ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2022 – December 31, 2022

PROJECT TITLE: Emerging Weed Issues in Rice

PROJECT LEADER AND PRINCIPAL INVESTIGATORS:

Project Leader:
Whitney Brim-DeForest, CE Farm Advisor, Sutter, Yuba, Placer, and Sacramento Co.

Principal UC Investigators:
Luis Espino, CE Farm Advisor, Butte, Glenn Co.

Field and Greenhouse Operations:
Troy Clark, Jr. Specialist, UCCE Sutter-Yuba, UCCE Butte County
Marco Giron, Jr. Specialist, UCCE Sutter-Yuba, UCCE Butte County
Taiyu Guan, Assistant Specialist, UCCE Sutter-Yuba

LEVEL OF 2022 FUNDING: $34,729

OBJECTIVES OF PROPOSED RESEARCH:
1. To continue working with the UC Davis herbarium to further refine identification of the different watergrass species
2. To create a new key for watergrass identification in rice
3. To refine the online map to display the 2019 weed species survey results
4. To further analyze the data produced up to this point to distribute to growers
5. To provide individual reports of all of the watergrass herbicide screening results to the growers and PCA's who provided samples in 2020

BACKGROUND AND SUMMARY:
Over the past several years, there have been several new weed species identified, including *Ludwigia decurrens* (winged water primrose), 6 biotypes of weedy rice, and possibly 2 new species or sub-species of *Echinochloa* spp. (watergrasses). Likewise, the California Department of Food and Agriculture has placed restrictions on Ludwigia and *Monochoria vaginalis* (false pickerelweed), in terms of seed production. For monochoria, this was partially because we were unable to establish a range for the weed. Only a couple of locations were recorded, although anecdotal evidence suggests that it is widespread throughout the rice-growing region. All of these instances occurred within the last 5-6 years and came as a relative surprise to the industry and growers. The last weed survey was conducted in the 1980's.

In 2017, at least 2 fields were identified with an unknown watergrass biotype. After extensive attempts at identification at both the UC Davis Herbarium, and with two *Echinochloa* experts at two other universities, we were unable to conclusively identify the species. An additional attempt at identification was undertaken in a joint effort with Amar Godar (former SRA with Kassim Al-Khatib) and Ellen Dean (at the UC Davis herbarium) using multiple samples from the herbicide resistance screening samples. These results were also inconclusive. Since identification appears difficult, the research team has been focusing on control methods in the meantime.

The overall goal of this research is to continue to address emerging weed issues promptly. In 2019, we collected a survey of soil samples from across the rice-growing region, to establish a baseline of the weed species and biotypes present across the California rice region. This was in response to the growing list of new weeds identified in the past 5 to 10 years. In 2020 we finished the baseline survey, concluded the herbicide screening for the 2018 watergrass samples, and conducted a larger watergrass survey. In 2021, we conducted the herbicide screening for the 2020 watergrass samples (two replications), and the phenotyping of the same samples (two replications). We submitted representative samples of each to the UC Davis herbarium.

In 2022, we reanalyzed data from the herbicide screenings, sent reports to all 64 growers and PCAs, made contacts and connections to further our watergrass identification and studies, and finished the website hosting the ArcGIS maps for the 2019 rice weed survey.

OBJECTIVES AND EXPERIMENTS CONDUCTED, BY LOCATION, TO ACCOMPLISH OBJECTIVES:

Objective 1: To continue working with the UC Davis herbarium to further refine identification of the different watergrass species

In 2021, we submitted 64 representative samples from our watergrass survey to the UC Davis herbarium. By spring of 2022, samples had dried enough to begin to work on identification. In spite our best efforts, we were unable to conclusively identify the species. In spite of the lack of identification, the samples are now housed permanently at the UC Davis herbarium, and can be accessed once we have more information on identification.

Brim-DeForest has been reaching out to scientists worldwide for assistance with the identification, and as of January 2023, has been in contact with a researcher from Texas who has the same species. She will be working with him to identify the species. She also will be working on a genetic analysis, possibly with a professor from Japan who previously collaborated with Albert Fischer, or with a researcher from Colorado State who is working on other *Echinochloa* spp.

Objective 2: To create a new key for watergrass identification in rice

Due to the lack of ability to identify the new species, the team will continue to work on refining the phenotypic characteristics of the watergrass species. Brim-DeForest made contact with a Turkish weed scientist also working with *Echinochloa* spp., and plans to work with him to jointly develop key characteristics to make a key possible. Once finalized, the key will be published through UCANR (to be peer-reviewed), and will be made widely available to the rice industry.

Objective 3: To refine the online map to display the 2019 weed species survey results

3.1 In the fall of 2019, a comprehensive survey took place by soil sampling from fields in each major rice-growing county. Fields were randomly selected: 10 from Glenn, Butte, Sutter, and Colusa Counties, 5 from Yolo and Yuba Counties, and 2 from Sacramento and Placer Counties (Figure 1).

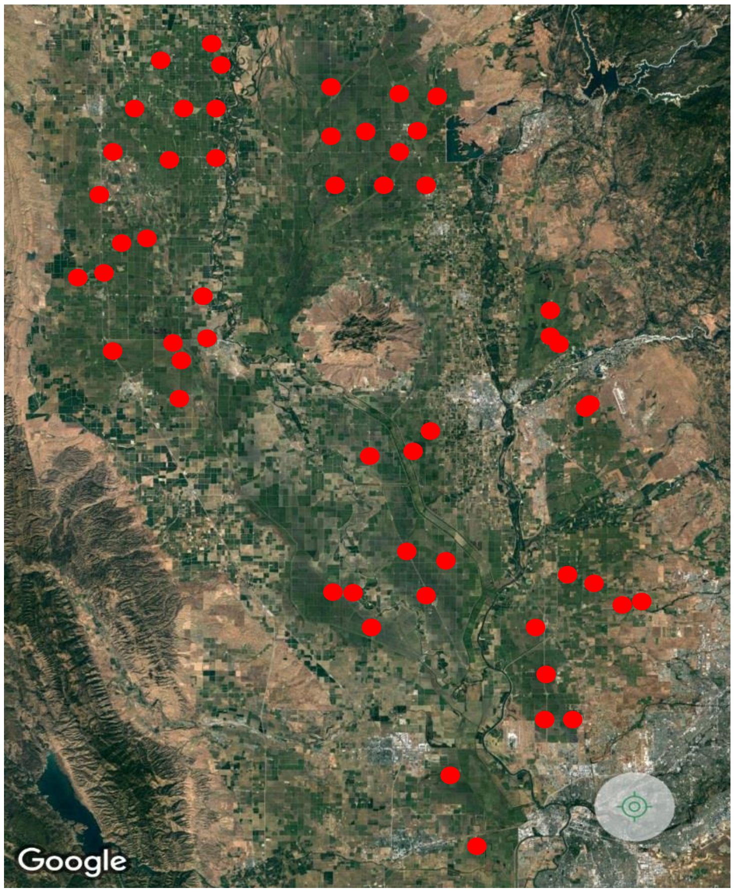

Figure 1. *Locations (in red) of the sampling locations of the 2019 weed survey, which took place in October-November 2019. The number of sites per county was as follows: 10 in Butte, Sutter, Colusa, and Glenn counties, 5 in Yuba and Yolo counties, and 2 in Sacramento and Placer counties.*

The samples were collected after the rice harvest, from October to November. Each field was sampled four times, randomly throughout the field, approximately a gallon of soil for each sample, for a total of approximately 4 gallons of soil from the top 6 inches of soil in each field. The samples were wet-chilled in freezers (to break dormancy) until the beginning of January 2020. Samples were then placed in pots and grown out in the Department of Plant Biology greenhouses in Davis, CA for approximately 3-4 months. Each sample (four per location) were split equally into two 12-in by 12-in flats: one pot was flooded and one pot was kept at saturation (0 mPa). The total number of pots per location was 8 (4 flooded, 4 flushed). The two types of irrigation per sample were to ensure that weeds species that emerge under only one irrigation type versus the other were allowed to emerge.

Each soil sample was marked simply for the presence or absence of known weed species. Any unidentifiable or unknown species were grown to flowering and were identified by Advisor Brim-DeForest. Samples were averaged per field, and averages for all samples in each county are summarized in Table 1 (only major weed species at this time).

Table 1. *Presence-absence of each major weed species in rice over the major 8 rice-growing counties. For each county, the percentage of samples is the average of the samples per field, averaged over the number of sites per county.*

	Percentage of Locations (1 or more samples at site with species present)													
	Arrowhead	**Barnyard grass**	**Bulrush**	**Ducksalad**	**Early WG**	**Junglerice**	**Late WG**	**Monochoria**	**Redstem**	**Smallflower**	**Spranglestop**	**Waterhyssop**	**Cattail**	**Rice**
Glenn	0	10	30	90	0	0	20	0	100	100	10	80	10	80
Butte	0	20	80	100	0	0	10	10	100	100	40	100	0	80
Sutter	0	40	60	100	10	0	0	0	100	100	30	100	10	100
Colusa	0	40	90	100	10	0	10	0	100	100	10	100	30	100
Yolo	0	0	0	80	0	0	0	0	100	100	40	100	40	60
Yuba	0	20	20	100	0	0	20	0	100	100	20	100	40	100
Placer	0	0	100	100	0	0	0	0	100	100	0	100	0	50
Sacramento	0	0	50	100	0	0	0	0	100	100	50	100	0	0

Results. Data analysis indicates that redstem and smallflower umbrella sedge were the only two weed species found across all sites and counties. Ducksalad was found in all counties, as was waterhyssop, but not 100% of sites in each of those counties. Surprisingly, arrowhead was not found at any sites in any county. Junglerice was not found in any counties at any sites either, but junglerice tends to be found primarily around field edges, so the results are not surprising. Arrowhead is normally not a widespread species and often occurs around field edges. Bulrush was widespread (across all but Yolo counties), but was not found at 100% of sites in each county. Late watergrass, early watergrass, and barnyardgrass were found in all counties except for Placer, Sacramento, and Yolo counties. This could partially be because rice is not the primary crop in those counties, so there may be some crop rotation occurring in those fields.

The weed species survey was completed in 2020. In order to ensure that the data is available to growers, registrants, and other industry members, it needs to be easily accessible. Brim-DeForest has summarized the data by species across sites, as well as per site, and all maps have been loaded into ArcGIS. All of the data is available at: https://sites.google.com/ucdavis.edu/californiariceweedssurvey2019, and some representative maps can be found in Appendix 1.

Objective 4: To further analyze the data produced up to this point to distribute to growers

4.1 Herbicide Screening 2020 Samples. The 64 samples collected in 2020 were the same samples used in the phenotypic analysis of weedy rice (Table 2). The herbicides used for screening were: clomazone (Cerano®), thiobencarb (Bolero®), cyhalofop (Clincher®), benzobicyclon+halosulfuron (Butte®), penoxsulam (Granite GR®), bispyribac-sodium (Regiment®), and propanil (Stam® or SuperWham®). Rates were the recommended label rate (Table 3) with at least 4 replications per herbicide-sample combination.

Table 2. *Preliminary phenotypic identification for watergrass (Echinochloa sp.) samples used in herbicide screening.*

Description	Tentative Identification	No. of Samples	Percentage (%)
Small seeds, long awns	New biotype	22	34.4
Extra small seeds, no awns	Junglerice	2	3.1
Small seeds, variable awns	Barnyardgrass	31	48.4
Large seeds no awns	Watergrass	9	14.1

Screenings took place at the Rice Experiment Station greenhouse in Biggs, CA, starting in the summer of 2021. The foliar applications and granular applications were conducted at different timings, and each was replicated twice in time. There were 3 replications of each treatment per sample. All formulations were tested at the 1.5-2 leaf stage of the watergrass. Dormancy was broken for the watergrass by wet-chilling in the fridge for approximately two weeks before planting. Pots were seeded and then thinned down to 5 plants per pot. All liquid formulations (Clincher®, SuperWham®, and Regiment®) were applied with the label-recommended surfactant (crop oil, crop oil, and Dyneamic®, respectively). Applications for into the water herbicides were made onto the water surface of bins that were flooded to 4” above the soil surface of the pots (where the watergrass was planted). All herbicide treatments were applied with a cabinet track sprayer with an 8001-EVS nozzle delivering 40 gallons of spray solution per acre (at a pressure of approximately 20 psi). At 7 days after treatment, plants were evaluated for visual percent control (in comparison to an untreated control). At 14 days after treatment, the number of living plants per pot was counted, and fresh biomass was measured (per pot) by cutting plants at the soil surface and taking the weight (per pot). Dry biomass was measured after drying the fresh weight samples down to a constant weight.

Table 3. *Rates of herbicide applied in the 2020 herbicide screening on watergrass species. All rates are the recommended field rate, not the highest labeled rate.*

Trade Name	Active Ingredient	Rate
Cerano®	Clomazone	12 lb a^{-1}
Bolero®	Thiobencarb	23.3 lb a^{-1}
Butte®	Benzobicyclon + Halosulfuron	7.5 lb a^{-1}
Granite GR®	Penoxsulam	15 lb a^{-1}
Clincher®	Cyhalofop	15 fl oz a^{-1}
Regiment®	Bispyribac-sodium	0.57 oz a^{-1}
SuperWham®	Propanil	6 qt a^{-1}

Results. The majority of the samples of all species are resistant to all of the tested herbicides, with only SuperWham®/Stam® and Cerano® showing control of approximately 50% (or more) of the samples (Table 4 and 5). Late watergrass is widely resistant to all of the herbicides tested, with only SuperWham®/Stam® showing some degree of control of roughly 50% of the samples. Surprisingly, 100% of samples tested were resistant to Bolero®, Butte®, Clincher®, Regiment®, and Granite GR®.

The new biotype is best controlled with Cerano® (50% of samples) or SuperWham®/Stam® (76% of samples). Barnyardgrass is best controlled by SuperWham®/Stam® (90% of samples), and Cerano® (45% of samples).

Although the new biotype shows widespread resistance, its impact on yields is likely explained by more than just herbicide resistance and is likely due to its competitive ability as well.

Table 4. *Percentage of total samples that are uncontrolled (tolerant) per species/herbicide combination for the foliar-applied herbicides.*

	Samples (%)		
Identification	**cyhalofop (R)**	**propanil (R)**	**bispyribac-sodium (R)**
Barnyardgrass (*E. crus-galli*)	74	10	84
Junglerice (*E. colona*)	0	50	50
Late Watergrass (*E. phyllopogon*)	100	56	100
New Biotype (*Echinochloa* sp.)	77	14	91
Total	**77**	**19**	**88**

Table 5. *Percentage of total samples that are uncontrolled (tolerant) per species/herbicide combination for the granular-applied herbicides.*

Identification	Samples (%)			
	thiobencarb (R)	**benzobicyclon + halosulfuron (R)**	**clomazone (R)**	**penoxsulam (R)**
Barnyardgrass (*E. crus-galli*)	87	77	55	84
Junglerice (*E. colona*)	0	50	0	50
Late Watergrass (*E. phyllopogon*)	100	100	67	100
New Biotype (*Echinochloa* sp.)	91	82	50	91
Total	**88**	**81**	**53**	**88**

.

4.2 Field Testing of Experimental Herbicides. A field experiment was conducted in a grower's field in 2019 in Yuba County in cooperation with an herbicide manufacturer (results are not available for publication at this time). The manufacturer had seen promising results in watergrass control in 2018 in an experimental trial in Butte County and wanted to see if the results were replicable in another location. This particular Yuba County field was first identified in 2017, and it had an unidentifiable watergrass population at the time that had not been controlled with several different herbicides (with multiple applications). In the 2019 experiment, we tested an experimental chemical against a registered chemical. Unfortunately, the results were not promising, showing little to no control of the watergrass in this field.

In 2020, the same experimental chemical was tested at a grower's field in Glenn County. The biotype in the field was multiple-herbicide-resistant late watergrass (*Echinochloa phyllopogon*), resistant to thiobencarb and ALS-inhibitors. The chemical did appear to have a small (but insignificant) amount of control on the late watergrass biotype.

In 2021, the same experimental chemical was tested at two different grower's fields, both in Colusa County. The biotypes in one field were late watergrass (unknown susceptibility, but was controlled by grower-applied herbicides in the surrounding field), and in the other field, the unknown biotype, late watergrass, and barnyardgrass. The grasses were not well-controlled in either field, but grass pressure was very high, especially in the second field.

In 2022, the experimental chemical was tested again, but unfortunately the field was oversprayed by propanil shortly after the experimental herbicide applications, and so no data was collected.

We also collaborated with UPL in 2022, to try a tank mix combination study for late season watergrass control, to provide alternative options to growers beyond the propanil-propanil application, as we are concerned about the development of resistance (Table 6). Phytotoxicity was low with all of the combinations, with the exception of Regiment followed by SuperWham, which had severe stunting (Table 7). Weed control (of watergrass) was good, with SuperWham +

Shark and SuperWham + Loyant providing the best control (Table 8). Yields were highest in the SuperWham only treatment (Table 9).

Table 6. *Rates for tank mixes of SuperWham (propanil) applied in combination with other herbicides.*

	Treatment	Rate (per Acre)
1	Untreated Control	
2	SuperWham + COC	6 qts + 1% v/v
3	SuperWham + Abolish	6 qts + 2 pt
4	SuperWham + Clincher + COC	6 qts + 15 fl oz + 2% v/v
5	Regiment + Dyneamic + UAN fb SuperWham + COC	0.8 fl oz + 2% v/v fb 6 qts +1 % v/v
6	SuperWham + Shark	6 qts + 4.0 oz
7	SuperWham + Loyant + MSO	6 qts + 1.3 pts + 0.50pts
8	SuperWham + Clincher + Abolish	6 qts + 15 fl oz + 2 pt

Table 7. *Phytotoxicity (% stunting) at 7, 14, and 28 days after application for tank mixes of SuperWham (propanil) applied in combination with other herbicides.*

			Phytotoxicity (Stunting)		
	Treatment	Rate (per Acre)	*7 DAS*	*14 DAS*	*28 DAS*
1	Untreated Control		0.00	0.00	0.00
2	SuperWham + COC	6 qts + 1% v/v	5.00	0.00	0.00
3	SuperWham + Abolish	6 qts + 2 pt	6.25	0.00	0.00
4	SuperWham + Clincher + COC	6 qts + 15 fl oz + 2% v/v	6.25	0.00	0.00
5	Regiment + Dyneamic + UAN fb SuperWham + COC	0.8 fl oz + 2% v/v fb 6 qts +1 % v/v	16.25	25.00	15.00
6	SuperWham + Shark	6 qts + 4.0 oz	7.50	0.00	0.00
7	SuperWham + Loyant + MSO	6 qts + 1.3 pts + 0.50pts	8.75	0.00	0.00
8	SuperWham + Clincher + Abolish	6 qts + 15 fl oz + 2 pt	6.25	0.00	0.00

Table 8. *Percent weed control (watergrass only) at 7, 14, and 28 days after application compared to the untreated control for tank mixes of SuperWham (propanil) applied in combination with other herbicides.*

			Weed Control (%)		
			7 DAS (6/29/22)	*14 DAS (7/6/22)*	*28 DAS (7/28/22)*
	Treatment	Rate (per Acre)	*Echinochloa spp.*	*Echinochloa spp.*	*Echinochloa spp.*
1	Untreated Control		30.00	26.25	21.25
2	SuperWham + COC	6 qts + 1% v/v	25.00	70.00	56.25
3	SuperWham + Abolish	6 qts + 2 pt	8.33	59.17	77.92
4	SuperWham + Clincher + COC	6 qts + 15 fl oz + 2% v/v	33.33	65.42	71.67
5	Regiment + Dyneamic + UAN fb SuperWham + COC	0.8 fl oz + 2% v/v fb 6 qts +1 % v/v	0.00	47.50	0.00
6	SuperWham + Shark	6 qts + 4.0 oz	45.83	90.00	87.50
7	SuperWham + Loyant + MSO	6 qts + 1.3 pts + 0.50pts	50.00	81.67	83.33
8	SuperWham + Clincher + Abolish	6 qts + 15 fl oz + 2 pt	8.33	50.42	50.42

Table 9. *Yields (lbs/A) for rice, adjusted to 14% moisture for tank mixes of SuperWham (propanil) applied in combination with other herbicides.*

	Treatment	Rate (per Acre)	*Yield (lbs/A)*
1	Untreated Control		9787.36
2	SuperWham + COC	6 qts + 1% v/v	10199.06
3	SuperWham + Abolish	6 qts + 2 pt	9556.62
4	SuperWham + Clincher + COC	6 qts + 15 fl oz + 2% v/v	9992.33
5	Regiment + Dyneamic + UAN fb SuperWham + COC	0.8 fl oz + 2% v/v fb 6 qts +1 % v/v	9558.29
6	SuperWham + Shark	6 qts + 4.0 oz	9928.94
7	SuperWham + Loyant + MSO	6 qts + 1.3 pts + 0.5 pts	9826.63
8	SuperWham + Clincher + Abolish	6 qts + 15 fl oz + 2 pt	9650.92

Objective 5: To provide individual reports of all of the watergrass herbicide screening results to the growers and PCA's who provided samples in 2020

We sent out 64 individualized reports to our collaborators across the rice-growing region, with data on all of the currently-registered herbicides and their efficacy on each field. The reports also contained specific management information tailored to each sample, to provide the best set of tools to each grower or PCA for management of the resistant watergrass, regardless of species. We also provided a preliminary identification for each sample. A sample full report is provided in Appendix 2 (attached).

GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

In 2019, we collected a survey of soil samples from across the rice-growing region, to establish a baseline of the weed species and biotypes present across the California rice region. This was in response to the growing list of new weeds identified in the past 5 to 10 years. The survey was completed in 2020, and we started working last year on putting the results online (in ArcGIS) into a database that can be used for reference of weed species distribution in California rice fields. In 2020, we also concluded the herbicide screening for the 2018 watergrass samples and conducted a larger watergrass survey (collecting 64 samples from across 8 counties). In 2021, we completed a phenotypic analysis for the 64 samples, submitted representative samples of each to the UC Davis herbarium, and completed an herbicide screening with all of the samples using all registered California grass herbicides. In 2022, we completed the ArcGIS maps of weed species, and they are now live at: **https://sites.google.com/ucdavis.edu/californiariceweedssurvey2019**. We reanalyzed the watergrass data to provide a better overall picture of the situation in California, and made several national and international weed science contacts to assist with identification and development of a new key. We continued to test new herbicide combinations for control of watergrass, especially for late-season control.

APPENDIX 1

Sample screenshots from Rice Weed Survey Site:
https://sites.google.com/ucdavis.edu/californiariceweedssurvey2019

Figure 2. *Landing page for UCCE Rice Weed Survey 2019.*

Figure 3. *County-level summarized data for sprangletop in ArcGIS. Larger size circles indicate a greater percentage of sampled fields containing the weed species in each county.*

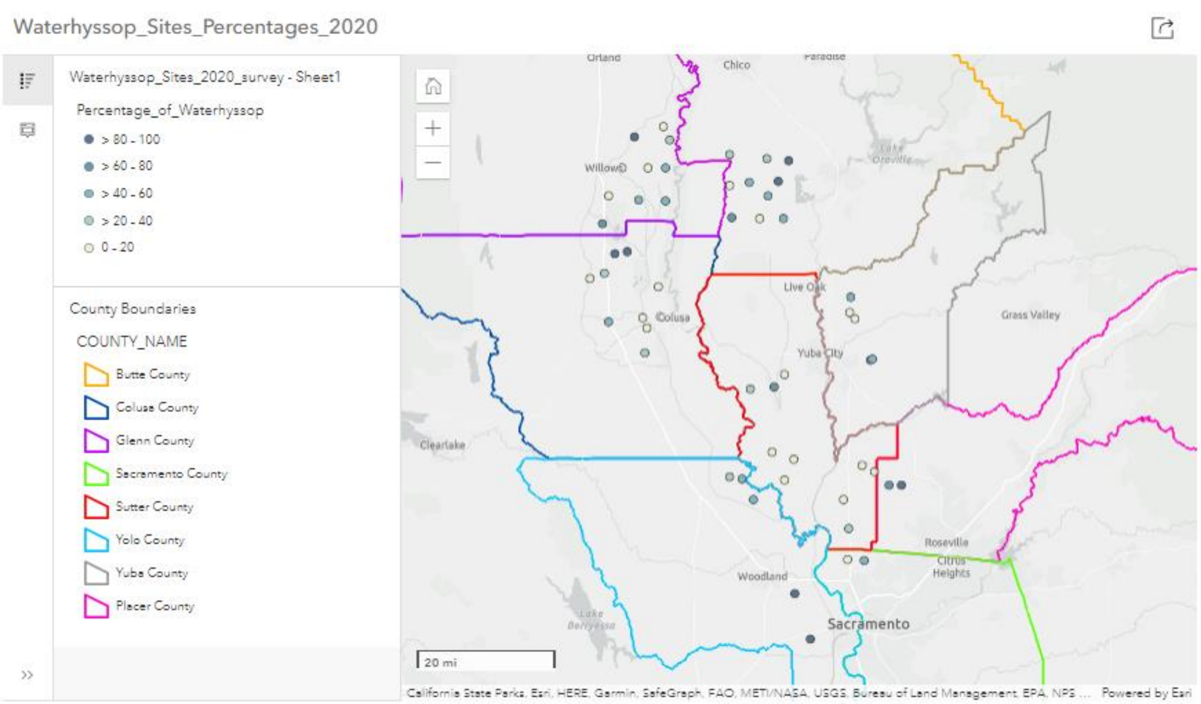

Figure 4. *Site-level summarized data for waterhyssop in ArcGIS. Darker-colored size circles indicate a greater percentage of soil in each sampled field that contain the weed species.*

APPENDIX 2:

Sample grower report:

2021 Greenhouse Herbicide Resistant Watergrass Screening

Grower: [redacted]
Email: [redacted]
County: Yuba
Date Collected: Fall 2020
Field Location: [redacted]
Common Name: Barnyardgrass

Formulation	Herbicide	Active Ingredient	Rate	Susceptible	Resistant	Avg. % Control (Dry Weight)
Foliar	SuperWham	propanil	6 qt a^{-1}	X		95
	Regiment	bispyribac-sodium	0.57 oz a^{-1}	X		76
	Clincher	cyhalofop	15 fl oz a^{-1}	X		87
Granular	Butte	benzobicyclon + halosulfuron	7.5 lb a^{-1}		X	11
	Granite GR	penoxsulam	15 lb a^{-1}		X	19
	Cerano	clomazone	12 lb a^{-1}	X		74
	Bolero	thiobencarb	23.3 lb a^{-1}		X	23

General Recommendations:
Always use maximum label rates for best control (where conditions allow). This screening was conducted using ‘standard’ field rates, so the maximum label rate might provide better control in some cases. When planning an herbicide program, rotate modes of action both between seasons, and within seasons. For example, Bolero (thiobencarb) should not be followed by an application of Abolish (thiobencarb) later in the season. Likewise, Granite GR (penoxsulam), an ALS-inhibitor, should be rotated (between seasons) with a chemical that is not an ALS-inhibitor. For example, Cerano (clomazone), or Bolero/Abolish (thiobencarb).

Whitney Brim-Deforest-Rice Advisor/ County Director wbrimdeforest@ucanr.edu
Taiyu Guan- Assistant Specialist tyguan@ucanr.edu
Troy Clark- Junior Specialist troclark@ucanr.edu
Sutter-Yuba UCCE (530) 822-7515

GRANULAR HERBICIDES:

Benzobicyclon+halosulfuron resistance (Butte):
Your sample showed resistance to Butte (when compared to a susceptible sample). Butte is not a strong grass herbicide, and is only labeled for “suppression”. Use in complement with other early-applied

herbicides such as Cerano or Granite GR. Possible rotational options (for early season applications), are Granite GR (penoxsulam) or Bolero (thiobencarb). A pre-emergent application of Abolish (thiobencarb) may also be an option.

Penoxsulam resistance (Granite GR):
Your sample showed resistance to Granite GR (when compared to a susceptible sample). Possible rotational options (for early season applications), are Cerano (clomazone) or Bolero (thiobencarb). A pre-emergent application of Abolish (thiobencarb) may also be an option).

Thiobencarb resistance (Bolero):
Your sample showed resistance to Bolero (when compared to a susceptible sample). Possible rotational options (for early season applications), are Cerano (clomazone) or Granite GR (penoxsulam). League MVP (thiobencarb + imazosulfuron) and pre-emergent Abolish (thiobencarb) are not recommended as rotational options.

ADDITIONAL OPTIONS FOR GRASS CONTROL :
Deep Water:
Maintaining a deep flood (of at least 4-6 inches) can suppress some grass emergence. Deeper water will provide more suppression. Deep water also improves herbicide efficacy for granular herbicide applications, and the deep water may also improve efficacy of pre-emergent herbicides. Keeping the water on the field as long as possible will improve control. Watergrass typically emerges in the first 30 days after water is put on the field, so longer flood duration is better.

Stale Seedbed:
A stale seedbed has been shown to provide good control of watergrass in heavily infested fields. To implement a stale seedbed, prepare field as normal (in spring). Field can be tilled or untilled. If untilled, please keep in mind that watergrass seeds typically only emerge from the top 6 cm (3-4 inches) of soil.

Once the seedbed is prepared, flood the field until water is 3-4 inches deep, then turn off water and let it sub into the soil. This will increase watergrass germination. Roughly 1-2 weeks later, spray a non-selective herbicide (make sure field is fully drained to ensure coverage). Tillage can also be utilized in place of an herbicide, but avoid deep tillage, as it will bring up additional grass seeds. Timing of herbicide application or tillage will depend on temperature. Warmer temperatures cause faster emergence of grass. Two weeks should be more than enough time to bring up most of the grass population that will be germinable (able-to-germinate), regardless of temperature.

If not planting rice, this process (flushing/flooding, followed by tillage or herbicide application) can be repeated multiple times throughout the season. If planting rice, flood up the field after the application of the non-selective herbicide (follow label for instructions on flood timing).

Rotation to Drill- or Dry-Seeded System:
Drill-seeding or dry-seeding rice allows for the use of Harbinger or Prowl (pendimethalin), which is a different mode of action from all other currently-registered rice herbicides. If using Prowl, it is best used in a drill-seeded system, due to the possible injury to emerging rice plants. Harbinger can be used in a dry-seeded system, where seed is flown on instead of drilled. For more information on application methodology, refer to the herbicide label.