.5-1 LSR	0	0	5	7	0	0	0	0	66	98	100	100	100	37	66	96	100	100	98	32
Cliffhanger + MSO	10.3 floz + 1% v/v	0.5-1 LSR	0	0	5	5	0	0	0	0	83	100	100	100	100	27	80	100	100	100	92	40
Zembu	14.9 lb	DOS	0	0	15	42	0	0	10	40	100	100	100	100	100	100	100	100	100	100	100	100
Cliffhanger + MSO	10.3 floz + 1% v/v	3.5-4 LSR																				
Cerano	10 lb	DOS	0	0	3	5	0	0	0	0	94	99	100	100	100	72	93	100	100	100	97	85
Cliffhanger + MSO	10.3 floz + 1% v/v	3.5-4 LSR																				
Cliffhanger + Granite SC + MSO	10.3 floz 2.5 floz + 1% v/v	3.5-4 LSR	0	0	5	5	0	0	0	0	66	100	100	100	93	23	60	100	100	100	97	28
Cliffhanger + MSO	10.3 floz + 1% v/v	0.5-1 LSR	0	0	5	5	0	0	0	0	88	100	100	100	100	80	85	100	100	100	98	88
Regiment CA + Grandstand CA + Dyne-Amic	0.8 oz 0.5 pt + 5 floz	Mid-Tiller																				
Cliffhanger + MSO	10.3 floz + 1% v/v	0.5-1 LSR	0	0	3	3	0	0	0	0	84	71	93	80	80	67	79	66	96	66	91	82
RebelEX CA + MSO	20 floz + 1.25 %v/v	Mid-Tiller																				
Cliffhanger + MSO	10.3 floz + 1% v/v	0.5-1 LSR	0	0	5	5	0	0	0	0	94	99	100	100	100	93	90	100	100	100	93	92
Regiment CA + Dyne-Amic	0.8 oz + 5 floz	Mid-Tiller																				
SuperWham! + COC	4 qt + 2.5 % v/v	Full-Tiller																				
Cliffhanger + MSO	10.3 floz + 1% v/v	0.5-1 LSR	0	0	20	5	0	0	0	0	91	99	100	100	100	90	91	100	100	100	98	94
SuperWham! + Grandstand CA + COC	4 qt 0.5 pt + 2.5 % v/v	Full-Tiller																				
Untreated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Untreated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The greatest rice chlorosis and necrosis were 18% and 10% at 7 DAT at 1-leaf smallflower umbrellasedge stage treatment (Table 4). At 14 DAT, there were minor phytotoxicity and chlorosis on

rice plants. Rice gradually recovered from injury and appeared normal at 21 DAT. Due to the Cerano applications, watergrass species were almost not present at the treated plots. Hence, the data was not applicable for them. Loyant at 6-inches tall application was the most effective treatment for smallflower umbrella sedge control at 42 DAT with 90% control. All treatments achieved 100% control of ducksalad at 42 DAT (Table 5-8). This study suggest that Loyant is safe and effective to be used late in the growing season up to 6 to 10-inches tall smallflower umbrellasedge.

Table 3. Herbicide Treatments.

Treat. No	Treatment Description	Rate	Rate Unit	Alt Rate	Alt Unit	Appl. Method	Appl. Timing
1	Cerano	672	g ai/ha	12	lb/A	POST	DOS
	Loyant	40	g ai/ha	1.33	pt/A	POST	1 leaf
	MSO			0.5	pt/A	POST	1 leaf
2	Cerano	672	g ai/ha	12	lb/A	POST	DOS
	Loyant	40	g ai/ha	1.33	pt/A	POST	4” SMF
	MSO			0.5	pt/A	POST	4” SMF
3	Cerano	672	g ai/ha	12	lb/A	POST	DOS
	Loyant	40	g ai/ha	1.33	pt/A	POST	6” SMF
	MSO			0.5	pt/A	POST	6” SMF
4	Cerano	672	g ai/ha	12	lb/A	POST	DOS
	Loyant	40	g ai/ha	1.33	pt/A	POST	8” SMF
	MSO			0.5	pt/A	POST	8” SMF
5	Cerano	672	g ai/ha	12	lb/A	POST	DOS
	Loyant	40	g ai/ha	1.33	pt/A	POST	10” SMF
	MSO			0.5	pt/A	POST	10” SMF
UTC	clomazone	672	g ai/ha	12	lb/A	POST	DOS

Table 4. Rice response of different application timing of Loyant applied at 0, 7, 14, 21, 28, and 42 days after each application.

TRT	PHY						CHL						NEC					
D	7		14		21		7		14		21		7		14		21	
1	18	A	4	a	0	a	10	a	5	a	0	a	5	Ab	4	a	0	A
2	15	A	5	a	0	a	8	a	5	a	0	a	5	Ab	2	a	0	A
3	12	A	4	a	0	a	6	a	0	a	0	a	0	B	0	a	0	A
4	10	A	0	a	0	a	4	a	0	a	0	a	0	B	0	a	0	A
5	10	A	0	a	0	a	0	a	0	a	0	a	0	B	0	a	0	A
U	0	B	0	a	0	a	0	b	0	a	0	a	0	B	0	a	0	A

Abbreviations: TRT, Treatments; D, days after treatment; UTC, untreated control; PHY, general phytotoxicity; CHL, chlorosis; NEC, necrosis. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 5. Weed control data of different Loyant application timings at 14 DAT.

Treatments	SMF	DKS	RDS
1	70a	100a	100a
2	68a	100a	100a
3	65a	100a	100a
4	70a	100a	100a
5	65a	100a	100a
UTC	0b	0b	0b

Abbreviations: UTC, untreated control; SMF, smallflower umbrellasedge; DKS, ducksalad; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 6. Weed control data of different Loyant application timings at 21 DAT.

Treatments	SMF	DKS	RDS
1	85a	100a	100a
2	75a	100a	100a
3	80a	100a	100a
4	80a	100a	100a
5	75a	100a	100a
UTC	0b	0b	0b

Abbreviations: UTC, untreated control; SMF, smallflower umbrellasedge; DKS, ducksalad; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 7. Weed control data of different Loyant application timings at 28 DAT.

Treatments	SMF	DKS	RDS
1	90a	100a	100a
2	80a	100a	100a
3	90a	100a	100a
4	85a	100a	100a
5	80a	100a	100a
UTC	0b	0b	0b

Abbreviations: UTC, untreated control; SMF, smallflower umbrellasedge; DKS, ducksalad; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 8. Weed control data of different Loyant application timings at 42 DAT.

Treatments	SMF	DKS	RDS
1	70a	100a	100a
2	75a	100a	100a
3	90b	100a	100a
4	78a	100a	100a
5	75a	100a	100a
UTC	0c	0b	0b

Abbreviations: UTC, untreated control; SMF, smallflower umbrellasedge; DKS, ducksalad; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

All treatment of Loyant gave similar yields with lower yield in treatment 3. In addition, the yields of all Loyant treatment two times higher than the yield in untreated control (table below)

Treatments	lb/acre
1	6,224
2	6,288
3	5,349
4	6,072
5	6,155
Untreated Control	3,512

b. Effects of Loyant on rice panicles development under California water seeded rice system.

A field study was conducted in 2022 at California Rice Experiment Station in Biggs, CA to determine the effects of Loyant on rice and weed control when applied after rice panicle initiation (Table 9). This study has shown significant information in developing stewardship plans to use Loyant. We were particularly interest to see if late applications of Loyant can cause seed blanking. In this study, pre-germinated M-209 rice variety was planted at 160 lb/A rate on May 26, 2022, at CA Rice Experiment Station. Clomazone at 12 lb/A was applied at the day of seeding and follow-up with RebelEx (cyhalofop-butyl + penoxsulam) at 20 fl oz/A at 40 days after seeding. Loyant at 1.33 and 2.66 pt/A, and 2,4-D choline salt at 2.5 pt/A were applied on July 19, 2022, after rice panicle initiation. Finally, two additional Loyant treatments at 60 days pre-harvest (PHI) were applied as 1.33 and 2.66 pt/A. Plots were pumped out to no standing water on the soil surface the day prior to applications and were reflooded to 4-inches 48 hours after applications.

To evaluate rice tolerance after panicle initiation, rice percent injury was determined at 0, 7, 14, 21, 28, 35, and 42 days after applications. The study was conducted as randomized complete block design

with four replicates. All plots were also evaluated for weed control and crop injury at 7, 14, 21, 28, and 42 days after treatments. Loyant at 2.66 pt/A was the most effective treatment to control weeds (Table 10-14). The results showed that treatments did not cause injury on rice, including Loyant at 2.66 pt/A Table 15. The study also showed that all treatments did not cause visual injury on rice including 2.66 pt/A rate. There was no significant difference between treatments in grain blanking, seeds per panicles, and 1000 grain weight (Table 16)

Table 9. Herbicide Treatments.

Treat. No	Treatment Description	Rate	Rate Unit	Alt Rate	Alt Unit	Appl. Method	Appl. Timing
1	clomazone	672	g ai/ha	12	lb/a	PRE	DOS
	cyhalofop-butyl penoxsulam	313 44	g ai/ha g ai/ha	20	fl oz/a	POST	4 LF RICE
	Loyant MSO	39	g ai/ha	1.33 0.5	pt/a	POST	50-60 DAP
2	clomazone	672	g ai/ha	12	lb/a	PRE	DOS
	cyhalofop-butyl penoxsulam	313 44	g ai/ha g ai/ha	20	fl oz/a	POST	4 LF RICE
	Loyant MSO	78	g ai/ha	2.66 0.5	pt/a	POST	50-60 DAP
3	clomazone	672	g ai/ha	12	lb/a	PRE	DOS
	cyhalofop-butyl penoxsulam	313 44	g ai/ha g ai/ha	20	fl oz/a	POST	4 LF RICE
	2,4-D choline salt MSO	1330	g ae/ha	2.5 0.5	pt/a	POST	50-60 DAP
4	clomazone	672	g ai/ha	12	lb/a	PRE	DOS
	cyhalofop-butyl penoxsulam	313 44	g ai/ha g ai/ha	20	fl oz/a	POST	4 LF RICE
	Loyant MSO	39	g ai/ha	1.33 0.5	pt/a	POST	60 D PHI
5	clomazone	672	g ai/ha	12	lb/a	PRE	DOS
	cyhalofop-butyl penoxsulam	313 44	g ai/ha g ai/ha	20	fl oz/a	POST	4 LF RICE
	Loyant MSO	78	g ai/ha	2.66 0.5	pt/a	POST	60 D PHI
UTC	untreated control	-	-	-	-	-	-

Replications: 4, Design: Randomized Complete Block (RCB), Treatment units: Treated Plot, Experimental unit size Width: 10 feet, Length: 20 feet.

Table 10. Weed control data of different rates of Loyant at 7 DAT.

Treatments	WTG		SMF		RDS	
1	98	A	50	a	98	A
2	98	A	45	a	98	A
3	98	A	48	a	99	A
4	99	A	56	a	100	A
5	98	A	65	a	100	A
Untreated Control	0	B	0	b	0	B

Abbreviations: WTG, watergrass; SMF, smallflower umbrellasedge; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 11. Weed control data of different rates of Loyant at 14 DAT.

Treatments	WTG		SMF		RDS	
1	99	a	55	a	100	A
2	99	a	63	a	100	A
3	99	a	65	a	100	A
4	99	a	75	a	100	A
5	99	a	80	a	100	A
Untreated Control	0	b	0	b	0	B

Abbreviations: WTG, watergrass; SMF, smallflower umbrellasedge; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 12. Weed control data of different rates of Loyant at 21 DAT.

Treatments	WTG		SMF		RDS	
1	99	a	70	a	100	A
2	99	a	86	a	100	A
3	99	a	70	a	100	A
4	99	a	93	a	100	A
5	99	a	96	a	100	A
Untreated Control	0	b	0	b	0	B

Abbreviations: WTG, watergrass; SMF, smallflower umbrellasedge; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 13. Weed control data of different rates of Loyant at 28 DAT.

Treatments	WTG		SMF		RDS	
1	99	a	86	a	100	A
2	99	a	96	a	100	A
3	99	a	88	a	100	A
4	99	a	95	a	100	A
5	99	a	96	a	100	A
Untreated Control	0	c	0	b	0	B

Abbreviations: WTG, watergrass; SMF, smallflower umbrellasedge; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 14. Weed control data of different rates of Loyant at 42 DAT.

Treatments	WTG		SMF		RDS	
1	99	a	95	a	100	A
2	99	a	97	a	100	A
3	99	a	90	a	100	A
4	99	a	95	a	100	A
5	99	a	99	a	100	A
Untreated Control	0	c	0	b	0	B

Abbreviations: WTG, watergrass; SMF, smallflower umbrellasedge; RDS, redstem. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 15. Rice response of Loyant herbicide applied at at 1.33 and 2.66 pt/A at 7, 14, and 21 DAT.

TRT	PHY						CHL						NEC						STN					
D	7		14		21		7		14		21		7		14		21		7		14		21	
1	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	A
2	2	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	A
3	4	a	0	a	0	a	1	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	A
4	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	A
5	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	a	0	A
U	0	a	0	a	0	a	0	a	0	a	0	b	0	a	0	a	0	a	0	a	0	a	0	A

Abbreviations: D, days after treatments; U, untreated control; PHY, phytotoxicity; CHL, chlorosis; NEC, necrosis; STN, stunting. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 16. Grain blanking, number of rice seeds per panicle, and 1000 grain weight of different rates of Loyant at harvest time.

Treatments	Grain Blanking (%)	Seeds per Panicle (#)	1000 grain weight (g)
1	9 a	86 a	37.7 A
2	11 a	83 a	36.2 A
3	14 a	80 a	35.9 A
4	25 a	84 a	42.1 A
5	34 a	80 a	37.6 A
Untreated Control	14 a	82 a	42.4 A

Weight is adjusted at 14% moisture. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Yield rice was reduced only when Loyant applied 60 Days before harvest for both 1x and 2x rated. We will further investigate this observation to help registrant refine their label.

Treatments	Rice yield (lb/A)
1	7,770
2	7,061
3	7,357
4	5,849
5	5,105
Untreated Control	3,487

c. Cattail (*Typha* spp.) control with Loyant in drill-seeded California rice

The overall objective of this study is to determine the effects of Loyant on common cattail, *Typha* L. Cattail is emerging weed problem in the Delta rice region production. The study was conducted in Sacramento-San Joaquin Delta region of California/McDonald island. Loyant was applied at 1.33 and 2.66 pt/A; triclopyr at 1 pt/A; and Loyant at 1.33 plus triclopyr at 1 pt/A were applied on July 8, 2022, at full-tiller M206 rice growing stage (Table 17). Herbicides were applied on 80x80 inch plots to a range of cattails from two- to three leaf stages up to six feet tall growth stages. Visual weed cattail control and rice injury were rated at 7, 14, 21, 28, 35, and 42 days after treatments using a scale where 0 means no injury and 100 means plant kill. The results showed that all rates of Loyant including the

highest rate of Loyant at 2.66 pt/A did not cause injury on rice (Table 18). All Loyant treatments (treatments 1, 3, and 4) achieved 100% cattails control up to three feet tall growth stages. However, cattails control for three to six feet tall plants were s 96, 0, 85, and 100% for treatments 1, 2, 3, and 4, respectively (Table 19). The 2022 study showed that cattail can be control with Loyant, however, the study will be repeated in 2023 to confirm our findings allowing the registrant to add this weed to the label.

Table 17. Herbicide Treatments.

Treat. No	Treatment Description	Rate	Rate Unit	Alt Rate	Alt Unit	Appl. Method	Appl. Timing
1	Loyant MSO	39	g ai/ha	1.33 0.5	pt/a	POST	Full-Tiller
2	triclopyr MSO	420	g ae/ha	1 0.5	pt/a	POST	Full-Tiller
3	Loyant triclopyr MSO	39 420	g ai/ha g ae/ha	1.33 1 0.5	pt/a	POST	Full-Tiller
4	Loyant MSO	78	g ai/ha	2.66 0.5	pt/a	POST	Full-Tiller
UTC	untreated control	-	-	-	-	-	-

Replications: 4, Design: Randomized Complete Block (RCB), Treatment units: Treated Plot, Experimental unit size Width: 80 inches, Length: 80 inches.

Table 18. Rice injury at 7, 14, and 21 days after Loyant treatment.

TRT	PHY			CHL			NEC			STN		
D	7	14	21	7	14	21	7	14	21	7	14	21
1	1 a	2 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 A
2	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 A
3	1 a	1 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 A
4	1 a	3 a	3 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 A
U	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 A

Abbreviations: D, days after treatments; U, untreated control; PHY, phytotoxicity; CHL, chlorosis; NEC, necrosis; STN, stunting. The same lowercase letters within a column indicate means are not statistically different at α=0.05.

Table 19. Loyant cattails control at 7, 14, 21, 28, and 42 days after treatment.

Treatments	7	14	21	28	42
1	0 a	6 a	35 a	75 a	96 A
2	0 a	0 b	0 b	0 b	1 B
3	0 a	17 a	45 a	78 a	85 A
4	0 a	30 a	75 a	96 a	100 A
Untreated Control	0 a	0 b	0 b	0 b	0 B

The same lowercase letters within a column indicate means are not statistically different at α=0.05.

d. Efficacy of single and sequential applications of SuperWham on rice

This objective of this study is to evaluated single and sequential application SuperWham herbicide applied at different timing. Rice was planted on May 23, 2022. All treatment received 8 lb/A Cerano treatment at day of seeding. SuperWham was applied at 3 qt/A at 1-3 rice leaf stage (LS), 6 qt/A at 4 LS, and sequential treatments at 4 qt/A at 4-5 and 6 LS. All SuperWham treatments included NIS at 1%. Crop injury was minimal for any given application timing. All application timings had 90% or more control over grass-weeds (Table 20). The 1-3 leaf stage application timing had lowest control over sedges, ricefield bulrush and smallflower, as well as ducksalad at 40 days after treatment. The application of SuperWham at 6qt/A at 4 leaf stage had the highest control of all weeds at 40 days after treatment, however, at 60 days after treatment, sequential application of SuperWham give the greatest weed control (Table 20).

Table 20. Weed control and rice injury as affected by different SuperWham application.

			CROP INJURY (%)								WEED CONTROL (%)											
			20 DAT				40 DAT				40 DAT						60 DAT					
HERBICIDE PROGRAM	RATE/ACRE	GRASS TIMING	BLEACHING	CHLOROSIS	STUNTING	STAND REDUCTION	BLEACHING	CHLOROSIS	STUNTING	STAND REDUCTION	WATERGRASSES	SPRANGLETOP	RICEFIELD BULRUSH	SMALLFLOWER	DUCKSALAD	REDSTEM	WATERGRASSES	SPRANGLETOP	RICEFIELD BULRUSH	SMALLFLOWER	DUCKSALAD	REDSTEM
Cerano	8 lb	DOS	3	2	7	17	0	7	15	3	97	97	82	67	63	100	100	94	100	55	77	100
SuperWham! + NIS	3 qt + 1% v/v	1-3 LS																				
Cerano	8 lb	DOS	12	2	5	5	0	0	2	0	98	95	93	75	75	85	98	95	82	85	72	100
SuperWham! + NIS	6 qt + 1% v/v	4 LS																				
Cerano	8 lb	DOS	10	0	17	18	0	0	5	0	100	98	99	93	82	73	100	97	90	93	80	100
SuperWham! + NIS	4 qt + 1% v/v	4-5 LS																				
SuperWham! + NIS	4 qt + 1% v/v	6 LS																				
Cerano	8 lb	DOS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Rice yields as affected with SuperWham applications

Treatments	Rate	Timing	Yield (lbs/ac)
Cerano	8 lbs./ac	DOS	3291.92[b]
Cerano SuperWham CA! + NIS	8 lbs./ac 3 qt./ac + 1% v/v	DOS 1-3 LS Grasses	5,782[a]
Cerano SuperWham CA! + NIS	8 lbs./ac 6 qt./ac + 1% v/v	DOS 4 LS Grasses	5,922[a]
Cerano SuperWham CA! + NIS SuperWham CA! + NIS	8 lbs./ac 4 qt./ac + 1% v/v 4 qt./ac + 1% v/v	DOS 4 LS Grasses 6 LS Grasses	6,049[a]

Objective 2. Conduct intensive research to evaluate new herbicides that address critical weed control needs in California rice cropping systems to ensure that they are efficacious compatible, and useful for California rice production.

Pyraclonil (Zembu), a PPO-inhibitor, is a granular formulation currently under development for weed control in CA rice by Nichino America, Inc. PPO-inhibitors are important for weed control in rice because no confirm weed resistance to this mode of action has been reported in California rice fields. In addition, Zembu provide good control for broadleaf weeds and grasses. Previous studies demonstrated that Zembu would be best used as part of a comprehensive weed control program. Zembu is less effective on sprangletop, smallflower sedge and ricefield bulrush. This year, we have conducted several studies to evaluate Zembu applied in a program, coformulation of Zembu with Cerano and Strada.

a. Weed control and rice safety with pyraclonil (Zembu)

In 2022 growing season, a field study examined Zembu (a granular formulation of 1.8% pyraclonil) at rate 14.9 lbs/A applied day of seeding (DOS) in conjunction with later application propanil, Butte, Cerano, thiobencarb, Regiment, Granite, and Clincher, all applied according to label (Table 22). Weed control and crop phytotoxicity were recorded throughout the growing season.

Rice injury with Zembu was more and persist longer than what we have observed in prior years. Rice stunting, chlorosis and stand reduction by Zembu were 7, 18, and 13%, respectively, at 40 days after planting. Watergrass, sprangletop, ducksalad, smallflower, and redstem control was excellent with Zembu. The herbicide programs of Zembu followed by Butte plus SuperWham: and Zembu followed by Bolero UltraMax followed by SuperWham showed exceptional control of all weeds present in the field at 40 DAS (100% control) (Table 21). The program consisting of Zembu followed by propanil was similarly effective in controlling all weeds except ricefield bulrush. Results from these studies are promising in terms of weed control and rice response. Integration of a new mode of action into herbicide programs provides an additional mechanism in California water-seeded rice weed control.

Table 21. Rice injury and weed control as affected by Zembu (pyraclonil) herbicide applied on rice in 2022 at the rice experiment station at Biggs, California.

			CROP INJURY (%)								WEED CONTROL (%)											
			20 DAT				40 DAT				20 DAT						40 DAT					
HERBICIDE PROGRAM	RATE/ACRE	TIMING	BLEACHING	CHLOROSIS	STUNTING	STAND REDUCTION	BLEACHING	CHLOROSIS	STUNTING	STAND REDUCTION	WATERGRASSES	SPRANGLETOP	RICEFIELD BULRUSH	SMALLFLOWER	DUCKSALAD	REDSTEM	WATERGRASSES	SPRANGLETOP	RICEFIELD BULRUSH	SMALLFLOWER	DUCKSALAD	REDSTEM
Zembu	14.9 lb	DOS	3	7	22	27	0	7	18	13	97	100	100	100	100	100	96	100	71	100	100	100
Zembu	14.9 lb	DOS	0	0	12	10	0	3	17	5	97	100	100	100	100	100	96	100	94	100	100	100
SuperWham! + COC	6 qt + 2.5% v/v	Mid-Tiller																				
Zembu	14.9 lb	DOS	3	13	40	32	0	5	17	12	95	100	100	100	100	100	95	100	93	100	100	100
Butte	7.5 lb	1.5 LSR																				
SuperWham! + COC	6 qt + 2.5% v/v	Mid-Tiller																				
Zembu	14.9 lb	DOS	5	0	20	17	0	5	18	17	98	100	100	100	100	100	97	90	100	100	100	100
Bolero UltraMax	23.3 lb	1.5 LSR																				
SuperWham! + COC	6 qt + 2.5% v/v	Mid-Tiller																				
Untreated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Rice yield as affected by Zembu treatments

Treatments	Rate	Timing	Yield (lbs/ac)
Zembu	14.9 lbs./ac	DOS	7,527[a]
Zembu SuperWham CA! + COC	14.9 lbs./ac 6 qt./ac + 2.5% v/v	DOS Mid-Tiller	8,138[a]
Zembu Butte SuperWham CA! + COC	14.9 lbs./ac 7.5 lbs./ac 6 qt./ac + 2.5% v/v	DOS 1.5 LSR Mid-Tiller	8,592
Zembu Cerano SuperWham CA! + COC	14.9 lbs./ac 6 lbs./ac 6 qt./ac + 2.5% v/v	DOS DOS Mid-Tiller	8,352[a]
Zembu Bolero UltraMax SuperWham CA! + COC	14.9 lbs./ac 23.3 lbs./ac 6 qt./ac + 2.5% v/v	DOS 1.5 LSR Mid-Tiller	6,840[a]
Zembu Regiment CA + Dyne-Amic SuperWham CA! + COC	14.9 lbs./ac 8 oz./ac + 5floz./ac 6 qt./ac + 2.5% v/v	DOS Early-Tiller Mid-Tiller	7,495[a]
Zembu Granite GR SuperWham CA! + COC	14.9 lbs./ac 15 lbs./ac 6 qt./ac + 2.5% v/v	DOS 3 LSR Mid-Tiller	7,596[a]
Zembu Loyant + MSO SuperWham CA! + COC	14.9 lbs./ac 21.9 floz/ac + 0.5 pt./ac 6 qt./ac + 2.5% v/v	DOS Early-Tiller Mid-Tiller	8,141[a]
NAI-1891(3.3% ai) Bolero UltraMax SuperWham CA! + COC	8.1 lbs./ac 23.3 lbs./ac 6 qt./ac + 2.5% v/v	DOS 1.5 LSR Mid-Tiller	7,738[2]
NAI-1891(3.3% ai) Regiment CA + Dyne-Amic SuperWham CA! + COC	8.1 lbs./ac 8 oz./ac + 5floz./ac 6 qt./ac + 2.5% v/v	DOS Early-Tiller Mid-Tiller	9,078[a]
Untreated Control (#2)	-	-	3,054[b]

b. Efficacy of Zembu plus Strada combination

This study was conducted to determine whether Strada CA (Orthosulfamuron) provided any additional control of bulrush and sprangletop in plots treated with Zembu. Strada was applied either as powder directly into the water at DOS, along with Zembu, or with a pinpoint spray at 1-leaf rice stage. Bulrush control was not increased with the addition of Strada, but sprangletop control was somewhat increased in plots with Strada. There is an increase of almost 10% Sprangletop control when Strada was added to the Zembu treatment. This increase may not be adequate and additional herbicide need to be used to control sprangletop.

c. Weed control with ROXY rice technology

ROXY RPS® was planted into shallow flood waters at 150 lb/A seeding rate on May 26, 2022 at the Rice Experiment Station in Biggs, CA. Herbicide treatments were applied as listed in the table (below). All ALB2023 applications were made to bare ground on the day of seeding with additional herbicides applied at either 3-4 LSR/ 20-25 days after planting (DAP), or 5 LSR or 30-35 days after seeding (DAS). Each treatment listed was replicated only 3 times in randomized complete blocks design due to water limitations from long-term drought conditions. The crop was visually evaluated for chlorosis, bleaching, stunting and stand reduction at 7, 14, and 28 DAS. Weed control was also visually rated at 7, 14, and 28 DAS. Key weed species included watergrass, sprangletop, rice field bulrush, amd smallflower umbrella sedge.

There was severe root and shoot stunting injury observed in all treated plots with exception of treatment 7 at and 14 days. Stunting injury dissipated by 28 DAS for all treatments except treatment 6. There was 20, 75, and 47% stand reduction observed in treatment 5, 6 and 10, respectively, at 28 DAS. Weed control was greater than 85% for all weeds tested at 7 DAS in all treated plots. This increased to 90% or greater at 14 DAS for all treated plots. Control of Echinochloa decreased from 93 to 89% in treatment 2 from 14 to 28 DAS. All other treated plots had 95% control or greater of all weeds tested. The following tables show the average crop injury and weed control ratings for all treatment combinations, organized chronologically. Stunting was 30% or greater for all plots treated with ALB2023 or ALB2024 at 7 DAS. Weed control was 100% for all weeds rated except Echinochloa spp. Echinochloa was noted to have necrotic spotting in many of the treated plots.

Trtmt - Treatment group; **blch** - bleaching; **chlor** - chlorosis; **stnt** - stunting; **stand red.** - stand reduction; **Echi** - *Echinochloa crus-galli* /Watergrass; **SP** - sprangletop (*Leptochloa fascicularis*); **BL** - Bulrush (*Schoenoplectus mucronatus*); **SM** - Smallflower (*Cyperus difformis*); **DS** - Ducksalad (*Heteranthera limosa*); **Mono** - *monochoria*; **WH** - water hyssop (*Bacopa sp.*); **RS** - Redstem (*Ammannia sp.*)

Treatment	Product and Rate	Application timing
1	Untreated control (UTC)	Pre-seeding/ Bare ground
2	ALB 2023 (1.5 pt/A)	Pre-seeding/ Bare ground
3	ALB 2023 (1.75 pt/A)	Pre-seeding/ Bare ground
4	ALB 2023 (2.0 pt/A)	Pre-seeding/ Bare ground
5	ALB 2023 (2.25 pt/A)	Pre-seeding/ Bare ground
6	ALB 2023 (2.0 pt/A)	Pre-seeding/ Bare ground
	Alb 2024 (1.5 pt/A)	3-4 LSR/ 20-25 DAP
	MSO (0.5% v/v)	
7	Butte (7.5 lbs/A)	DOS
	Granite SC (2.5 fl oz/A)	5 LSR/ 30-35DAP
	Grandstand CA (0.5 pt/A)	
	NIS (0.25% v/v)	
8	ALB 2023 (2.0 pt/A)	Pre-seeding/ Bare ground
	Granite SC (2.5 fl oz/A)	5 LSR/ 30-35DAP
	MSO (0.5% v/v)	
9	ALB 2023 (2.0 pt/A)	Pre-seeding/ Bare ground
	Granite SC (2.5 fl oz/A)	5 LSR/ 30-35DAP
	Grandstand CA (0.5 pt/A)	
	NIS (0.25% v/v)	
10	ALB 2023 (2.0 pt/A)	Pre-seeding/ Bare ground
	Granite SC (2.5 fl oz/A)	5 LSR/ 30-35DAP
	Loyant (2.0 pt/A)	
	Clincher (11 fl oz/A)	
	MSO (0.5% v/v)	

DAP - Days after planting; DOS - Day of seeding

7 DAS												
	Crop injury (%)				Weed control (%)							
Trtmt	Blch	chlor	stnt	stand red.	Echi	Sprangle	bulrush	smallflwr	ducksalad	monoch	waterhyss	redstem
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	30	0	95	100	100	100	100	100	100	100
3	0	0	47	0	87	100	100	100	100	100	100	100
4	0	0	60	0	96	100	100	100	100	100	100	100
5	0	0	67	0	98	100	100	100	100	100	100	100
6	0	0	75	0	99	100	100	100	100	100	100	100
7	0	0	7	0	97	100	100	100	100	100	100	100
8	0	0	68	0	94	100	100	100	100	100	100	100
9	0	0	53	0	97	100	100	100	100	100	100	100
10	0	0	75	0	100	100	100	100	100	100	100	100

Stunting remained severe at 14 DAS. It was noted that most ROXY RPS® rice was still in early stages of development and had not yet rooted to the soil. Any plot rated with 50% or more stunting injury had not yet emerged through the water surface. Untreated plants were as tall above the water surface as below at this point in time. Weed control remained at 90% or greater for all weed rated. Necrotic spotting was again observed on Echinochloa spp. plants as well as observed bulrush.

14 DAS												
	Crop injury (%)				Weed control (%)							
Trtmt	Blch	chlor	stnt	stand red.	Echi	Sprangle	bulrush	smallflwr	ducksalad	monoch	waterhyss	redstem
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	33	0	93	100	99	100	100	100	100	100
3	0	0	50	0	90	100	100	100	100	100	100	100
4	0	0	50	0	98	100	100	100	100	100	100	100
5	0	0	62	0	100	100	99	100	100	100	100	100
6	0	0	70	0	99	100	100	100	100	100	100	100
7	0	0	3	0	98	100	100	100	100	100	100	100
8	0	0	82	0	97	100	100	100	100	100	100	100
9	0	0	63	0	97	100	100	100	100	100	100	100
10	0	0	82	0	98	100	100	100	100	100	100	100

Stand reduction was greatly reduced between 14 and 28 DAS for all treated plots except treatment 6. Slight necrotic spotting (<10%) on leaf tips was observed on ROXY RPS® rice in plots treated with both ALB 2023 and ALB 2024 (treatment 6). Weed control was 97% or greater for all weeds with the exception of Echinochloa spp. treated with low rates of ALB2023 (treatment 2).

28 DAS												
	Crop injury (%)				Weed control (%)							
Trtmt	Blch	chlor	stnt	stand red.	Echi	Sprangle	bulrush	smallflwr	ducksalad	monoch	waterhyss	redstem
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	89	100	100	100	98	97	98	100
3	0	0	0	0	98	100	100	100	97	97	97	100
4	0	0	0	2	99	100	100	100	100	100	100	100
5	0	0	0	20	100	100	100	100	100	100	100	100
6	0	0	20	75	100	100	100	100	100	100	100	100
7	0	0	0	0	100	100	100	100	100	100	100	100
8	0	0	0	12	100	100	100	100	100	100	100	100
9	0	0	0	3	98	100	100	100	100	100	100	100
10	0	0	0	47	100	100	100	100	100	100	100	100

Final yield was lowest in the untreated control plots (treatment 1), and highest in treatments with ALB2023 applied at 1.75 pts/acre (treatments 3), ALB 2023 applied at 2.25 pts/acre (treatment 5), and treatments with ALB 2023 applied at 2 pts/acre in combination with Granite SC and other herbicides (treatments 8, 9, 10). Final yields for these treatments including ALB2023 were similar to a standard herbicide program of Butte, Granite SC, and Grandstand CA (treatment 7).

Yield	
Trtmt	**lbs/acre**
1 (control)	5,784
2	6,873
3	8,035
4	7,138
5	8,327
6	7,386
7	8,399
8	7,975
9	8,842
10	7,905

Weed control and rice injury with TVE29 grass control herbicide.

FMC new grass control herbicides is a new herbicide with new mode of action. It is a grass control herbicide that inhibits dihydro-orotate dehydrogenase enzyme (DHODH) that is critical for pyrimidine synthesis. No herbicide with this mode of action is commercialize on any crop worldwide. Our 2022 study showed that this herbicide provided outstanding grass control when applied at both day of seeding or after rice established. This herbicide gave complete control of all grass. In addition, this herbicide caused slight rice stunting but plant quickly recovered from stunting.

d. Determine tolerance of common California commercial rice varieties to TVE-29.

The objective of this study is to evaluate common California commercial rice varieties to tolerance to TVE-29 applied at Day of seeding and early postemergence application. Varieties M-206 (MP1), M-209 (MP2), M-211 (MP3), M-105 (MP4), L-208 (MP5), and CM-203 (MP6) were hand seeded in a field with 3 blocks of 10’x30’ plots separated by levees on May 27, 2022 at the Rice Experiment Station in Biggs, CA. TVE-29 was applied at different rates and timings in combination with a 2.5 leaf stage rice (LSR) application of Shark H20, which was compared to an untreated control (UTC) and a standard herbicide treatment are shown in the table below. The day of seeding (DOS) application was made on May 27, 2022, and the 1-2 LSR application was made on June 7, 2022. TVE29 was applied in a granular formulation to the flooded plots. Rice was visually evaluated for chlorosis, bleaching, stunting, and stand reduction at 7, 14, and 28 days after application (DAA) for both TVE-29 application timings. Weed control results from each treatment were averaged across all replicates.

Treatment #	Product, Rate, and Timing
1	"UTC" - Shark H20 7.5 oz/ac (2.5 LSR)
2	TVE-29 125 g ai/ha (DOS)
	Shark H20 7.5 oz/ac (2.5 LSR)
3	TVE-29 250 g ai/ha (DOS)
	Shark H20 7.5 oz/ac (2.5 LSR)
4	TVE-29 150 g ai/ha (1-2 LSR)
	Shark H20 7.5 oz/ac (2.5 LSR)
5	TVE-29 300 g ai/ha (1-2 LSR)
	Shark H20 7.5 oz/ac (2.5 LSR)
6	Butte 9 lb/ac (1-2 LSR)
	Shark H20 7.5 oz/ac (2.5 LSR)
	SuperWham 4 qt/ac (M-tiller)
	Agridex 0.5 v/v (M-tiller)
	Grandstand 6 qt/ac (M-tiller + 7 days)
	SuperWham 4 qt/ac (M-tiller + 7 days)
	Agridex 0.5 v/v (M-tiller + 7 days)

Overall, very minimal crop injury was recorded across the entire trial, 10% and less total phytotoxicity if present at all. The only injuries observed in the treatments were stunting, necrosis, and stand reduction. The DOS treatments remained mostly free of injury through 28 DAA with the exception of minimal stunting observed at 7 and 14 DAA but did not persist in the final rating. The 1-2 LSR applications experienced mostly necrosis, which was also present in the UTC plots therefore could be due to another factor rather than the TVE-29 application. Of all the plots that experienced stand reduction, although minimal injury was observed, could be due to the plots being hand seeded rather than the TVE-29 application. The tables below show the average crop injury ratings for all treatments:

Seven Days after treatment

Minimal stunting occurred in both DOS treatments, 2 and 3, but not the 1-2 LSR treatments. At both DOS treatment rates, the stunting injury was observed only in MP4. Necrosis was observed in treatments 4, 5, and 6 across all varieties.

treatment	cultivar	bleaching	chlorosis	stunting	necrosis	other
1	MP1	0	0	0	0	0
	MP2	0	0	0	0	0
	MP3	0	0	0	0	0
	MP4	0	0	0	0	0
	MP5	0	0	0	0	0
	MP6	0	0	0	0	0
2	MP1	0	0	0	0	0
	MP2	0	0	0	0	0
	MP3	0	0	0	0	0
	MP4	0	0	3	0	0
	MP5	0	0	0	0	0
	MP6	0	0	0	0	0
3	MP1	0	0	0	0	0
	MP2	0	0	0	0	0
	MP3	0	0	0	0	0
	MP4	0	0	3	0	0
	MP5	0	0	0	0	0
	MP6	0	0	0	0	0
4	MP1	0	0	0	5	0
	MP2	0	0	0	5	0
	MP3	0	0	0	5	0
	MP4	0	0	0	5	0
	MP5	0	0	0	5	0
	MP6	0	0	0	5	0
5	MP1	0	0	0	5	0
	MP2	0	0	0	5	0
	MP3	0	0	0	5	0
	MP4	0	0	0	5	0
	MP5	0	0	0	5	0
	MP6	0	0	0	7	0
6	MP1	0	0	0	7	0
	MP2	0	0	0	5	0
	MP3	0	0	0	5	0
	MP4	0	0	0	5	0
	MP5	0	0	0	5	0
	MP6	0	0	0	5	0

14 days after treatment

Stunting injuries were again only observed in the DOS treated plots but now present in different varieties that were not consistent in both treatments 2 and 3. Necrosis in the 1-2 LSR treated plots and standard herbicide program plots persisted and seemed to slightly increase.

treatment	cultivar	bleaching	chlorosis	stunting	necrosis	other
1	MP1	0	0	0	0	0
	MP2	0	0	0	0	0
	MP3	0	0	0	0	0
	MP4	0	0	0	0	0
	MP5	0	0	0	0	0
	MP6	0	0	0	0	0
2	MP1	0	0	0	0	0
	MP2	0	0	2	0	0
	MP3	0	0	3	0	0
	MP4	0	0	5	0	0
	MP5	0	0	0	0	0
	MP6	0	0	0	0	0
3	MP1	0	0	3	0	0
	MP2	0	0	0	0	0
	MP3	0	0	0	0	0
	MP4	0	0	0	0	0
	MP5	0	0	2	0	2
	MP6	0	0	0	0	0
4	MP1	0	0	0	7	0
	MP2	0	0	0	5	0
	MP3	0	0	0	7	0
	MP4	0	0	0	7	0
	MP5	0	0	0	5	0
	MP6	0	0	0	8	0
5	MP1	0	0	0	8	0
	MP2	0	0	0	5	0
	MP3	0	0	0	8	0
	MP4	0	0	0	7	0
	MP5	0	0	0	7	0
	MP6	0	0	0	10	0
6	MP1	0	0	0	8	0
	MP2	0	0	0	7	0
	MP3	0	0	0	7	0
	MP4	0	0	0	5	0
	MP5	0	0	0	7	0
	MP6	0	0	0	10	0

28 days after treatment

The stunting injury previously observed in the DOS treatments was no longer present but was observed in treatments 4, 5, and 6, consistently in MP1. Across all treatments, minimal necrosis was observed, which was also somewhat present in the UTC plots. Stand reduction was observed in treatments 4, 5, and 6 at similar rates but could be due to hand seeding.

treatment	cultivar	bleaching	chlorosis	stunting	necrosis	other
1	MP1	0	0	0	0	0
	MP2	0	0	0	0	0
	MP3	0	0	0	0	0
	MP4	0	0	0	0	0
	MP5	0	0	0	0	0
	MP6	0	0	0	0	0
2	MP1	0	0	0	5	0
	MP2	0	0	0	5	0
	MP3	0	0	0	5	0
	MP4	0	0	0	5	0
	MP5	0	0	0	5	0
	MP6	0	0	0	5	0
3	MP1	0	0	0	5	0
	MP2	0	0	0	5	0
	MP3	0	0	0	5	0
	MP4	0	0	0	5	0
	MP5	0	0	0	5	0
	MP6	0	0	0	5	0
4	MP1	0	0	2	5	0
	MP2	0	0	0	5	2
	MP3	0	0	0	5	3
	MP4	0	0	0	7	2
	MP5	0	0	0	5	3
	MP6	0	0	0	5	0
5	MP1	0	0	2	5	3
	MP2	0	0	0	5	2
	MP3	0	0	0	5	2
	MP4	0	0	0	5	2
	MP5	0	0	0	7	2
	MP6	0	0	0	5	2
6	MP1	0	0	3	5	3
	MP2	0	0	5	3	5
	MP3	0	0	2	5	3
	MP4	0	0	0	7	2
	MP5	0	0	5	5	5
	MP6	0	0	0	5	3

Rice yield of five rice varieties as affected by TVE29.

Treatment	Cultivar	Yield (lb/ac)
"Untreated Check" + Shark H20 7.5 oz/ac (2.5 LSR)	M-206	6,053
	L-208	6,300
	M-211	7,774
	M-105	6,991
	CM-203	5,553
	M-209	5,099
TVE-29 125 g ai/ha (DOS) Shark H20 7.5 oz/ac (2.5 LSR)	M-206	7,945
	L-208	6,511
	M-211	8,402
	M-105	8,120
	CM-203	6,277
	M-209	9,001
TVE-29 250 g ai/ha (DOS) Shark H20 7.5 oz/ac (2.5 LSR)	M-206	9,558
	L-208	6,980
	M-211	8,661
	M-105	6,466
	CM-203	6,404
	M-209	9,001
TVE-29 150 g ai/ha (1-2 LSR) Shark H20 7.5 oz/ac (2.5 LSR)	M-206	8,489
	L-208	6,873
	M-211	8,128
	M-105	8,080
	CM-203	6,710
	M-209	8,784
TVE-29 300 g ai/ha (1-2 LSR) Shark H20 7.5 oz/ac (2.5 LSR)	M-206	7,995
	L-208	6,204
	M-211	7,587
	M-105	8,398
	CM-203	6,798
	M-209	8,448
Butte 9 lb/ac (1-2 LSR) Shark H20 7.5 oz/ac (2.5 LSR) SuperWham 4 qt/ac (M-til) Agridex 0.5 v/v (M-til) Grandstand 6 qt/ac (M-til + 7 days) SuperWham 4 qt/ac (M-til + 7 days) Agridex 0.5 v/v (M-til + 7 days)	M-206	9,038
	L-208	6,555
	M-211	7,797
	M-105	7,994
	CM-203	7,033
	M-209	9,520

e. Weed Control and Rice Injury as Affected by TVE-29 Herbicide Program

The objective of this study is to evaluate weed control and crop safety when TVE-29 is included in typical California commercial weed control programs. Rice variety M-209 was air seeded over a field on May 23, 2022 at the Rice Experiment Station in Biggs, CA. Herbicide programs with different rates and application timings of TVE-29 are shown in the table below.

Treatment #	**Product, Rate, and Timing**
1	Untreated Check (UTC)
2	TVE-29 8.9 lb/ac (day of seeding (DOS))
	Shark H2O 7.5 oz/ac (2.5 leaf stage rice (LSR))
3	TVE-29 8.9 lb/ac (DOS)
	Butte 7.5 lb/ac (1-2 LSR)
4	TVE-29 8.9 lb/ac (DOS)
	Bolero 23.3 lb/ac (1-2 LSR)
	SuperWham 6 qt/ac (M-til)
	Agridex 0.5 v/v (M-til)
5	TVE-29 8.9 lb/ac (DOS)
	Londax 1.66 oz/ac (1-2 LSR)
	SuperWham 6 qt/ac (M-til)
	Agridex 0.5 v/v (M-til)
6	TVE-29 8.9 lb/ac (DOS)
	Grandstand 6 qt/ac (M-til)
	SuperWham 6 qt/ac (M-til)
	Agridex 0.5 v/v (M-til)
7	TVE-29 13.4 lb/ac (1-2 LSR)
	Shark H2O 7.5 oz/ac (2.5 LSR)
8	TVE-29 13.4 lb/ac (1-2 LSR)
	Butte 7.5 lb/ac (DOS)
9	TVE-29 13.4 lb/ac (1-2 LSR)
	Cerano 6 lb/ac (DOS)
	SuperWham 6 qt/ac (M-til)
	Agridex 0.5 v/v (M-til)
10	Butte 9 lb/ac (1-2 LSR)
	SuperWham 4 qt/ac (M-til)
	Agridex 0.5 v/v (M-til)
	Grandstand 6 qt/ac (M-til+7 days)
	SuperWham 4 qt/ac (M-til+7 days)
	Agridex 0.5 v/v (M-til+7 days)

The DOS application was made one day before seeding, May 22, 2022, and the 1-2 leaf stage rice (LSR) application was made on June 2, 2022. TVE-29 was applied in a granular formulation to the flooded plots at either application timing. Each treatment was replicated 3 times in randomized complete blocks design. The crop was visually evaluated for chlorosis, bleaching, stunting, and other injury at 7, 14, and 28 days after application (DAA) for both TVE-29 application timings. Weed control was visually rated at 7, 14, 28, 42, and 56 DAA. The weed species observed were watergrass, sprangletop, ricefield, smallflower Umbrella, ducksalad, monochoria spp., water hyssop, and redstem.

The 8.9 lb/ac DOS treatments of TVE-29 in combination with Bolero, SuperWham, and Agridex; Londax, SuperWham, and Agridex; and Grandstand, SuperWham, and Agridex had at least 96% or greater control of grasses and sedges and 91% or greater control of broadleaf weeds through 56 days after application. The 13.4 lb/ac 1-2 LSR application of TVE-29 in combination with Cerano, SuperWham, and Agridex had the greatest weed control with 95%, 97%, and 98% control of grasses, sedges, and broadleaves, respectively, through 56 DAA. There was minimal crop injury, 5% or less, of necrotic tips and stunting reported. TVE-29 applied at 8.9 lb/ac on the DOS in combination with Bolero, SuperWham, and Agridex seems to have the most consistent weed control overall. The tables below show the average crop injury and weed control ratings for all treatments:

Legend:

Trtmt – Treatment number; **Echi.** - Watergrass (*Echinochloa spp.*); **ST** - Sprangletop (*Leptochloa fascicularis*), **BR** - Rice Field Bulrush (*Schoenoplectus mucronatus*), **SF** - Smallflower Umbrella Sedge (*Cyperus difformis*); **DS** - Ducksalad (*Heteranthera limosa*); **Mono**. - *Monochoria spp.*; **RS** - Redstem (*Ammannia sp.*); **N/A** – No rating needed

Seven days after treatment

There was only weed growth in treatment one. The only weed present in the UTC plots was *Echinochloa* spp. with 4-6 plants/m2. All other treated plots were clean. UTC and treated plots had minor leaf curling/cupping, which could be from recent wind and heat.

	Crop injury (%)					Weed Control (%)							
Trtmt	bleaching	chlorosis	stunting	necrosis	other	Echi.	ST	BR	SF	DS	Mono.	WH	RS
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	100	100	100	100	100	100	100	100
3	0	0	0	0	0	100	100	100	100	100	100	100	100
4	0	0	0	0	0	100	100	100	100	100	100	100	100
5	0	0	0	0	0	100	100	100	100	100	100	100	100
6	0	0	0	0	0	100	100	100	100	100	100	100	100
7	0	0	0	0	0	88	100	100	100	100	100	100	100
8	0	0	0	0	0	100	100	100	100	100	100	100	100
9	0	0	0	0	0	100	100	100	100	100	100	100	100
10	0	0	0	0	0	85	100	100	100	100	100	100	100

14 days after treatment

Negligible stunting began to show up at the 14 DAA ratings but does not seem to show a pattern linked to TVE29 applications since crop stunting occurred with both TVE-29 application timings and untreated control. Echinochloa spp. started showing up in all plots but at a significantly reduced amount than the UTC plots. There was some ducksalad in most plots but it had not emerged above the water and was very necrotic. All plots seem to have similar weed control at this point.

	Crop injury (%)					Weed Control (%)							
Trtmt	bleaching	chlorosis	stunting	necrosis	other	Echi.	ST	BR	SF	DS	Mono.	WH	RS
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	95	100	100	100	100	100	100	100
3	0	0	5	0	0	95	100	100	100	100	100	100	100
4	0	0	5	0	0	97	100	100	100	100	100	100	100
5	0	0	3	0	0	99	100	100	100	100	100	100	100
6	0	0	5	0	0	100	100	100	100	100	100	100	100
7	0	0	0	0	0	99	100	100	100	47	100	100	100
8	0	0	5	0	0	88	100	100	100	100	100	100	100
9	0	0	5	0	0	95	100	100	100	100	100	100	100
10	0	0	0	0	0	85	100	100	100	100	100	100	100

28 days after treatment

There is still some negligible stunting and necrosis that does not seem to follow any sort of pattern. More weeds had emerged and the UTC plots had 100-125 plants/m2. TVE29 weed control was excellent with all treatments. However, it seemed that the plots with the DOS TVE-29 application had more consistent weed control except for control of sedges in treatments 5, 6, and 9.

	Crop injury (%)					Weed Control (%)							
Trtmt	bleaching	chlorosis	stunting	necrosis	other	Echi.	ST	BR	SF	DS	Mono.	WH	RS
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	100	100	98	99	92	100	98	98
3	0	0	2	0	0	98	100	100	100	99	100	100	96
4	0	0	3	0	0	98	100	99	99	99	100	100	100
5	0	0	3	2	0	99	100	63	99	98	100	95	95
6	0	0	0	0	0	99	100	58	100	78	100	93	92
7	0	0	0	0	0	95	97	96	99	85	100	100	99
8	0	0	2	0	0	99	100	100	100	100	100	99	95
9	0	0	0	0	0	99	100	73	99	60	100	91	98
10	0	0	0	0	0	72	100	100	100	100	100	100	93

42 days after treatment

TVE29 continue to show excellent grass control including barnyardgrass, late water grass, early watergrass, and sprangletop However, weed control with treatments 2 and 7 slightly decreased. There did not seem to be a significant difference between application timing at this point.

	Crop injury (%)					Weed Control (%)							
Trtmt	Bleaching	chlorosis	stunting	necrosis	other	Echi.	ST	BR	SF	DS	Mono.	WH	RS
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	100	96	86	97	95	100	100	98
3	0	0	0	0	0	100	100	100	100	100	100	100	93
4	0	0	0	0	0	100	100	96	100	100	100	100	100
5	0	0	0	0	0	100	99	100	100	100	100	100	100
6	0	0	0	0	0	100	100	100	100	97	100	100	100
7	0	0	0	0	0	100	92	88	90	83	100	97	93
8	0	0	0	0	0	100	100	100	100	100	100	100	92
9	0	0	0	0	0	100	100	100	100	98	100	100	100
10	0	0	0	0	0	100	97	100	100	100	100	100	100

56 days after treatment

All treatments gave near perfect weed control except treatments 2 and 7 were. Redstem control, however, was poor with treatment 8. Again, the remaining weeds had necrotic and chlorotic spots in all treated plots. This research showed that California rice cultivar tested exhibit adequate tolerance to TVE29

	Crop injury (%)					Weed Control (%)							
Trtmt	bleaching	chlorosis	stunting	necrosis	other	Echi.	ST	BR	SF	DS	Mono.	WH	RS
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	N/A	N/A	N/A	N/A	N/A	100	98	88	72	90	100	100	100
3	N/A	N/A	N/A	N/A	N/A	100	100	100	100	100	100	100	82
4	N/A	N/A	N/A	N/A	N/A	100	100	97	100	100	100	100	100
5	N/A	N/A	N/A	N/A	N/A	100	97	99	96	100	100	100	100
6	N/A	N/A	N/A	N/A	N/A	100	99	99	97	100	100	100	100
7	N/A	N/A	N/A	N/A	N/A	100	95	85	78	100	100	100	88
8	N/A	N/A	N/A	N/A	N/A	100	100	100	100	100	100	100	33
9	N/A	N/A	N/A	N/A	N/A	100	100	100	97	100	100	100	100
10	N/A	N/A	N/A	N/A	N/A	98.67	99	100	100	100	100	100	99

Rice yield as affected by TVE29 applied alone or in combination with other herbicides

Treatment	Yield (lb/ac)
Untreated Check	3,292
TVE-29 8.9 lb/ac (day of seeding (DOS))	6,987
Shark H2O 7.5 oz/ac (2.5 leaf stage rice (LSR))	
TVE-29 8.9 lb/ac (DOS)	8,256
Butte 7.5 lb/ac (1-2 LSR)	
TVE-29 8.9 lb/ac (DOS)	8,528
Bolero 23.3 lb/ac (1-2 LSR)	
SuperWham 6 qt/ac (M-til)	
Agridex 0.5 v/v (M-til)	
TVE-29 8.9 lb/ac (DOS)	7,639
Londax 1.66 oz/ac (1-2 LSR)	
SuperWham 6 qt/ac (M-til)	
Agridex 0.5 v/v (M-til)	
TVE-29 8.9 lb/ac (DOS)	7,058
Grandstand 6 qt/ac (M-til)	
SuperWham 6 qt/ac (M-til)	
Agridex 0.5 v/v (M-til)	
TVE-29 13.4 lb/ac (1-2 LSR)	7,099
Shark H2O 7.5 oz/ac (2.5 LSR)	
TVE-29 13.4 lb/ac (1-2 LSR)	7,640
Butte 7.5 lb/ac (DOS)	
TVE-29 13.4 lb/ac (1-2 LSR)	6,911
Cerano 6 lb/ac (DOS)	
SuperWham 6 qt/ac (M-til)	
Agridex 0.5 v/v (M-til)	
Butte 9 lb/ac (1-2 LSR)	8,141
SuperWham 4 qt/ac (M-til)	
Agridex 0.5 v/v (M-til)	
Grandstand 6 qt/ac (M-til+7 days)	
SuperWham 4 qt/ac (M-til+7 days)	
Agridex 0.5 v/v (M-til+7 days)	

g. Effect of TVE29 Simulated Drift Rates on Peached, Prunes, Almond, Walnut, Pistachio and Grapes.

The overall objective of this study is to determine the effects of simulated drift rates of a new novel rice herbicide tetflupyrolimet (TVE29) on tree and vine crop sensitivity. Simulated TVE29 drift treatments were applied to three-years old almond, walnut, pistachio, peach, and prune trees as well as to an established wine grape. In this research, two locations were used for simulated herbicide drift experiments. They were an orchard with almond, peach, prune, pistachio, and walnut that were planted on March 3, 2020, and an established "Grenache" vineyard in west Davis, CA. Trees and vines were subjected to a single simulated drift treatment on June 6, 2022. TVE29 was applied at four rates resembling a plausible drift rate: 0.5, 1, 3 and 10%, where the fractional rates were based on use rate in rice, 125 g ai ha^{-1}, Experiments were conducted as a randomized complete block with four replicates, experimental units were single trees and vines, and each species was considered a separate experiment. Herbicides were applied from the top to the ground, on one side of the canopy. A handheld, CO2-pressurized 2 nozzle spray boom with XR8004(AI) nozzles at 40 PSI pressure delivers 0.40 GPM were used. All herbicide treatments were delivered by same person for consistency of the study.

Visual injury ratings and symptom evaluations were done at 24, 48, and 72 hours as well as at 7, 14, 21, 28, 35, 42, and 90 days after herbicide applications. Injury ratings were made by the same person to ensure consistency based on a scale where 0 means no injury and 100 means death. Photos of trees and injured leaves were taken at each injury rating time from the same side, distance, and perspective. None of the simulated TVE29 drift rates caused a detectable injury during the 2022 growing season. This research showed no injury symptoms were observed from all TVE29 simulated drift rates on the crops tested. There is no difference in trunk diameter between nontreated control and all TVE29 simulated drift treatments. We are going to conduct this study in 2023 to confirm out finding.

h. Weed control with Vantek herbicide in water seeded rice

Herbicide-resistant weeds are widespread in the California water-seeded rice cropping system, due to minimal to no crop rotations and a limited number of available herbicides. Pendimethalin is a potential new tool for California rice growers, since it has no observed resistance and has activity on important weedy grasses, like watergrasses and bearded sprangletop.

Preliminary work done in 2020 and 2021, demonstrated that Vantek, a pendimethalin based formulation, to be a suitable option as a delayed preemergence application, after the 4 leaf stage of rice, when crop injury potential is reduced to an acceptable level. Delaying the application, though, provides the early emerging grasses a chance to grow and not be affected by Vantek at the time of the application. Therefore, if Vantek is applied as a delayed preemergence, it should be in a mixture with post emergent herbicides to control the emerged grasses. Vantek will provide residual activity over late emerging grasses and provide assurance for late season weed control. Different herbicide mixtures can also provide a broader weed control spectrum. The objectives of this study were to observe rice response and weed efficacy from various rates of Vantek alone, and Vantek in herbicide mixtures with other post emergent grass herbicides.

The study was conducted at the Rice Experiment Station in Biggs, CA under a randomized complete block design with three replications. Each plot size was 10 ft by 20 ft with a 7 ft-wide levee on the perimeter of each plot to prevent contamination among plots. Pre-germinated M-209 rice seed was air seeded onto the flooded field with 4-5 inches of standing water at a rate of 160 lbs/A on May 23, 2022. The 4-5 leaf stage rice (LSR) application took place on June 14, 2022. The mid-tiller application followed on June 28, 2022. Applications were carried out with a 10 ft boom with six 8003 flat fan nozzles at 30 psi set to deliver 20 Gal/A. The flood water was lowered to a skim on the soil surface for the applications and brought back up to 4-5 inches after 48 hours. Vantek was applied alone and in mixture with propanil, bispyribac-sodium, and cyhalofop at 4-5 LSR. The Vantek rates were 2.1 pt/A, 4.2 pt/A, and 8.4 pt/A.

Visual ratings of crop injury were conducted at 20 and 40 days after treatment (DAT) as described earlier in this report. Chlorosis, stunting and stand reduction were recorded. Total rice injury was determined from the combination of all observed injury. Plant height was recorded at 43 DAT, measuring from the soil surface to the tallest extended leaf from two random samples in each plot. Tiller counts was collected at 50 DAT from two random 1 ft2 area in each plot. Visual percent weed control was conducted at 14, 24, and 56 DAT from 0 to 100 where 0=no injury and 100 = plant kill.

Herbicide mixtures with saflufenacil were also tested in this study, added as a mixture to Vantek plus the post emergent grass herbicide, but results are not presented in this report due to inconsistency of results and high rice injury. Future work is planned to further address saflufenacil proper use in water-seeded rice. Saflufenacil is also not registered in water-seeded rice, but from preliminary work done in 2021, it was observed to provide control over broadleaves and suppression on the sedge species, therefore, it demonstrated to have potential.

The rice response was similar across treatments, 3 to 40% injury at 20 DAT and 0 to 14% at 40 DAT (Table 22). A delayed preemergence application of Vantek demonstrates to reduce injury to adequate levels. All treatments had similar injury levels to the standard treatment of Cerano at day of seeding followed by SuperWham CA and Grandstand CA. There was no difference among the three levels of Vantek rates, all recording minimal visible injury. Mixture with Clincher CA appeared to have greater injury levels, but not significant and the rice would eventually recover. Plant height and tiller count was similar across all treatments (Table 22). There was no difference across pendimethalin rates, demonstrating safe use on rice as a delayed preemergence.

Watergrass control was highest in treatments with an herbicide mixture than the treatments with Vantek alone at the 4-5 LSR application timing (Table 23). Vant
ek has no activity on emerged grasses, and at time of application the majority of emerged watergrasses were about 4 leaf stage. The watergrass pressure in the field was on average 15 watergrasses per square foot at the time of application. SuperWham CA, Clincher CA and Regiment CA are excellent post emergent grass herbicides. In our field site there is no recorded resistance to any of these herbicides.

Across all treatments, watergrass control was adequate by 24 and 56 DAT (Table 23). Vanek provided residual activity to prevent new watergrasses to emerge later in the season. Control was similar to the Standard treatment of Cerano applied at day of seeding. Sprangletop control was variable among treatments at both rating timings (Table 23), most likely due to the low pressure of sprangletop in the field site. Sprangletop pressure in the nontreated plots was 1-2 plants per square foot by 24 DAT. It was hard to tell how much effect Vantek had on sprangletop control. Future work is planned to address the benefit of Vantek on sprangletop control in the field.

Smallflower and ricefield bulrush had 47-95% control at 14 DAT from the herbicide mixtures with Regiment CA and SuperWham CA (Table 23). By 24 DAT most plots had adequate control over the sedges after the SuperWham plus Grandstand mixture at mid-tiller rice, 91-100%. At 56 DAT, all treatments had adequate control of the sedges (Table 23). Ducksalad control was adequate at 14 DAT for treatments with Regiment CA mixture, 98% or greater (Table 23). By 24 and 56 DAT ducksalad control was excellent at all treatments (Table 23).

The delayed preemergence application of Vantek is the most suitable to reduce rice injury to adequate levels, and at the time of application, it will be necessary to be accompanied by other post emergent grass herbicides to control emerged weedy grasses. Vantek can provide residual activity for control of later emerging watergrasses that will carry throughout the season. In fields were resistance has been confirmed to the post emergent grass herbicides, a mixture of post emergent herbicides may be necessary and future work will be carried out on this topic. Vantek has demonstrated potential in the water-seeded rice system, and can be an integral tool for control herbicide-resistant grasses and late emerging grasses.

i. Testing GWN-10723 a New Herbicide in Rice

A field studies were conducted to evaluate rates of a new herbicide (GWN-10723) in water seeded rice. This herbicide looked very promising to control grasses and other weeds. We will continue our research in 2023 seeking optimization to use of this herbicide.

j. Oxaziclomefone New Grass Control Herbicide Evaluation

A field and greenhouse studies were conducted to evaluate rates of a new herbicide, oxaziclomefone, to control grasses in water seeded rice. This herbicide efficacy looks very promising to control grasses at selected rates. We will continue our research in 2023 seeking optimizatiing the efficacy of oxaziclomefone.

Herbicides	Rate/Acre	Timing	Total Rice Injury 20 DAT	Total Rice Injury 40 DAT	Plant Height 43 DAT	Tiller Count 50 DAT	Yield
			% of nontreated		mm	count/ft^2	Lbs ac^{-1}
Vantek Clincher CA Loyant	2.1 pt 15 floz 21.9 floz	4-5 LSR Mid-till	7	12	63	36	3,542
Vantek SuperWham! CA SuperWham! CA Grandstand CA	2.1 pt 3 qt 5 qt 0.67 pt	4-5 LSR Mid-till	2	6	65	48	6,086
Vantek Clincher CA SuperWham! CA Grandstand CA	2.1 pt 13 floz 6 qt 0.67 pt	4-5 LSR Mid-till	13	12	70	48	5,218
Vantek Regiment CA SuperWham! CA Grandstand CA	2.1 pt 0.53 oz 6 qt 0.67 pt	4-5 LSR Mid-till	2	0	64	62	7,116
Vantek Clincher CA Loyant	4.2 pt 15 floz 21.9 floz	4-5 LSR Mid-till	14	7	67	30	4,611
Vantek SuperWham! CA SuperWham! CA Grandstand CA	4.2 pt 3 qt 5 qt 0.67 pt	4-5 LSR Mid-till	8	7	67	51	6,713
Vantek Clincher CA SuperWham! CA Grandstand CA	4.2 pt 13 floz 6 qt 0.67 pt	4-5 LSR Mid-till	17	4	65	48	6,270
Vantek Regiment CA SuperWham! CA Grandstand CA	4.2 pt 0.53 oz 6 qt 0.67 pt	4-5 LSR Mid-till	3	2	65	62	8,017
Vantek Clincher CA Loyant	8.4 pt 15 floz 21.9 floz	4-5 LSR Mid-till	15	14	67	33	4,047
Vantek SuperWham! CA SuperWham! CA Grandstand CA	8.4 pt 3 qt 5 qt 0.67 pt	4-5 LSR Mid-till	6	3	68	46	6,911
Vantek Clincher CA SuperWham! CA Grandstand CA	8.4 pt 13 floz 6 qt 0.67 pt	4-5 LSR Mid-till	15	9	65	43	5,268
Vantek Regiment CA SuperWham! CA Grandstand CA	8.4 pt 0.53 oz 6 qt 0.67 pt	4-5 LSR Mid-till	4	2	66	54	8,033
Cerano 5MEG SuperWham! CA Grandstand CA Regiment CA BAS 800 06H	12 lbs 6 qt 0.67 pt 0.53 oz 50 oz	DOS Mid-till	2	0	68	57	6,809
Nontreated	-	-	-	-	69	23	3,292
LSD p=0.05			66	42	10	24	3,254

[a]The 4-5 LSR application was at 23 days after seeding; LSR, leaf stage rice. Mixtures with SuperWham! CA had adjuvant COC at 1 %v/v, Clincher CA had COC at 2.5 %v/v, Regiment CA had MSO at 0.25 %v/v. [b]Mid-till application was at 37 days after seeding; mid-till, middle of rice tillering stage; DOS, day of seeding. Mixtures of SuperWham! CA and Grandstand CA had NIS at 0.25 %v/v. Mixtures of Clincher CA and Loyant had MSO-

[c]Ratings are after the 4-5 LSR application; DAT, days after treatment.[d]Total rice injury includes combined injury from chlorosis, stunting, and stand reduction. Yield was not collected from treatments with a dash due to low rice stand.

Table 23. Weed control efficacy of Vantek in various herbicide mixtures for a season-long herbicide programs in CA water-seeded rice, 2022 field study[abcd]

Herbicides	Rate/Acre	Timing	Weed Control													
			14 DAT				24 DAT					56 DAT				
			Watergrass	Smallflower	Ricefield bulrush	Ducksalad	Watergrass	Sprangletop	Smallflower	Ricefield bulrush	Ducksalad	Watergrass	Sprangletop	Smallflower	Ricefield bulrush	Ducksalad
			% of nontreated													
Vantek Clincher CA Loyant	2.1 pt 15 floz 21.9 floz	4-5 LSR Mid-till	9	0	0	0	50	100	0	0	98	97	100	50	84	100
Vantek SuperWham! CA SuperWham! CA Grandstand CA	2.1 pt 3 qt 5 qt 0.67 pt	4-5 LSR Mid-till	60	47	47	2	73	0	100	100	100	87	0	100	100	100
Vantek Clincher CA SuperWham! CA Grandstand CA	2.1 pt 13 floz 6 qt 0.67 pt	4-5 LSR Mid-till	98	0	0	0	98	100	96	96	99	100	100	100	100	98
Vantek Regiment CA SuperWham! CA Grandstand CA	2.1 pt 0.53 oz 6 qt 0.67 pt	4-5 LSR Mid-till	99	95	93	98	99	0	100	100	98	97	0	100	99	100
Vantek Clincher CA Loyant	4.2 pt 15 floz 21.9 floz	4-5 LSR Mid-till	2	2	2	0	60	100	10	10	100	93	67	80	87	100
Vantek SuperWham! CA SuperWham! CA Grandstand CA	4.2 pt 3 qt 5 qt 0.67 pt	4-5 LSR Mid-till	63	47	47	2	80	0	97	97	100	88	33	98	100	100
Vantek Clincher CA SuperWham! CA Grandstand CA	4.2 pt 13 floz 6 qt 0.67 pt	4-5 LSR Mid-till	94	0	0	0	94	100	97	98	99	99	100	71	96	100
Vantek Regiment CA SuperWham! CA Grandstand CA	4.2 pt 0.53 oz 6 qt 0.67 pt	4-5 LSR Mid-till	99	63	63	99	99	0	100	100	100	98	0	100	99	100
Vantek Clincher CA Loyant	8.4 pt 15 floz 21.9 floz	4-5 LSR Mid-till	16	0	0	0	57	100	5	5	100	92	100	84	90	100
Vantek SuperWham! CA SuperWham! CA Grandstand CA	8.4 pt 3 qt 5 qt 0.67 pt	4-5 LSR Mid-till	73	62	62	5	78	33	100	100	99	91	33	100	99	100
Vantek Clincher CA SuperWham! CA Grandstand CA	8.4 pt 13 floz 6 qt 0.67 pt	4-5 LSR Mid-till	86	30	30	33	90	100	91	91	99	98	100	96	96	98
Vantek Regiment CA SuperWham! CA Grandstand CA	8.4 pt 0.53 oz 6 qt 0.67 pt	4-5 LSR Mid-till	87	92	88	99	99	0	100	100	99	100	0	100	100	100
Cerano 5MEG SuperWham! CA Grandstand CA	12 lbs 6 qt 0.67 pt	DOS Mid-till	96	0	0	0	98	100	98	98	99	99	100	99	95	100
LSD p=0.05			86	-	-	-	52	-	95	95	-	37	-	66	38	-

[a]The 4-5 LSR application was at 23 days after seeding; LSR, leaf stage rice. Mixtures with SuperWham! CA had adjuvant COC at 1 %v/v, Clincher CA had COC at 2.5 %v/v, Regiment CA had MSO at 0.25 %v/v.

[b]Mid-till application was at 37 days after seeding; mid-till, middle of rice tillering stage; DOS, day of seeding. Mixtures of SuperWham! CA and Grandstand CA had NIS at 0.25 %v/v. Mixtures of Clincher CA and Loyant had MSO

[c]Ratings are after the 4-5 LSR application; DAT, days after treatment.

[d]LSD, least significant difference. A dash indicates the data did not meet normality requirements. Averaged over three replications.

Objective 3. Develop thermal model for growth and development of the weedy rice that can be used to predict emergence and growth of weedy rice.

"Weedy" red rice is a problematic weed due to its phenotypic similarities with cultivated rice. Limited herbicide availability has driven a need for non-chemical control options for managing this pest. One pre-planting strategy that is being explored is the stale seedbed methodology which aims to maximize soil seedbank withdrawals via germination. This technique is adapted in rice by flooding a field, waiting for germination and emergence of weed seedlings, and completed with a mechanical or chemical control application. Optimization of this process is dependent on maximizing weed seed germination which is primarily influenced by both temperature and moisture availability. Germinability across a range of these factors is not well understood in California weedy rice. Thus, this study was aimed to determine germinability of California weedy rice accessions under various temperature and water potential treatments. Previously described red weedy accessions 1, 2, 3, and 5 along with M-206, a common California rice cultivar, were exposed to temperatures from 10-40°C in combination with water potentials of 0, -0.2, -0.4, or -0.8 MPa until either germination or weed seed decay occurred. Statistical analysis indicated a 3-way interaction between accession, temperature, and water potential. Germination reached 95% when seeds were exposed to temperatures between 20-35°C in combination with 0 or -0.2 MPa. Germination was lowest when seeds were water stress (-0.8 MPa), temperatures were colder than 20°C, or warmer than 35°C. These results could be utilized in the decision-making process for successfully implementing the stale seedbed methodology targeting weedy rice via maximizing germination. The results from this study and the results from previous water and burial depth weedy rice emergence study will be combined to develop thermal model for growth and development of the weedy rice that can be used to predict emergence and growth of weedy rice.

Objective 4. Study mechanism of herbicide resistance in weeds and identify programs to manage resistant biotypes, provide diagnosis services to growers and PCA to confirm

a. <u>Diagnostic and detection of herbicide resistance in Farmers' fields</u>

For seeds collected from 2021 growing season, testing of suspected herbicide resistant weeds was conducted on 44 seed samples. Growers and PCA submitted weed seeds samples including barnyardgrass, early and late watergrass, smallflower umbrella sedges, sprangletop, ricefield bulrush, and redstem. We tested the response of these weed to several herbicides not only to confirm resistance to particular herbicide but also to give growers herbicide options in case they have resistance in their fields. For 2021, we have tested 18, 7, 7, 2, 1, and 1 sample of barnyardgrass, early watergrass, breaded sprangletop, redstem, smallflower umbrella sedge, late watergrass (Table 24). Most of the sample tested showed resistance to at least one herbicide. We had several sample with multiple

resistance. We provided each grower with extensive report that include photos of plant response to different herbicides and recommendations to select alternative herbicide to control their resistant weed. The summary of results is in Table 24.

We will continue to test suspected resistant weed populations provided by growers and PCA. This implies conducting the greenhouse tests during the winter in order to have results available to growers in a timely manner before they have to make decisions on their herbicide program. For each sample received, we tested all herbicides that are recommended to control the weed. The protocol is similar to 2021 protocol. Growers/PCA(s) received reports that not only show if the weed is resistance to particular herbicide(s) but also provided herbicide alternatives for controlling of this particular biotype. The reporting method to growers allows visual results along with the resistance data. This approach has been well received by the growers and PCA who utilized the service. At this point, we have received 48 sample to be tested in 2022.

Table 24. Number of Observed Herbicide Resistance from 2020-2021 Herbicide Resistant Screening Samples

Weed Species[1] [Total number received; number of successful testing for both pre and post emergent herbicides]	Herbicides								
	Bolero	Butte	Cerano	Clincher	Grandstand	Granite SC	Propanil	Regiment	Shark H20
	----------			Number of resistant samples[2]			----------		
Barnyardgrass [18; 14]	2(1*)	0	0	9(6*)			16	15	
Early watergrass [7; 7]	1*	1	1*	1(2*)			7	6	
Late watergrass [1; 1]	1*	0	0	1			1	1	
Bearded Sprangletop [7; 5]	1*	0	0	2					
Smallflower Umbrella Sedge [1; 1]	0	0			0	0	0	0	0
Redstem [2; 2]					0	0	0	0	

[1]Two numbers in the brackets: The first = total number of seed samples received; The second = total number of seed samples tested (few samples did not germinate)

[2]Wherever there are two numbers: The first = "conclusively resistant"; The second = partial control (susceptible).

*Average visual percent control ratings ranged from 70% - 79%

PUBLICATIONS OR REPORTS:

1. Galvin, L. B., Becerra-Alvarez, and K. Al-Khatib. 2022. Assessment of oxyfluorfen-tolerant rice systems and implications for rice-weed management in California. J. Pest Management. https://doi.org/10.1002/ps.7111.
2. Becerra-Alvarez, A. A. R. Ceseski, and K. Al-Khatib. 2022. Weed control and rice response from clomazone applied at different timings in a water-seeded system. Weed Techn. DOI: https://doi.org/10.1017/wet.2022.34.
3. Ohadi S, G. Laguerre, J. Madsen, K. Al-Khatib. 2022. Toward understanding the impact of nuisance algae bloom on the reduction of rice seedling emergence and establishment. Weed Sci. 70:95–102. doi: 10.1017/wsc.2021.69.
4. Ceseski, A. R, A. S. Godar, and K. Al-Khatib. 2022. The stale-drill establishment method for rice: weed community, rice stand development, and yield components of two vigorous japonica cultivars. Field Crops Research. 276: 108369. https://doi.org/10.1016/j.fcr.2021.108369
5. Galvin, L. D., D. Inci, M. Mesgaran, W. Brim-DeForest, and K. Al-Khatib. 2022. Flooding depths and burial effects on seedling emergence of five California weedy rice (*Oryza sativa* spontanea) accessions. Weed Science. DOI: https://doi.org/10.1017/wsc.2021.82.
6. Unan, R., I. Deligoz, and K. Al-Khatib. 2022. Protocol for ethyl methanesulphonate (EMS) mutagenesis application in rice. Research and Innovation, European Commission. https://open-research-europe.ec.europa.eu/articles/1-19/v1.
7. Sara Rosenberg, S., A. Crump, W. Brim-DeForest, B. Linquist, L. Espino, K. Al-Khatib, M. M. Leinfelder-Miles, and Cameron M. Pittelkow. 2022. Crop rotations in California rice systems: Baseline assessment of barriers and opportunities. Frontiers in Agronomy. https://doi.org/10.3389/fagro.2022.806572..
8. Ceseski, R. A., A. Godar and K. Al-Khatib. 2022. Combining stale seedbed with deep rice planting: A novel approach to herbicide resistance management. Weed Technology. https://doi.org/10.1017/wet.2022.2.
9. Ceseski, R. A. and K. Al-Khatib. 2021. Seeding depth effects on elongation, emergence, and early development of California rice cultivars. Crop Science. 61:2012-2022. https://doi.org/10.1002/csc2.20504.
10. Ohadi, S., Godar A., Madsen, J., Al-Khatib, K. 2021. Response of rice algal assemblage to fertilizer and chemical application: implications for the early algal bloom management. Agronomy. 1:542. https://doi.org/10.3390/agronomy11030542
11. Brim-DeForest, W. B, K. Al-Khatib, A. J. Fischer. 2021. Emergence and early growth of multiple-herbicide resistant and susceptible late watergrass (*Echinochloa phyllopogon*). Weed Techn. DOI: 10.1017/wet.2021.86.
12. Galvin, L. B., K. Al-Khatib. 2022. Application of Pre-emergent Oxyfluorfen as a Novel Chemical Control Option for California Weedy Rice (Oryza sativa spontanea). Proceeding Weed Science Society America. 62:231.

13. Ceseski, A. R. and K. Al-Khatib. 2022. Target-Site And Nontarget Pathways of ALS Inhibitor Resistance in Cyperus difformis. Proceeding Weed Science Society America. 62:204.
14. Becerra-Alvarez, A. and K. Al-Khatib. 2022. Tracking Herbicide-Resistant Weeds in California Rice Through a Community. Proceeding Weed Science Society America. 62:204.97.
15. Inci, D., B. Hanson, and K. Al-Khatib. 2022. Nut and Fruit Crops Response to Simulated Drift Rates of Florpyrauxifen-benzyl Drift in California. Proceeding Weed Science Society America. 62:92.
16. Marsh, S. L., A. Becerra-Alvarez, A. R. Ceseski, S. Estrada, and K. Al-Khatib. 2022. Weed Control and Rice Response to Pyraclonil, A New Broad-Spectrum Herbicide in California Rice. Proceeding Weed Science Society America. 62:58.
17. Galvin, L.B., K. Al-Khatib. 2022. California rice, the "Environmental Crop". Integrated strategies for pest management in the Sacramento Valley. Proceeding 10th annual International IPM symposium. 10: 66.
18. 7. Inci, D., B. Hanson, and K. Al-Khatib. 2022. Simulated Off-Target drift of Florpyrauxifen-benzyl in Orchards and Vineyards. Proceeding Western Society Weed Science. 75:115.
19. Ceseski, A. R. and K. Al-Khatib. 2022. The Stale-drill Cropping Method in California Rice: Challenges and Potential for Small-grain Systems. Proceeding Western Society Weed Science. 75:71.
20. Galvin, L. and K. Al-Khatib. 2002. Utilization of Pre-emergent Oxyfluorfen to Control Weedy (Red) Rice (Oryza sativa Spontanea), Proceeding Western Society Weed Science. 75:70.
21. Maya T. Delong, M. T., L. B. Galvin, and K. Al-Khatib. 2022. California Weedy Rice Germination at Various Temperatures. Proceeding Western Society Weed Science. 75:60.
22. Rosenberg, S. R., W. Brim-DeForest, B. Linquist, L. Espino, K. Al-Khatib, M. M. Leinfelder-Miles, and C. M. Pittelkow. 2022. Cost Benefit Analysis of Crop Rotations in California Rice Systems. Proceeding Western Society Weed Science. 75:18.
23. Rasim Unan, R., L. B. Galvin, and K. Al-Khatib. 2022. California Weedy Rice Populations Response to Clethodim. Proceeding Western Society Weed Science. 75:17.
24. Marsh, S. L, A. Becerra-Alvarez, A. R. Ceseski, S. Estrada, and K. Al-Khatib. 2022. Performance of a New Broad-Spectrum Herbicide in California Rice. Proceeding Western Society Weed Science. 75:16.
25. Becerra-Alvarez, A. and K. Al-Khatib. 2022. Tracking Herbicide-Resistant Weeds in California Rice Through a Community-Driven Approach. Proceeding Western Society Weed Science. 75:15.
26. Al-Khatib, K. 2021. Understanding the use and application of adjuvants. Proceeding annual meeting of California weed science society. 73: 12.
27. Becerra-Alvarez, A., A. R. Ceseski, S. Estrada, and K. Al-Khatib. 2021. Rice response and weed control from clomazone applied at different timing in a continuous flood system. Proceeding annual meeting of California weed science society. 73:48.
28. Ceseski, A. R. and K. Al-Khatib. 2021. Enhanced Metabolism of ALS Inhibitors in Cyperus difformis. Proceeding annual meeting of California weed science society. 73:49.

29. Galvin, L., W. Brim-DeForest, and K. Al-Khatib. 2021. California weedy rice (Oryza sativa spontanea) emergence patterns under field conditions, implications for management. Proceeding annual meeting of California weed science society. 73:53.
30. Inci, D. and K. Al-Khatib. 2021. Efficacy of florpyrauxifen-benzyl in California water seeded rice. Proceeding annual meeting of California weed science society. 73:61.
31. Inci, D., K. Al-Khatib, and B. Hansen. 2021. Determining tree and vine crop response to simulated florpyrauxifen-benzyl drift. Proceeding annual meeting of California weed science society. 73:63.
32. Laguerre, G., S. Ohadi, J. Madsen, and K. Al-Khatib. 2021. Understanding the effect of algaecide application's timing on early algae infestation in California rice production. Proceeding annual meeting of California weed science society. 73:68.
33. Ohadi, S., Godar A., Madsen, J., and Al-Khatib, K. 2021. Response of rice algal assemblage to fertilizer and chemical application: implications for the early algal bloom management. Agronomy. 1:542. https://doi.org/10.3390/agronomy11030542

GENERAL SUMMARY OF CURRENT YEARS RESULTS

Research was conducted to develop effective weed management programs in three rice cropping systems including continuous flooded rice, partially flooded rice (pinpoint) and drill seeded rice. Weed control program in rice require early herbicide applications such as thibencarb, clomazone, or Butte followed up by postemergence herbicide. The efficacy of these programs would depend on herbicides in the program, time of application and water level.

We have conducted research to determine the potential to incorporate new herbicides to manage weeds including herbicide resistant weeds. Our field research showed that Loyant has a broad-spectrum weed control activity. It controls selected grasses sedges, and broadleaf weed species. Our research showed that Loyant has good control of smallflower umbrellasedge, a troublesome weed in California rice, when applied at early rice growth stages. Our research also suggested that Loyant is effective and safe to use late in the growing season up. Loyant applied at 1.33 and 2.66 pint/A rates did not cause significant grain blanking and was similar to blanking in nontreated control. We also have found that the new herbicide Zembu (Pyraclonil) is good tool to control several grasses, smallflower sedge, and broadleaf weeds. We suggest that Zembu need to be used in a program to give broaden its weed control spectrum. The herbicide programs of Zembu followed by Butte plus propanil; propanil plus Loyant; and Clincher plus Granite showed exceptional control of all weeds present in the field.

Afield study was conducted to evaluate crop injury and weed control of TVE29, anew grass control herbicide with novel mode of action. We have also evaluated the tolerance of six California rice varieties to TVE29. This herbicide was safe on all varieties tested. It also provided exception grass control. We think that TVE29 will have positive impact on our weed control in rice. We have conducted research to determine the efficacy of ALB2023 and ALB2024 to use in ROXY Rice Production System® and ROXY trait rice for weed control and crop safety. The research continued to show that Roxy rice is effective and promising technology. ALB2023 applied at different rates were safe on rice with excellent control of most grasses and broadleaf weeds. ALB2023, however, showed

poor control of ricefield bulrush. We continue to work to use Vantek herbicide, a new offer from BASF, to control grasses on water seeded rice. Our research showed the potential of using Vantek at 3 to 5 rice leaf stage. We will try to optimize the use of Vantek in the coming growing season. We have initiated a new project to study the potential to use two new herbicides in California water seeded rice, oxaziclomefone and GWN-10723. Our preliminary research showed that these herbicides have good potential to control grasses in rice. We will continue working to improve the efficacy of these herbicides.

In the last four years, Gowan company marketed benzobicyclon in combination with halosulfuron under the trade name Butte. In 2023 growing season, Gowan will market benzobicyclon alone under trade name Cliffhanger. Butte was sold as a granule formulation; however, Cliffhanger will be sold as liquid formulation. In 2022, we studied the efficacy of different rates and time of applications of Cliffhanger. Our research showed that Cliffhanger provide slightly better control of grasses compare to Butte. We will continue this research in 2023 to optimize the efficacy of Cliffhanger. We will study the efficacy of 1 and 12 oz/A of Cliffhanger. The label in 2023 may allow 10 oz/A but in 2024 the label will increase the rate to 12 oz.

We continue to work to develop important data to help manage weedy rice. Weedy" red rice is a problematic weed due to its phenotypic similarities with cultivated rice. Limited herbicide availability has driven a need for non-chemical control options for managing this pest. One pre-planting strategy that is being explored is the stale seedbed methodology which aims to maximize soil seedbank withdrawals via germination. This technique is adapted in rice by flooding a field, waiting for germination and emergence of weed seedlings, and completed with a mechanical or chemical control application. Optimization of this process is dependent on maximizing weed seed germination which is primarily influenced by both temperature and moisture availability. Germinability across a range of these factors is not well understood in California weedy rice. Our research aimed to determine germinability of California weedy rice accessions under various temperature and water potential treatments. Previously described weedy rice accessions 1, 2, 3, and 5 along with M-206, a common California rice cultivar, were exposed to temperatures from 10-40°C in combination with water potentials of 0, -0.2, -0.4, or -0.8 MPa until either germination or weed seed decay occurred. Research showed that germination reached 95% when seeds were exposed to temperatures between 20-35°C in combination with 0 or -0.2 MPa. Germination was lowest when seeds were water stress (-0.8 MPa), temperatures were colder than 20°C, or warmer than 35°C. These results could be utilized in the decision-making process for successfully implementing the stale seedbed methodology targeting weedy rice via maximizing germination. The results from this study and the results from previous water and burial depth weedy rice emergence study will be combined to develop thermal model for growth and development of the weedy rice that can be used to predict emergence and growth of weedy rice

We have tested more than 36 samples of suspected herbicide resistant weed populations that were collected by growers and PCA including barnyardgrass, early and late watergrass, smallflower umbrella sedges, sprangletop, and redstem. Most of the sample tested showed resistance to at least one herbicide. We had several seed samples with multiple resistance. We provided each grower with extensive report that include photos of plant response to different herbicides and recommendations to select alternative herbicide to control their herbicide resistant weed. In 2022, both our field and lab

program seek to assist California rice growers in their critical weed control issues of preventing and managing herbicide-resistant weeds, achieve economic and timely broad-spectrum control and comply with personal and environmental safety requirements.