

Weed Control Update

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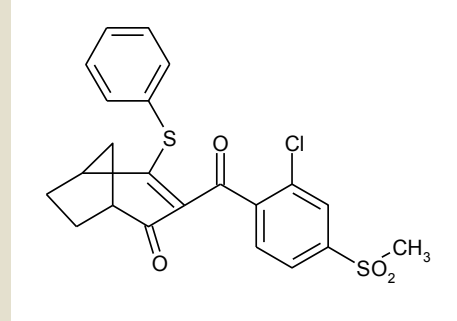
University of California

Outline

- Optimization of Butte herbicide
- Herbicide resistance research
- New herbicides
- Emerging issues

Benzobicyclon

- Benzobicyclon is a pro herbicide: Benzobicyclon hydrolysate (a metabolite) is a potent HPPD inhibitor.



- Butte: benzobicyclon + Halosulfuron
- Benzobicyclon (101 g ai/A) + Halosulfuron (21 g ai/A)
- Lactose based, light weight, granular herbicide formulation
 - Developed specifically for California
- Field Use Rates: 7.5 – 9.0 lbs./A
- Inhibition of 4-HPPD; HRAC: F2, WSSA Group: 27

Herbicidal activity and spectrum

- **Key chemical attributes:**
 - **Low water solubility – 0.052 mg/L**
 - **Strong affinity to soil – Koc 2,989-21,178**
- **Active from both soil and water – exhibits residual characteristics.**
- **Good crop safety**
- **A new mode of action for California & US Rice Production**
- **Potent activity on a broad spectrum of important rice weeds at 101 - 121 g ai/A**

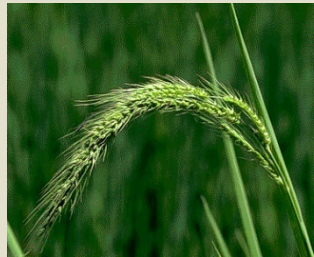
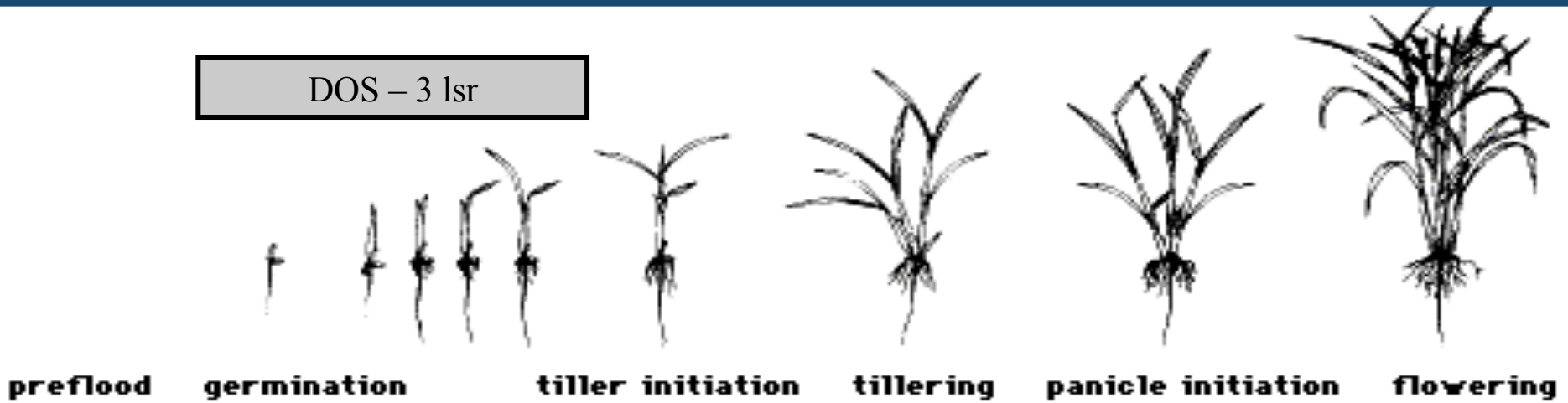


- + control
- no control
- ± suppression

Barnyardgrass
E. watergrass
L. watergrass
Sprangletop
SF umbrella
RF Bulrush
CA arrowhead
Ducksalad
Redstem
Monochoria

| | | | | | | | | | | |
|---------------------|-------|-------|-------|---|---|---|---|-------|----|---|
| Benzo + Halo | + / ± | + / ± | + / ± | + | + | + | ± | + / ± | -- | + |
|---------------------|-------|-------|-------|---|---|---|---|-------|----|---|

DOS – 3 lsr



Watergrass:
½ leaf – 2 leaf



Sprangletop:
PRE – 2.5 leaf



Sedges.:
PRE – 5 leaf



Water Management

4” at time of application

| # | Herbicide programs | Rate/Acre | Timing |
|----|---|--|-------------------|
| 1 | Butte | 7.50 lb | DOS |
| 2 | Butte | 9.00 lb | DOS |
| 3 | Butte | 7.50 lb | 1 lsr |
| 4 | Butte | 9.00 lb | 1 lsr |
| 5 | Butte STAM 80 EDF + Grandstand + COC | 7.50 lb 5.00 lb + 8.00 oz + 2.50% v/v | 1 lsr 1 tiller |
| 6 | Butte Regiment + (NIS + UAN) | 7.50 lb 0.67 oz + (0.25% + 2.00%) v/v | 1 lsr 1 tiller |
| 7 | Butte Clincher + COC | 7.50 lb 13.00 oz + 2.50% v/v | 1 lsr 1 tiller |
| 8 | Butte Granite GR | 7.50 lb 15.00 lb | 1 lsr 2.5 lsr |
| 9 | Butte Granite GR | 7.50 lb 15.00 lb | 1 lsr 5 lsr |
| 10 | Butte Granite SC + COC | 7.50 lb 2.80 oz + 1.25% v/v | 1 lsr 2.5 lsr |
| 11 | Butte Granite SC + COC | 7.50 lb 2.80 oz + 1.25% v/v | 1 lsr 5 lsr |
| 12 | Cerano Butte | 12.00 lb 7.50 lb | DOS 1 lsr |
| 13 | Cerano Butte | 12.00 lb 7.50 lb | DOS DOS |
| 14 | Untreated | - | - |

| Weed Control | | | | | | | | | |
|-------------------------------|-------------------|----------------------------|------------|------------|-------------------------------|-------------------|----------------------------|------------|------------|
| 40 DAS | | | | | 60 DAS | | | | |
| Late watergrass/Barnyardgrass | Ricefield bulrush | Smallflower umbrella sedge | Duck salad | Monochoria | Late watergrass/Barnyardgrass | Ricefield bulrush | Smallflower umbrella sedge | Duck salad | Monochoria |
| 93 | 100 | 100 | 100 | - | 91 | 100 | 100 | - | 100 |
| 91 | 100 | 100 | 100 | - | 90 | 100 | 100 | - | 100 |
| 88 | 100 | 100 | 100 | - | 86 | 100 | 100 | - | 100 |
| 90 | 100 | 100 | 100 | - | 88 | 100 | 100 | - | 100 |
| 99 | 100 | 100 | 100 | - | 99 | 100 | 100 | - | 100 |
| 99 | 100 | 100 | 100 | - | 99 | 100 | 100 | - | 100 |
| 98 | 100 | 100 | 100 | - | 97 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 99 | 100 | 100 | 100 | - | 99 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 99 | 100 | 100 | 100 | - | 98 | 100 | 100 | - | 100 |
| 99 | 100 | 100 | 100 | - | 99 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |

| Crop Injury | | | | | | Price ^a |
|-----------------|-----------|----------|-----------------|-----------|----------|--------------------|
| 20 DAS | | | 40 DAS | | | |
| Stand reduction | Bleaching | Stunting | Stand reduction | Bleaching | Stunting | |
| 8 | 0 | 12 | 2 | 0 | 0 | \$91.9 |
| 10 | 0 | 15 | 3 | 0 | 0 | \$110.3 |
| 8 | 0 | 9 | 3 | 0 | 0 | \$91.9 |
| 11 | 0 | 12 | 8 | 0 | 0 | \$110.3 |
| 7 | 0 | 8 | 0 | 0 | 0 | \$148.1 |
| 6 | 0 | 7 | 2 | 0 | 0 | \$128.7 |
| 8 | 0 | 9 | 3 | 0 | 0 | \$134.0 |
| 8 | 0 | 9 | 5 | 0 | 0 | \$155.6 |
| 7 | 0 | 8 | 3 | 0 | 0 | \$155.6 |
| 8 | 0 | 7 | 3 | 0 | 0 | \$147.9 |
| 10 | 0 | 7 | 4 | 0 | 3 | \$147.9 |
| 9 | 0 | 9 | 5 | 0 | 0 | \$154.4 |
| 8 | 0 | 8 | 5 | 0 | 0 | \$154.4 |
| 0 | 0 | 0 | 0 | 0 | 0 | - |

Butte-based programs in comparison to other programs

| # | Herbicide programs | Rate/Acre | Timing |
|---|---|--|-------------------------------|
| 1 | Untreated | - | - |
| 2 | Butte Grandstand + STAM 80 EDF + COC | 7.50 lb 6.00 oz + 5.00 lb + 1.00% v/v | DOS 1 tiller |
| 3 | Butte Londax + STAM 80 EDF + COC | 7.50 lb 1.33 oz + 5.00 lb + 1.00% v/v | DOS 1 tiller |
| 4 | Cerano Grandstand + STAM 80 EDF + COC STAM 80 EDF + COC | 12.00 lb 6.00 oz + 5.00 lb + 1.00% v/v 5.00 lb + 1.00% v/v | DOS 1 tiller Mid tiller |

| | | | |
|---|------------------------------------|---------------------------------|-------------------|
| 1 | Untreated | - | - |
| 2 | Butte | 7.50 lb | 2 lsr |
| 3 | Butte Regiment + Dyne-Amic | 7.50 lb 0.67 oz + 1.25% v/v | DOS 1 tiller |
| 4 | League MVP | 30.00 lb | 2 lsr |
| 5 | League MVP Regiment + Dyne-Amic | 30.00 lb 0.67 oz + 1.25% v/v | 2 lsr 1 tiller |
| 6 | Untreated | - | - |

| | | | |
|---|---|--|-----------------------------|
| 1 | Untreated | - | - |
| 2 | Bolero Regiment + Dyne-Amic STAM 80 EDF + COC | 23.30 lb 0.67 oz + 1.25% v/v 5.00 lb + 1.00% v/v | 2 lsr 1 tiller 35 DAS |
| 3 | League MVP Regiment + Dyne-Amic | 30.00 lb 0.67 oz + 1.25% v/v | 2 lsr 1 tiller |
| 4 | Butte Regiment + Dyne-Amic | 7.50 lb 0.67 oz + 1.25% v/v | 2 lsr 1 tiller |

| Weed Control | | | | | | | | | |
|-------------------------------|-------------------|----------------------------|------------|------------|-----------------|-------------------|----------------------------|------------|------------|
| 40 DAS | | | | | 60 DAS | | | | |
| Late watergrass/Barnyardgrass | Ricefield bulrush | Smallflower umbrella sedge | Duck salad | Monochoria | Late watergrass | Ricefield bulrush | Smallflower umbrella sedge | Duck salad | Monochoria |
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |
| 97 | 100 | 100 | 100 | - | 97 | 100 | 100 | - | 100 |
| 96 | 100 | 100 | 100 | - | 97 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |

| | | | | | | | | | |
|----|-----|-----|-----|---|----|-----|-----|---|-----|
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |
| 82 | 100 | 96 | 100 | - | 81 | 100 | 100 | - | 100 |
| 98 | 100 | 100 | 100 | - | 98 | 100 | 100 | - | 100 |
| 95 | 100 | 100 | 100 | - | 96 | 100 | 100 | - | 100 |
| 96 | 100 | 100 | 100 | - | 95 | 100 | 100 | - | 100 |
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |

| | | | | | | | | | |
|----|-----|-----|-----|---|----|-----|-----|---|-----|
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |
| 95 | 100 | 100 | 100 | - | 92 | 100 | 100 | - | 100 |
| 98 | 100 | 100 | 100 | - | 98 | 100 | 100 | - | 100 |
| 99 | 100 | 100 | 100 | - | 99 | 100 | 100 | - | 100 |

| Crop Injury | | | | | | | |
|-----------------|-----------|----------|-----------------|-----------|----------|---------|---------|
| 20 DAS | | | 40 DAS | | | Price* | |
| Stand reduction | Bleaching | Stunting | Stand reduction | Bleaching | Stunting | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | - |
| 9 | 0 | 3 | 4 | 0 | 4 | | \$146.2 |
| 7 | 0 | 4 | 5 | 0 | 6 | | \$163.4 |
| 24 | 35 | 28 | 21 | 0 | 17 | \$163.1 | |

| | | | | | | |
|---|---|----|---|---|---|---------|
| 0 | 0 | 0 | 0 | 0 | 0 | - |
| 5 | 0 | 3 | 1 | 0 | 1 | \$91.9 |
| 4 | 0 | 2 | 1 | 0 | 0 | \$141.2 |
| 2 | 0 | 9 | 2 | 0 | 1 | \$64.8 |
| 2 | 0 | 10 | 3 | 0 | 2 | \$114.1 |
| 0 | 0 | 0 | 0 | 0 | 0 | - |

| | | | | | | |
|---|---|---|---|---|---|---------|
| 0 | 0 | 0 | 0 | 0 | 0 | - |
| 6 | 0 | 9 | 4 | 0 | 3 | \$149.2 |
| 3 | 0 | 5 | 2 | 0 | 2 | \$114.1 |
| 2 | 0 | 5 | 1 | 0 | 2 | \$141.2 |

Butte-based programs in comparison to other programs

| # | Herbicide programs | Rate/Acre | Timing |
|---|---|--|-------------------------------|
| 1 | Untreated | - | - |
| 2 | Butte Grandstand + STAM 80 EDF + COC | 7.50 lb 6.00 oz + 5.00 lb + 1.00% v/v | DOS 1 tiller |
| 3 | Butte Londax + STAM 80 EDF + COC | 7.50 lb 1.33 oz + 5.00 lb + 1.00% v/v | DOS 1 tiller |
| 4 | Cerano Grandstand + STAM 80 EDF + COC STAM 80 EDF + COC | 12.00 lb 6.00 oz + 5.00 lb + 1.00% v/v 5.00 lb + 1.00% v/v | DOS 1 tiller Mid tiller |

| | | | |
|---|------------------------------------|---------------------------------|-------------------|
| 1 | Untreated | - | - |
| 2 | Butte | 7.50 lb | 2 lsr |
| 3 | Butte Regiment + Dyne-Amic | 7.50 lb 0.67 oz + 1.25% v/v | DOS 1 tiller |
| 4 | League MVP | 30.00 lb | 2 lsr |
| 5 | League MVP Regiment + Dyne-Amic | 30.00 lb 0.67 oz + 1.25% v/v | 2 lsr 1 tiller |
| 6 | Untreated | - | - |

| | | | |
|---|---|--|-----------------------------|
| 1 | Untreated | - | - |
| 2 | Bolero Regiment + Dyne-Amic STAM 80 EDF + COC | 23.30 lb 0.67 oz + 1.25% v/v 5.00 lb + 1.00% v/v | 2 lsr 1 tiller 35 DAS |
| 3 | League MVP Regiment + Dyne-Amic | 30.00 lb 0.67 oz + 1.25% v/v | 2 lsr 1 tiller |
| 4 | Butte Regiment + Dyne-Amic | 7.50 lb 0.67 oz + 1.25% v/v | 2 lsr 1 tiller |

| Weed Control | | | | | | | | | |
|-------------------------------|-------------------|----------------------------|------------|------------|-----------------|-------------------|----------------------------|------------|------------|
| 40 DAS | | | | | 60 DAS | | | | |
| Late watergrass/Barnyardgrass | Ricefield bulrush | Smallflower umbrella sedge | Duck salad | Monochoria | Late watergrass | Ricefield bulrush | Smallflower umbrella sedge | Duck salad | Monochoria |
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |
| 97 | 100 | 100 | 100 | - | 97 | 100 | 100 | - | 100 |
| 96 | 100 | 100 | 100 | - | 97 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |

| | | | | | | | | | |
|----|-----|-----|-----|---|----|-----|-----|---|-----|
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |
| 82 | 100 | 96 | 100 | - | 81 | 100 | 100 | - | 100 |
| 98 | 100 | 100 | 100 | - | 98 | 100 | 100 | - | 100 |
| 95 | 100 | 100 | 100 | - | 96 | 100 | 100 | - | 100 |
| 96 | 100 | 100 | 100 | - | 95 | 100 | 100 | - | 100 |
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |

| | | | | | | | | | |
|----|-----|-----|-----|---|----|-----|-----|---|-----|
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |
| 95 | 100 | 100 | 100 | - | 92 | 100 | 100 | - | 100 |
| 98 | 100 | 100 | 100 | - | 98 | 100 | 100 | - | 100 |
| 99 | 100 | 100 | 100 | - | 99 | 100 | 100 | - | 100 |

| Crop Injury | | | | | |
|-----------------|-----------|----------|-----------------|-----------|----------|
| 20 DAS | | | 40 DAS | | |
| Stand reduction | Bleaching | Stunting | Stand reduction | Bleaching | Stunting |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 3 | 4 | 0 | 4 |
| 7 | 0 | 4 | 5 | 0 | 6 |
| 24 | 35 | 28 | 21 | 0 | 17 |

| Price* |
|---------|
| - |
| \$146.2 |
| \$163.4 |
| \$163.1 |

| | | | | | | |
|---|---|----|---|---|---|---------|
| 0 | 0 | 0 | 0 | 0 | 0 | - |
| 5 | 0 | 3 | 1 | 0 | 1 | \$91.9 |
| 4 | 0 | 2 | 1 | 0 | 0 | \$141.2 |
| 2 | 0 | 9 | 2 | 0 | 1 | \$64.8 |
| 2 | 0 | 10 | 3 | 0 | 2 | \$114.1 |
| 0 | 0 | 0 | 0 | 0 | 0 | - |

| | | | | | | |
|---|---|---|---|---|---|---------|
| 0 | 0 | 0 | 0 | 0 | 0 | - |
| 6 | 0 | 9 | 4 | 0 | 3 | \$149.2 |
| 3 | 0 | 5 | 2 | 0 | 2 | \$114.1 |
| 2 | 0 | 5 | 1 | 0 | 2 | \$141.2 |

Butte – Granite based program

| # | Herbicide programs | Rate/Acre | Timing |
|---|--|---|-----------------------------------|
| 1 | Untreated | - | - |
| 2 | Butte Granite GR | 7.50 lb 15.00 lb | SPIKE LEAF 3.5 Isr |
| 3 | Butte Granite GR Grandstand + STAM 80 EDF + COC | 7.50 lb 15.00 lb 6.00 oz + 5.00 lb + 1.00 % v/v | SPIKE LEAF 3.5 Isr 35 DAS |
| 4 | Butte Granite GR | 7.50 lb 13.00 lb | SPIKE LEAF 3.5 Isr |
| 5 | Butte Granite GR Grandstand + STAM 80 EDF + COC | 7.50 lb 13.00 lb 6.00 oz + 5.00 lb + 1.00 % v/v | SPIKE LEAF 3.5 Isr 35 DAS |
| 6 | Butte Granite SC + COC | 7.50 lb 2.50 oz + 1.00 % v/v | SPIKE LEAF 25-30 DAS |
| 7 | Butte Granite SC + COC Grandstand + STAM 80 EDF + COC | 7.50 lb 2.50 oz + 1.00% v/v 6.00 oz + 5.00 lb + 1.00 % v/v | SPIKE LEAF 25-30 DAS 35 DAS |
| 8 | Cerano Granite SC + COC | 8.00 lb 2.50 oz + 1.00 % v/v | DOS 25-30 DAS |
| 9 | Cerano Granite SC + COC Grandstand + STAM 80 EDF + COC | 12.00 lb 2.50 oz + 1.00% v/v 6.00 oz + 5.00 lb + 1.00 % v/v | DOS 25-30 DAS 35 DAS |

| Weed Control | | | | | | | | | |
|-------------------------------|-------------------|----------------------------|------------|------------|-------------------------------|-------------------|----------------------------|------------|------------|
| 40 DAS | | | | | 60 DAS | | | | |
| Late watergrass/Barnyardgrass | Ricefield bulrush | Smallflower umbrella sedge | Duck salad | Monochoria | Late watergrass/Barnyardgrass | Ricefield bulrush | Smallflower umbrella sedge | Duck salad | Monochoria |
| 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 99 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |
| 100 | 100 | 99 | 100 | - | 100 | 100 | 98 | - | 100 |
| 100 | 100 | 100 | 100 | - | 100 | 100 | 100 | - | 100 |

| Crop Injury | | | | | | Price ^a |
|-----------------|-----------|----------|-----------------|-----------|----------|--------------------|
| 20 DAS | | | 40 DAS | | | |
| Stand reduction | Bleaching | Stunting | Stand reduction | Bleaching | Stunting | |
| 0 | 0 | 0 | 0 | 0 | 0 | - |
| 8 | 0 | 15 | 2 | 0 | 6 | \$155.6 |
| 10 | 0 | 16 | 2 | 0 | 7 | \$201.9 |
| 7 | 0 | 9 | 3 | 0 | 4 | \$147.1 |
| 8 | 0 | 8 | 2 | 0 | 3 | \$193.4 |
| 8 | 0 | 3 | 1 | 0 | 2 | \$143.1 |
| 6 | 0 | 3 | 1 | 0 | 2 | \$197.4 |
| 16 | 21 | 13 | 4 | 0 | 2 | \$92.9 |
| 18 | 19 | 15 | 3 | 0 | 3 | \$147.2 |

Rice yield as affected by Butte and Granite applications

| Treatment | Rate (per acre) | Timing | Stunting (%) | Yield (Ib/A) |
|-----------------|-----------------|--------------|--------------|--------------|
| Butte | 7.5 Ib | 1 1st | 4 | 8.472 |
| Butte + Granite | 7.5 Ib + 2.0 oz | 1 + 3 1st | 10 | 8,529 |
| Butte + Granite | 7.5 Ib + 2.4 oz | 1 + 3 1st | 10 | 8,639 |
| Butte + Granite | 7.5 Ib + 2.8 oz | 1 + 3 1st | 13 | 8,295 |
| Butte + Granite | 7.5 Ib + 2.0 oz | 1 + 5 1st | 4 | 9,397 |
| Butte + Granite | 7.5 Ib + 2.4 oz | 1 + 5 1st | 5 | 9,580 |
| Butte + Granite | 7.5 Ib + 2.8 oz | 1 + 5 1st | 9 | 8,711 |
| Butte + Granite | 7.5 Ib + 2.0 oz | 1 + 1 tiller | 5 | 8,623 |
| Butte + Granite | 7.5 Ib + 2.4 oz | 1 + 1 tiller | 4 | 8,851 |
| Butte + Granite | 7.5 Ib + 2.8 oz | 1 + 1 tiller | 5 | 8,687 |
| LSD (0.05) | | | 10 | 1,454 |

Herbicide Resistance

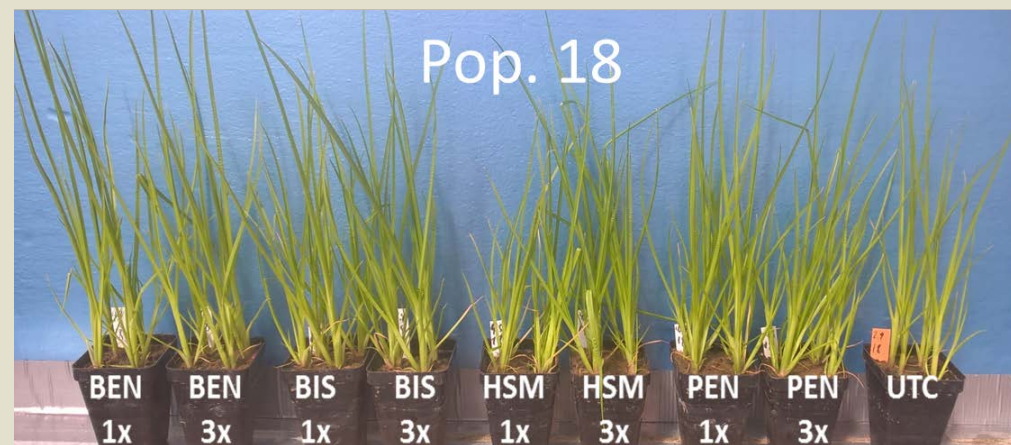
| | Species | Common Name | Year Discovered | Site of Action |
|----|---|----------------------------|-----------------|--|
| 1 | <i>Sagittaria montevidensis</i> | California Arrowhead | 1993 | ALS inhibitors (B/2) |
| 2 | <i>Cyperus difformis</i> | Smallflower Umbrella Sedge | 1993 | ALS inhibitors (B/2) |
| 3 | <i>Ammannia auriculata</i> | Eared Redstem | 1997 | ALS inhibitors (B/2) |
| 4 | <i>Schoenoplectus mucronatus</i> (= <i>Scirpus mucronatus</i>) | Ricefield Bulrush | 1997 | ALS inhibitors (B/2) |
| 5 | <i>Echinochloa phyllopogon</i> (= <i>E. oryzicola</i>) | Late Watergrass | 1998 | ACCase inhibitors (A/1) |
| 6 | <i>Echinochloa phyllopogon</i> (= <i>E. oryzicola</i>) | Late Watergrass | 1998 | Lipid Inhibitors (thiocarbamates) (N/8) |
| 7 | <i>Ammannia coccinea</i> | Redstem | 2000 | ALS inhibitors (B/2) |
| 8 | <i>Echinochloa crus-galli</i> var. <i>crus-galli</i> | Barnyardgrass | 2000 | Multiple Resistance: 2 Sites of Action ACCase inhibitors (A/1) Lipid Inhibitors (thiocarbamates) (N/8) |
| 9 | <i>Echinochloa phyllopogon</i> (= <i>E. oryzicola</i>) | Late Watergrass | 2000 | Multiple Resistance: 2 Sites of Action ACCase inhibitors (A/1) Lipid Inhibitors (thiocarbamates) (N/8) |
| 10 | <i>Echinochloa oryzoides</i> | Early Watergrass | 2000 | Lipid Inhibitors (thiocarbamates) (N/8) |
| 11 | <i>Digitaria ischaemum</i> | Smooth Crabgrass | 2002 | Synthetic Auxins (O/4) |
| 12 | <i>Cyperus difformis</i> | Smallflower Umbrella Sedge | 2013 | PSII inhibitor (Ureas and amides) (C2/7) |
| 13 | <i>Schoenoplectus mucronatus</i> (= <i>Scirpus mucronatus</i>) | Ricefield Bulrush | 2014 | PSII inhibitor (Ureas and amides) (C2/7) |
| 14 | <i>Leptochloa fusca</i> var. <i>fascicularis</i> | Bearded Sprangletop | 2014 | ACCase Inhibitors (A/1) |
| 15 | <i>Leptochloa fusca</i> var. <i>fascicularis</i> | Bearded Sprangletop | 2014 | DOXP inhibitors (F4/13) |

Source: www.weedscience.org

| Species | Registered Herbicides | Modes of Action | Herbicide Resistance Recorded |
|---|-----------------------|-----------------|----------------------------------|
| <i>Echinochloa oryzoides</i> | 8 | 6 | 4 MOA's (multiple-resistance) |
| <i>E. phyllopogon</i> = <i>E. oryzicola</i> | 8 | 6 | 4 MOA's (multiple-resistance) |
| <i>E. crus-galli</i> | 8 | 6 | 2 MOA's (multiple-resistance) |
| <i>Leptochloa fusca ssp. fascicularis</i> | 4 | 3 | 2 MOA's (no multiple resistance) |
| <i>Cyperus difformis</i> | 9 | 4 | 2 MOA's (multiple-resistance) |
| <i>Schoenoplectus mucronatus</i> | 9 | 5 | 2 MOA's (multiple-resistance) |

Smallflower umbrella sedge (*Cyperus difformis*) cross-resistance to ALS inhibitors in California rice fields

- Study was conducted in the weed research greenhouse at the Rice Experiment Station (RES) in Biggs, Ca.
- Seed of 62 suspected-resistant smallflower populations plus a known susceptible were sown into 2.56 inch pots; pots were thinned to 3-4 plants each.
- Treatments were four ALS herbicides applied at two rates plus an untreated control (UTC), for a total of 9 treatments per replication.
 - BSM: Bensulfuron (Londax) @ $1\frac{1}{3}$ & 4oz/ac
 - BIS: Bispyribac (Regiment CA) $\frac{2}{3}$ & 2oz/ac
 - HSM: Halosulfuron (Halomax 75) $1\frac{1}{3}$ & 4oz/ac
 - PEN: Penoxsulam (Granite SC) 2.3 & 6.9oz/ac
- Plant mortality was assessed weekly as an average per pot, on a 0-100% scale of visual injury/ control.
- At harvest (3 WAT) pot-average height and per-plant dry biomass were measured



Survey of sprangletop for clomazone resistance

- Sample from 32 field were treated with clomazone at 1X and 3X the use rate
- Injury ratings, plant height and dry weight were measured

| Clomazone Resistant Bearded Sprangletop | | | |
|---|----|-------------------|------------------|
| Population | NT | 1x | 3x |
| % control | | | |
| 1 | 0 | 100 ^b | 100 ^c |
| 2 | 0 | 37.5 ^a | 60 ^{ab} |
| 3 | 0 | 100 ^b | 100 ^c |
| 4 | 0 | 93 ^b | 100 ^c |
| 5 | 0 | 100 ^b | 100 ^c |
| 6 | 0 | 100 ^b | 100 ^c |
| 7 | 0 | 100 ^b | 100 ^c |
| 8 | 0 | 100 ^b | 100 ^c |
| 9 | 0 | 50 ^a | 91 ^{bc} |
| 10 | 0 | 100 ^b | 100 ^c |
| 12 | 0 | 100 ^b | 100 ^c |
| 13 | 0 | 100 ^b | 100 ^c |
| 15 | 0 | 45 ^a | 50 ^a |
| 17 | 0 | 100 ^b | 100 ^c |
| 18 | 0 | 100 ^b | 100 ^c |
| 19 | 0 | 50 ^a | 50 ^a |
| 20 | 0 | 100 ^b | 100 ^c |
| 21 | 0 | 100 ^b | 100 ^c |
| 28 | 0 | 100 ^b | 100 ^c |
| 31 | 0 | 100 ^b | 100 ^c |
| 32 | 0 | 100 ^b | 100 ^c |

HERBICIDE RESISTANCE TESTING FORM

Name of weed: _____ Date of collection: _____

Submitter Information:

Name: _____
 Email: _____
 Phone #: _____

Grower Information:

Name: _____
 Email: _____
 Phone #: _____

Field/Site Information:

GPS Coordinates: _____
 Township, Section, Range: _____
 Nearest Road: _____
 Size of the farm: _____
 Percentage of farm that is suspected to be resistant: _____
 When was the resistance suspected in this field? _____

Please mark the tentative location of the field on the map



Please draw a brief map of field with location of sampling

How many plants were sampled: _____

| | Herbicides used | | Resistance | | Test result X-Resistant (This is for our purpose, yes/no) |
|----------------|--------------------------|--------------------------|--------------------------|--------------------------|--|
| | In the past | This year | Known | Suspected | |
| Avalon 8 EC | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Balan Ultra | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Cargus MEG | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Clashe CA | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Conquest CA | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Coprin GR | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Coprin SC | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Helios | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Legend MVP | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Legend | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ragwort CA | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| RivEdge 40 DF | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| RivShield 0.5F | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sentinel | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Shark H2O | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Stem 80 EDF CA | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Stem CA | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| SuperWheat CA | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Water Management

Source(s) of water:

- ☐ Pump
☐ Canal
☐ Both

Irrigation management:

- ☐ Continuous flood
☐ Furrow
☐ Lateral method

Was water compromised at least 50% of the season? ☐ Yes ☐ No

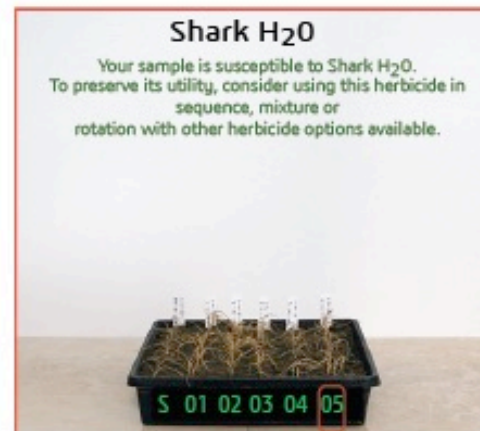
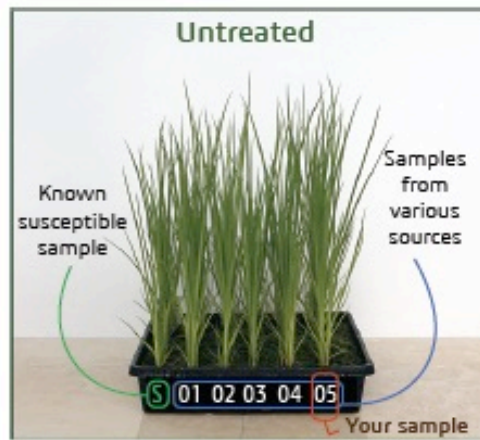
Sample Submission

- Information regarding:
 - Irrigation system
 - Herbicides used in the past
 - Field location



2017 Resistance testing

| Weed | Herbicides |
|-----------------------------|---|
| Echinochloa species complex | Thiobencarb, Cerano, Clincher, Propanil, Regiment, Butte, and Granite |
| Smallflower umbrella sedge | Thiobencarb, Propanil, Londax, Regiment, Granite, Butte, and Shark |
| Ricefield Bulrush | Propanil, Granite, Shark, and Grandstand |
| Redstem | Regiment, Granite, Propanil, and Grandstand |
| Sprangletop | Thiobencarb, Cerano, Butte, and Clincher |



Grower Results

- Growers and PCAs receive results before planting
- Information provided for each herbicide

Susceptible Population

LWG-15-LB



Untreated
Clincher CA
Abolish 8 EC
Granite SC
Regiment CA

Your Sample

LWG-15-04



Untreated
Clincher CA
Abolish 8 EC
Granite SC
Regiment CA

| Resistance status to the herbicides TESTED | Comments on the herbicides NOT TESTED |
|---|--|
| <p>Propanil Yes</p> <p>Londax Yes</p> <p>Strada CA Yes</p> <p>Abolish 8 EC PC</p> <p>Shark H₂O No</p> <p>Yes Your sample is RESISTANT to this herbicide.</p> <p>No Your sample is SUSCEPTIBLE to this herbicide.</p> <p>PC Your sample may have a very low level of resistance to this herbicide which might result in partial control or suppression only. If this herbicide is to be used in the coming season, follow product label recommendations for maximizing its control.</p> | <p>Bolero Ultramax = This herbicide is one of the options.</p> <p>Halomax = As your sample is resistant to Londax and Strada (other ALS-inhibitor herbicides), it is highly likely that your sample has cross resistance to Halomax.</p> <p>Granite GR, Granite SC, Regiment = First, these herbicides are labeled for partial control or suppression of smallflower umbrellasedge. Second, as your sample is resistant to Londax and Strada CA, there is a fair chance that your sample is also resistant to these (Granite GR, Granite SC, Regiment) ALS-inhibitor herbicides. In any case, do not rely exclusively on these herbicides for controlling your smallflower umbrellasedge.</p> <p>RiceEdge (propanil + halosulfuron) = See the comment for Halomax. If your sample is resistant to Halomax, then, this herbicide is NOT an option.</p> <p>League MVP (thiobencarb + imazosulfuron) = Similar control as Bolero Ultramax at minimum. Your sample is likely resistant to ALS-inhibitor component (imazosulfuron) of this pre-mixed herbicide product.</p> |
| <p>NOTES:</p> <p>Enclosed are;</p> <ul style="list-style-type: none"> - 2016 CALIFORNIA RICE WEED HERBICIDE SUSCEPTIBILITY CHART - MY HERBICIDE OPTIONS CHART - HERBICIDE RESISTANCE TESTING FORM (for 2016 season) <p>Feel free to ask questions regarding your sample or other general concerns about weed management in rice. Please use the sample reference # for inquiries.</p> | |

2016-2017 Resistant weed testing

| Weed\Herbicide | Abolish/ Bolero | Butte | Cerano | Clincher | Grandstand | Granite | Halomax | propanil | Regiment | Shark H2O |
|------------------------------------|--------------------|-------|--------|----------|------------|---------|---------|----------|----------|--------------|
| Barnyardgrass [35] | 34 | 0 | 0 | 5 6 | | 25 2 | | 2 26 | 34 | |
| Early watergrass [1] | 1 | | 0 | 0 1 | | 0 1 | | 0 | 1 | |
| Late watergrass [13] | 11 | 0 | 0 | 11 | | 11 | | 0 11 | 11 | |
| Redstem [1] | | | | | 0 | | 1 | 0 | | 0 |
| Ricefield bulrush [1] | | 0 | | | 0 | 1 | | 0 | | 0 |
| Smallflower umbrella sedge [46] | 0 13 | 0 | | | | | 43 | 41 | | 0 6 |
| Sprangletop [20] | 1 | 0 | 4 | 6 | | | | | | |

Numbers in the brackets are the total number of seed samples received

Wherever there are two number > The first = “conclusively resistant”; The second = slightly more tolerant compared to the susceptible control

2017-2018 Testing

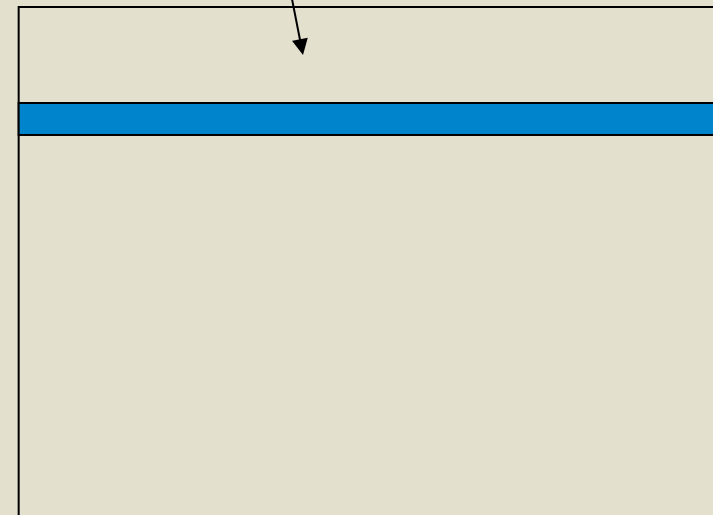
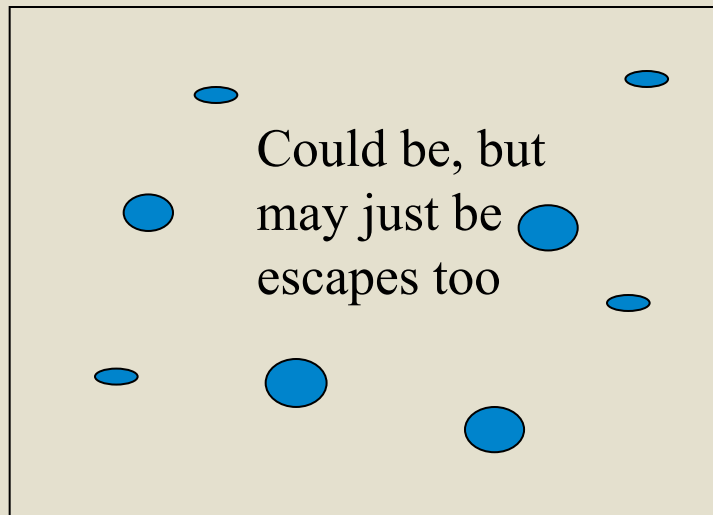
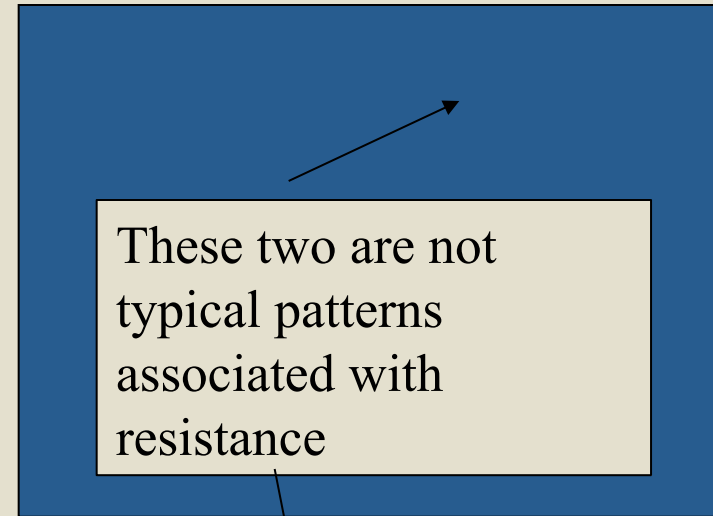
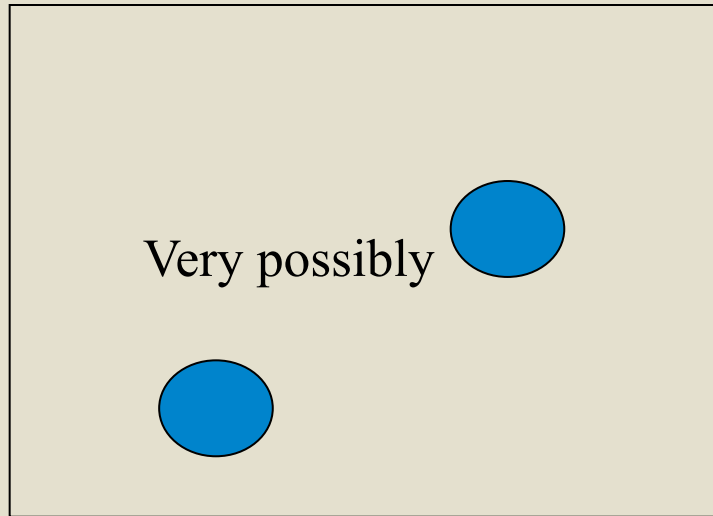
- Barnyardgrass like - 66 (All of them may not be *Echinochloa crus-galli*. Rather many of them could be *E. Muricata* and/or *E. walteri*)
- Late watergrass - 40 + 12 from same location
- Early watergrass - 3
- Sprangletop - 39
- Smallflower - 55
- Bulrush - 6
- Plantain - 3
- Redstem - 8

- Total = 220 + 12

Do I have resistant weeds?

- Failure to achieve expected weed control levels does not in most cases mean that a farmer has resistance
- Herbicide failure result of:
 - Unfavorable environmental conditions
 - Inadequate spray coverage
 - Oversized weed plants at application
- Surviving plants (escapes) in middle of a group of dead plants
- Same herbicide “mode of action” is used for several years

Look for Patterns in Escapes



Effect of water depth on breaded sprangletop in rice fields

- Water depth – 2, 4, 8 inches
- Two populations – Clomazone and susceptible populations
- Measurements: sprangletop population, plant height, number of tiller and seed production



Sprangletop plant growth and development as affected by water depth in rice field

| Population | Water depth (in) | # tiller/plant | Plant height (cm) | Seeds/plant |
|-------------|------------------|-----------------|-------------------|--------------------|
| Susceptible | 2 | 4 ^{ab} | 88 ^{ab} | 1211 ^{bc} |
| Resistant | 2 | 23 ^c | 94 ^b | 1429 ^{bc} |
| Susceptible | 4 | 0 ^a | 0 ^a | 0 ^a |
| Resistant | 4 | 6 ^{ab} | 41 ^{ab} | 1711 ^c |
| Susceptible | 8 | 0 ^a | 0 ^a | 0 ^a |
| Resistant | 8 | 0 ^a | 0 ^a | 0 ^a |

California rice Echinochloa weeds



Barnyardgrass
Echinochloa crus-galli



Early Watergrass
E. oryzoides

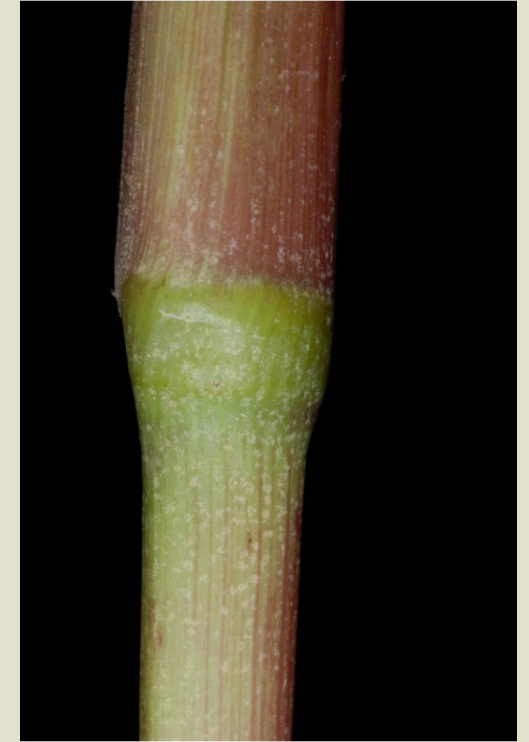


Late Watergrass
E. Phyllopogon



Junglerice, *Echinochloa colona*

Rough barnyardgrass (*Echinochloa muricata*)



Coast Cockspur Grass, *Echinochloa walteri*

