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Herbicide Trials in Delta Drill-Seeded Rice – 2019 and 2020

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Introduction:

Weeds are important pests of California rice systems, and weed management can account for roughly 17 percent of total operating costs (Espino et al., 2016). Integrated weed management uses cultural and chemical practices and considers the following:

- Prevention (e.g. using certified seed, equipment sanitation, maintaining roads and levees)
- Cultural practices (e.g. land leveling, crop rotation, tillage, winter flooding, drill-seeding)
- Fertilizer placement and management
- Water management
- Monitoring
- Herbicides

Herbicide are important tools. Certain conditions in California rice production systems, however, increase the likelihood of developing herbicide resistance, or the ability of certain weed biotypes to survive certain herbicide treatments when the weed species is usually killed by that herbicide (Al-Khatib et al., 2019). Such conditions include, but are not limited to, lack of crop rotation, the efficacy of certain herbicides on certain weeds causing them to get frequently used, and not having diverse chemistries available.

In 2019 and 2020, trials were conducted to evaluate the efficacy of a new herbicide product called Loyant (florpyrauxifen-benzyl; group 4 herbicide; Corteva Agriscience) in drill-seeded rice in the Sacramento-San Joaquin Delta region. Loyant is registered in rice growing states in the southern US but would be a new chemistry in California. Corteva Agriscience expects to have CA registration in time for the 2021 use season. Previous work by the company indicates that Loyant provides good control of broadleaf weeds (e.g. ducksalad, redstems), smallflower umbrella sedge, and ricefield bulrush. It has some activity on *Echinochloa* species (e.g. barnyardgrass, watergrass). The objective of the trials, by assessing different rates and treatment combinations, was to understand the efficacy and crop tolerance of Loyant for weed control in drill-seeded rice in California.

The trials took place in the Delta region on a Kingile muck soil. This soil classification is characterized as having upwards of 40 percent organic matter in the top foot of soil, and approximately 27,000 acres in the Delta are classified as the Kingile series. On high organic matter soils in the Delta, the typical practice is drill-seeding. Water-seeding, which is the typical practice in the Sacramento Valley, is not

successful in the Delta because the soil particles can float and move too easily, causing seed to get buried too deeply and germinate poorly.

Methods:

In 2019, the rice was drill-seeded on May 15th, and in 2020, seeding took place on April 13th. In both years, the variety was M.206. After planting, but before rice emergence, glyphosate herbicide was applied to manage weeds, primarily grasses, that had already emerged. Treatments are shown in Tables 1 and 2 (2019 and 2020, respectively). Applications were made using a CO_2 backpack sprayer, using flat fan nozzles, with an output volume of 20 gallons per acre. Since this was a commercial field, we did not have completely untreated plots and considered the Prowl treatment the "control". The permanent flood was applied within five days of herbicide application.

Table 1. *Herbicide treatments in the 2019 trial. Treatments were applied on June 9th, when rice was approximately at the 5-6 leaf stage. Applications were slightly delayed due to windy conditions in the week prior to application. Environmental conditions at application were as follows: air temperature 63 degrees F, relative humidity 54 percent, and wind speed 3 mph.*

Materials	Rate (unit of product/acre)	Herbicide Program denoted as
Loyant, Prowl H2O, MSO	1.37 pints, 5.5 pints, 0.5 pints	Loyant-high + Prowl
Loyant, Prowl H2O, MSO	1.024 pints, 5.5 pints, 0.5 pints	Loyant-low + Prowl
Loyant, MSO	1.37 pints, 0.5 pints	Loyant-high
Regiment, Sandea, Prowl H2O, SuperWham, MSO, UAN-32	0.2 ounces, 0.8 ounces, 5.5 pints, 6 quarts, 16 fluid ounces, 2 gallons/100 gal	Grower standard
Prowl H2O	5.5 pints	Prowl
Regiment, Sandea, Prowl H2O, Loyant, MSO, UAN-32	0.2 ounces, 0.8 ounces, 5.5 pints, 1.37 pints, 16 fluid ounces, 2 gallons/100 gal	Grower substitute

Table 2. *Herbicide treatments in the 2020 trial. Treatments were applied on May 8th, when the rice was approximately at the 3 leaf stage. Environmental conditions at application were as follows: air temperature degrees 78 F, relative humidity 47 percent, and wind speed 0-2.5 mph.*

Materials	Rate (unit of product/acre)	Herbicide Program denoted as
Loyant, Prowl H2O, MSO	1.37 pints, 5.5 pints, 0.5 pints	Loyant
Loyant, Clincher, Prowl H2O, MSO	1.37 pints, 15 fluid ounces, 5.5 pints, 0.5 pints	Loyant/Clincher
Loyant, Granite SC, Prowl H2O, MSO	1.37 pints, 2.8 fluid ounces, 5.5 pints, 0.5 pints	Loyant/Granite
Loyant, RebelEX CA, Prowl H2O, MSO	1.37 pints, 20 fluid ounces, 5.5 pints, 0.5 pints	Loyant/RebelEX

Regiment, Sandea, Prowl H2O, SuperWham, MSO, UAN-32	0.2 ounces, 0.8 ounces, 5.5 pints, 6 quarts, 16 fluid ounces, 2 gallons/100 gal	Grower standard
Prowl H2O	5.5 pints	Prowl
Loyant, Prowl H2O, SuperWham, MSO	1.37 pints, 5.5 pints, 6 quarts, 16 fluid ounces	Loyant/SuperWham

The experimental design was a randomized complete block design with four replicates. Plot size was 20 feet by 20 feet. We made crop injury observations on 7-day intervals from 7 to 42 days after treatment (DAT). We made weed density observations on 7-day intervals from 14 to 42 DAT. The most prominent weeds in the field were *Echinochloa* species (i.e. watergrass, barnyardgrass), but we also observed sprangletop (*Leptochloa fusca*) and sedges that we believed to be a flatsedge, like redroot flatsedge (*Cyperus erythrorhizos*) (Fig.1). The 2019 trial was harvested on November 1st, and the 2020 trial was harvested on September 29th. We measured grain yield from a 10.8-ft^2 (1-m^2) quadrat per plot.

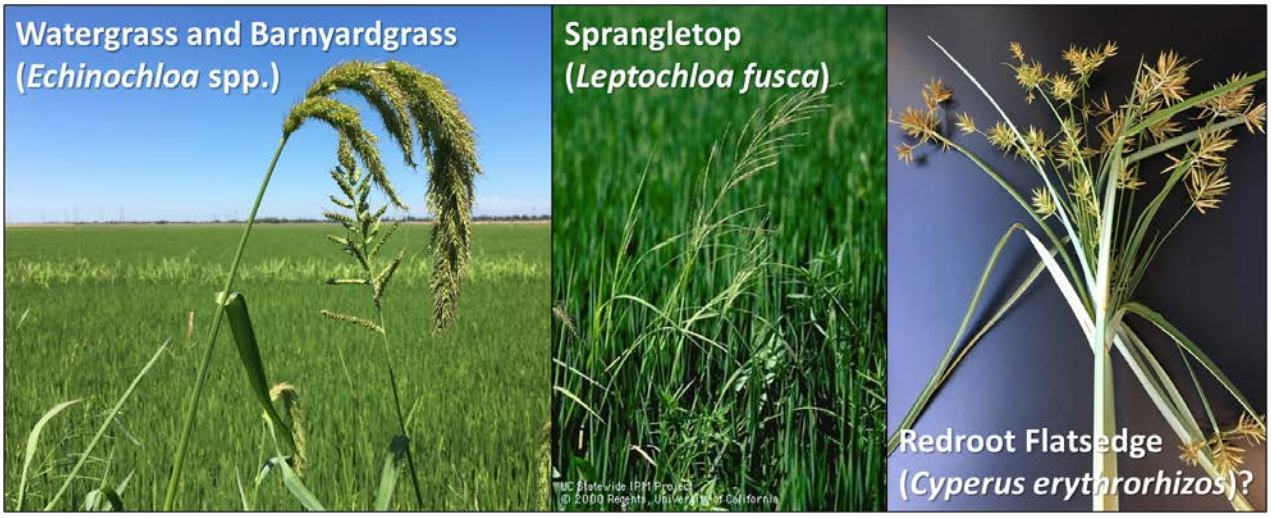

Figure 1. *Weeds present in the trial: watergrass, barnyardgrass, sprangletop, and sedges. Sprangletop was only observed in 2019. Photos by M. Leinfelder-Miles and UC IPM.*

Results and Discussion:

Crop Injury

Crop injury observations were characterized as crop chlorosis, tip burn, and leaf curling. In 2019 (Table 3), we observed noticeable crop chlorosis and tip burning in the grower standard treatment at 7 DAT, and slight effects in the grower substitute treatment. We observed slight to noticeable leaf curling in the Loyant treatments 14 DAT. Crop injury effects in all treatments were not observed by 21 DAT. In 2020 (Table 4), we did not observe crop chlorosis, but we did observe tip burning in several of the treatments. We also observed leaf curling in the Loyant treatments, which persisted longer into the season in 2020 compared to 2019. Corteva Agriscience has observed this symptom with Loyant in other trials where environmental stressors impact crop health, such as extreme cold or heat, drought, or poor fertility. We observed this symptom on the side of the plots closest to the field edge.

Table 3. *2019 crop injury on 7-day intervals from 7 days after treatment (DAT) to 14 DAT. Injury symptoms had disappeared by 21 DAT.*

Herbicide Program (Treatment)	Crop Chlorosis 7 DAT	Necrosis/Tip Burn 7 DAT	Crop Chlorosis 14 DAT	Leaf Curling 14 DAT
Loyant-high + Prowl	None	None	None	Noticeable Effect
Loyant-low + Prowl	None	None	None	Noticeable Effect
Loyant-high	None	None	None	Some Effect
Grower standard	Noticeable Effect	Noticeable Effect	Some Effect	None
Prowl	None	None	None	None
Grower substitute	Some Effect	Some Effect	None	Some Effect
	No Severe Effects Observed with any Program.			

Table 4. *2020 crop injury on 7-day inervals from 7 DAT to 42 DAT. Tip burn symptoms were no longer observed by 21 DAT; whereas, leaf curling persisted until 56 DAT.*

Herbicide Program (Treatment)	Necrosis/Tip Burn		Leaf Curling				
	7 DAT	14 DAT	14 DAT	21 DAT	28 DAT	35 DAT	42 DAT
Loyant	Slight Effect	None	Some Effect	Some Effect	Some Effect	Noticeable Effect	Noticeable Effect
Loyant/Clincher	Slight Effect	None	Some Effect	Slight Effect	Slight Effect	Slight Effect	Slight Effect
Loyant/Granite	None	None	Some Effect	Slight Effect	Slight Effect	Some Effect	Some Effect
Loyant/RebelEX	None	None	Some Effect	Slight Effect	Slight Effect	Slight Effect	Slight Effect
Grower standard	Some Effect	None	None	None	None	None	None
Prowl	Slight Effect	None	Slight Effect	None	None	None	None
Loyant/SuperWham	Noticeable Effect	Some Effect	Some Effect	Slight Effect	None	None	None
	No Severe Effects Observed with any Program.						

We observed no stunting, stand reduction, or differences in heading with any treatments in either year. In 2019, heading occurred at approximately 87 days (Aug 15th, approximately 1894 growing degree days), and in 2020, it occurred at approximately 109 days (July 31st, approximately 1893 growing degree days).

Weed Control

Treatment efficacy is shown in Tables 5 and 6. In 2019, all treatments had similar weed control with the exception of the Prowl treatment, which had statistically higher weed counts in many circumstances. Loyant does not control sprangletop, so that was the weed most commonly observed.

In 2020, overall weed pressure was lower than in 2019. While we observed approximately four weeds per square foot in an untreated strip of the field in 2019, we only observed about 1 weed per square foot in untreated strip in 2020. We also did not observe any sprangletop. There was a trend for the Prowl treatment to have the highest weed counts, but those counts were generally not statistically higher than counts in the Loyant plots. The treatments that had the best weed control were the grower standard and Loyant/SuperWham herbicide programs.

Table 5. *2019 weed counts on 7-day intervals from 14 days after treatment (DAT) to 42 DAT. Data were transformed for analysis. Arithmetic means are presented. Data represent number of weeds in the entire 400-ft^2 plot.*

Herbicide Program (Treatment)	14 DAT	21 DAT	28 DAT	28 DAT (excluding sprangletop)	42 DAT	42 DAT (excluding sprangletop)
Loyant-high + Prowl	0 b	2 b	10 b	4	10 b	4
Loyant-low + Prowl	0 b	5 b	12 ab	2	11 b	2
Loyant-high	1 b	2 b	6 b	2	8 b	2
Grower standard	0 b	6 b	13 ab	1	16 ab	1
Prowl	13 a	21 a	29 a	10	36 a	15
Grower substitute	2 b	6 b	14 ab	2	18 ab	6
Average	3	7	14	4	17	5
Coefficient of Variation (%)	56	44	36	53	34	58
Significance of treatment effect (P value)	<0.0001	<0.0001	0.015	0.0584	0.0036	0.0787

Table 6. *2020 weed counts on 7-day intervals from 14 DAT to 42 DAT. Data were transformed for analysis. Arithmetic means are presented. Data represent number of weeds in the entire 400-ft^2 plot.*

Herbicide Program (Treatment)	14 DAT	21 DAT	28 DAT	35 DAT	42 DAT
Loyant	3	5	2ab	3 ab	4 c
Loyant/Clincher	2	3	1ab	3 ab	5 bc
Loyant/Granite	4	3	1 b	9 ab	15 ab
Loyant/RebelEX	2	3	1ab	4 ab	9 abc
Grower standard	1	1	1 b	2 b	4 c
Prowl	3	0	8a	15 a	21 a
Loyant/SuperWham	1	2	1 b	2 b	3 c
Average	2	2	2	5	9
Coefficient of Variation (%)	113	74	154	119	95
Significance of treatment effect (P value)	0.1757	0.2314	0.0191	0.0085	0.0011

Yield

We found no differences in yield or seed moisture at harvest in either year (Table 7 and 8). In 2019, yield averaged 8965 pounds per acre averaged across treatments, and seed moisture averaged 13.7 percent. In 2020, our measured yields were uncharacteristically high for the region. Our explanation of the data is that we did our hand harvest in the early morning hours when there was a heavy dew. Because variability across the replicates was low, as indicated by the low coefficient of variation, we believe the data demonstrate relative comparability of herbicide programs, even though absolute values are high. While not statistically significant, there was a trend for the grower standard and the Loyant/SuperWham herbicide programs to have higher yields, which corresponds to the lower weed pressure in those treatments. We did not observe lodging in either year.

Table 7. *2019 harvest results. Yield was adjusted to 14 percent moisture.*

Herbicide Program (Treatment)	Seed Moisture (%)	Yield (lbs/ac)
Loyant-high + Prowl	13.8	9251
Loyant-low + Prowl	13.8	9122
Loyant-high	13.8	8632
Grower standard	14.0	8896
Prowl	13.8	8896
Grower substitute	13.1	8994
Average	13.7	8965
Coefficient of Variation (%)	5	3
Significance of treatment effect (P value)	0.0566	0.5748

Table 8. *2020 harvest results. Seed moisture as reported by the grower was 18.5 percent. Yield was adjusted to 14 percent moisture*.

Herbicide Program (Treatment)	Yield (lbs/ac)
Loyant	12575
Loyant/Clincher	12431
Loyant/Granite	13064
Loyant/RebelEX	12210
Grower standard	13438
Prowl	12335
Loyant/SuperWham	13534
Average	12798
Coefficient of Variation (%)	8
Significance of treatment effect (P value)	0.3755

Conclusions:

The purpose of these trials was to learn the efficacy and crop tolerance of Loyant (florpyrauxifen-benzyl) for weed control in drill-seeded rice in California. We tested Loyant at different rates (2019) and in combination with other products (2020). We observed Loyant to have good activity on the *Echinochloa* species but not on sprangletop, which was expected based on previous company trials. We observed Loyant treatments to have similarly low weed counts compared to the grower standard, and a Loyant/SuperWham herbicide program appears to provide comparable weed control to the grower standard. Tank mixes will be needed to manage sprangletop. We observed leaf rolling symptoms with the Loyant treatments which has been associated with stressed rice in prior testing. The Loyant label in review at the CA Department of Pesticide Regulation includes a statement about crop stress or environmental factors potentially impacting efficacy and crop tolerance. We did not, however, observe that the leaf rolling impacted yield. There were no significant differences in yield among the treatments in either year. These results demonstrate that Loyant could be used in drill-seeded rice herbicide programs, providing a different chemistry for herbicide resistance management.

The aforementioned information on products and practices is for educational purposes only and does not constitute an endorsement or recommendation by the University of California.

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