**Evaluation of Canarygrass Control and Potential Herbicide Resistance in Arizona Wheat.**

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## Introduction

Both broadleaf and grass weeds are common early season pests in wheat grown in Arizona. Broadleaf weeds are controlled easily with selective herbicides. Control of grass weeds with herbicides has been more of a challenge due to the importance of application timing and multiple weed germinations. Sequential applications or tank mixes of a broadleaf and grass herbicide has been common. This problem has lessened in recent years with the development of herbicides that can control both grass and broadleaf weeds and weeds that are from the one leaf to elongation stage of growth.

Prior to the mid 1990's Wild Oat *(Avena fatua)* was the primary grass weed in Arizona wheat. This weed was widespread across the county and effective herbicides were developed to control it. By around 1990, wild oat was replaced as the predominant grass weed by Littleseed canarygrass *(Phalaris minor)* in much of Arizona. Other grass weeds that are less common but that still cause significant problems are brome *( Bromus sp.)*, ryegrass *(Lolium sp.)* Rabbitfootgrass *(Polyprogon)* and wild barley *(Hordeum).*

There are seven species of Canarygrass *(Phalaris spp)* that can be found in the southwest. Two of these weeds canarygrass and hardinggrass are perennials. Shortspiked,Carolina,common,hood and littleseed are winter annuals. Littleseed canarygrass became the first documented case of weed resistance in the southwestern deserts in 2001.It was found to be resistant to some of the

ACCase inhibitors. Hood canarygrass was found in the South Gila Valley near Yuma, AZ in 2016. Hood canarygrass is prevalent in the central valley and coast dryland areas of California while littleseed canarygrass is prevalent in the low deserts of Arizona and California.

The purpose of this project was1) To determine if hood canarygrass that was found in the Gila Valley, AZ. in 2016 could be controlled with the herbicides that are used on littleseed canarygrass and 2) to determine if the resistance of Littleseed canary to the ACCase inhibitor herbicides that was found in the Imperial Valley, Ca. in 2001 has spread to Arizona.

**Hood Canarygrass (*Phalaris paradoxa*)**

Hood Canargrass was found in a 20-acre fied of mixed lettuce in the Gila Valley in 2016. Parts of the field had been sprayed with Sethoxydim at 1.5 pts/ac and it was not controlled. We had not previously encountered  this species of canarygrass in the low deserts of Arizona and a trial was established to determine if herbicides used to control littleseed canarygrass (*P.minor*) would be effective. Seven herbicides at their standard rates were included. The results appear in table1-2 and figure 1.

**Table 1**. **Hood Canarygrass Evaluation, Yuma, AZ**

Location: Yuma, AZ
Project ID: Hood Canarygrass
Pest Name: Phalaris paradoxa
Rating Unit: %control
Number of Subsamples 1

Study Director:
Investigator: Barry Tickes.

| Trt No. | Treatment Name | Plot | 1 | | |
|---|---|---|---|---|---|
| 1 | Axial | 101 | 15.0 | | |
| | | 206 | 0.0 | | |
| | | 307 | 0.0 | Mean = | 5.0 |
| 2 | Intensity | 102 | 5.0 | | |
| | | 201 | 5.0 | | |
| | | 302 | 5.0 | Mean = | 5.0 |
| 3 | Poast | 103 | 0.0 | | |
| | | 203 | 0.0 | | |
| | | 308 | 0.0 | Mean = | 0.0 |
| 4 | Fluaziflop | 104 | 0.0 | | |
| | | 207 | 15.0 | | |
| | | 303 | 15.0 | Mean = | 10.0 |
| 5 | Puma | 105 | 0.0 | | |
| | | 205 | 10.0 | | |
| | | 301 | 75.0 | Mean = | 28.3 |
| 6 | Discover | 106 | 0.0 | | |
| | | 202 | 0.0 | | |
| | | 306 | 0.0 | Mean = | 0.0 |
| 7 | Ospray | 107 | 100.0 | | |
| | | 208 | 100.0 | | |
| | | 309 | 90.0 | Mean = 96.7 | |
| 8 | Simplicity | 108 | 10.0 | | |
| | | 204 | 9.0 | | |
| | | 305 | 5.0 | Mean = | 8.0 |
| 9 | UTC | 109 | 0.0 | | |
| | | 209 | 0.0 | | |
| | | 304 | 0.0 | Mean = | 0.0 |

**Table 2. Hood Canarygrass Yuma Agricultural Center AOV Means Table**

Trial ID: Protocol ID:
Location: Study Director:
Project ID: Hood Canarygrass Investigator: Barry Tickes
Pest Name Phalaris paradoxa
Rating Unit %control
Number of Subsamples 1

| Trt No. | Treatment Name | Rate Unit | 1 |
|---|---|---|---|
| 7 | Ospray | 96.7 | a |
| 5 | Puma | 28.3 | b |
| 4 | Fluaziflop | 10.0 | bc |
| 8 | Simplicity | 8.0 | bc |
| 1 | Axial | 5.0 | c |
| 2 | Intensity | 5.0 | c |
| 3 | Poast | 0.0 | c |
| 6 | Discover | 0.0 | c |
| 9 | UTC | 0.0 | c |

| | |
|---|---|
| Replicate F | 0.537 |
| Replicate Prob(F) | 0.5945 |
| Treatment F | 13.439 |
| Treatment Prob(F) | 0.0001 |

Means followed by same letter do not significantly differ (P=.10, LSD)

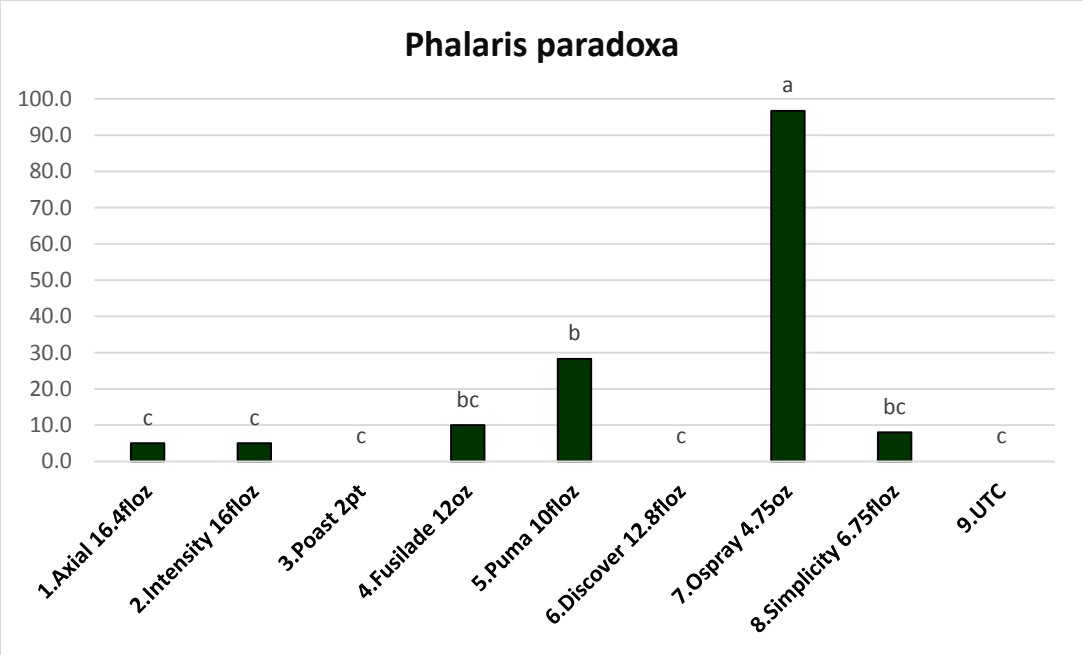

Figure 1. Evaluation results showing control of Hood Canarygrass *(Phalaris paradoxa)*. In this evaluation mesosulfuron was the active ingredient with better performance.

All of the herbicides included in this trial control littleseed canarygrass (*P.minor*) but only one, Osprey, controlled *P.paradoxa*. The herbicides that are used to control canarygrass fall into two modes of action. 1)The ACCase inhibitors which include clodinaflop (Discover), fenoxyprop (Tacoma), quizalaflop (Assure), sethoxydim (Poast) and fluaziflop (Fusilade),pinoxaden (Axial) and 2)The ALS inhibitors which include mesosulfuron (Osprey) and pyroxsulam (Simplicity). Herbicide resistance of Hood canarygrass to the ACCase inhibitors has been found in Australia, Iran, Israel, Italy, Mexico and Syria but has not been reported. In the U.S. Resistance to the ALS inhibitors has not been reported anywhere. It is difficult to determine where the seed for the Hood canarygrass found in the Gila Valley came from and if it was from a resistant population. We can conclude, however, that none of the ACCase herbicides was effective in controlling it. That leaves the ALS inhibitors, Osprey and Simplicity as potential treatments to control this weed if it ever becomes more widespread in Arizona wheat.

Simplicity (Pyroxsulam) was registered in 2013 in Arizona to control grass and broadleaf weeds in wheat. It is now widely used and effective in controlling a broad spectrum of weeds including Littleseed canarygrass. A trial was conducted to determine if this herbicide could also control Hood Canarygrass. The data is presented on tables 3-4 and figures 2-3.

**Table 3. Simplicity GoDri Formulation Comparison, Tolerance, Efficacy Assessment Data Summary *(Phalaris paradoxa)***

| | | | | | | |
|---|---|---|---|---|---|---|
| Rating Date | | | | Mar-27-2018 | | Apr-25-2018 |
| Rating Type | | | | CONTROL % | | CONTROL% |
| Rating Timing | | | | 56DAT | | 56DAT |
| No. | Name | Rate | Unit | Plot | 5 | 8 |
| 1 | Untreated Check | | | 101 | 0.0 | 0.0 |
| | | | | 207 | 0.0 | 0.0 |
| | | | | 306 | 0.0 | 0.0 |
| Mean = | | | | | 0.0 | 0.0 |
| 2 | SIMPLICITY 6.75fl oz/a | | | 102 | 75.0 | 60.0 |
| | ACT 90 0.5 % v/v | | | 203 | 40.0 | 50.0 |
| | | | | 304 | 70.0 | 50.0 |
| Mean = | | | | | 61.7 | 53.3 |
| 3 | SIMPLICITY G 1oz wt/a | | | 103 | 75.0 | 75.0 |
| | ACT 90 0.5% v/v | | | 205 | 80.0 | 50.0 |
| | | | | 301 | 75.0 | 80.0 |
| Mean = | | | | | 76.7 | 68.3 |
| 4 | SIMPLICITY G 1oz wt/a | | | 104 | 80.0 | 70.0 |
| | COC 1% v/v | | | 208 | 70.0 | 80.0 |
| | | | | 302 | 80.0 | 80.0 |
| Mean = | | | | | 76.7 | 76.7 |
| 5 | SIMPLICITY 6.75fl oz/a | | | 105 | 85.0 | 75.0 |
| | ACT90 0.25% v/v | | | 201 | 70.0 | 50.0 |
| | N-Pack 2.5 % v/v | | | 308 | 70.0 | 50.0 |
| Mean = | | | | | 75.0 | 58.3 |
| 6 | SIMPLICITY G 1oz wt/a | | | 106 | 85.0 | 60.0 |
| | ACT 90 0.25% v/v | | | 204 | 60.0 | 60.0 |
| | N-Pack 2.5% v/v | | | 307 | 70.0 | 50.0 |
| Mean = | | | | | 71.7 | 56.7 |
| 7 | SIMPLICITY G 1oz wt/a | | | 107 | 70.0 | 50.0 |
| | AIM 1fl oz/a | | | 202 | 40.0 | 50.0 |
| | ACT 90 0.25% v/v | | | 303 | 65.0 | 50.0 |
| Mean = | | | | | 58.3 | 50.0 |
| 8 | OSPREY 4.75 | oz | wt/a | 108 | 95.0 | 100.0 |
| | ACTIVATOR 90 | 0.5 | % v/v | 206 | 100.0 | 100.0 |
| | N-Pack AMS LIQUID | 2.5 | % v/v | 305 | 100.0 | 95.0 |
| Mean = | | | | | 98.3 | 98.3 |

**Table 4. Simplicity GoDri Formulation Comparison, Tolerance, Efficacy Assessment Data Summary (Phalaris paradoxa)**

| Rating Date | | | | Mar-27-2018 | | Apr-25-2018 | |
|---|---|---|---|---|---|---|---|
| Rating Type | | | | %CONTROL | | %CONTROL | |
| Trt No. | Treatment Name | Rate | Unit | 5 | | 8 | |
| 8 | OSPREY | 4.75 | oz wt/a | 98.3 | a | 98.3 | a |
| | ACTIVATOR 90 | 0.5 | % v/v | | | | |
| | N-Pack | 2.5 | % v/v | | | | |
| 3 | SIMPLICITY G | | oz wt/a | 76.7 | b | 68.3 | bc |
| | ACTIVATOR 90 | 0.5 | % v/v | | | | |
| 4 | SIMPLICITY G | 1 | oz wt/a | 76.7 | b | 76.7 | b |
| | COC | 1 | % v/v | | | | |
| 5 | SIMPLICITY | 6.75 | fl oz/a | 75.0 | b | 58.3 | cd |
| | ACTIVATOR 90 | 0.25 | % v/v | | | | |
| | N-Pack | 2.5 | % v/v | | | | |
| 6 | SIMPLICITY G | 1 | oz wt/a | 71.7 | bc | 56.7 | cd |
| | ACTIVATOR 90 | 0.25 | % v/v | | | | |
| | N-Pack | 2.5 | % v/v | | | | |
| 2 | SIMPLICITY | 6.75 | fl oz/a | 61.7 | bc | 53.3 | d |
| | ACTIVATOR 90 | 0.5 | % v/v | | | | |
| 7 | SIMPLICITY G | 1 | oz wt/a | 58.3 | c | 50.0 | d |
| | AIM | 1 | fl oz/a | | | | |
| | ACTIVATOR 90 | 0.25 | % v/v | | | | |
| 1 | Untreated Check | | 0.0 d | 0.0 | e | | |
| Replicate F | | | | 4.608 | | 1.169 | |
| Replicate Prob(F) | | | | 0.0290 | | 0.3392 | |
| Treatment F | | | | 32.106 | | 33.689 | |
| Treatment Prob(F) | | | | 0.0001 | | 0.0001 | |

Means followed by same letter do not significantly differ (P=.05, LSD)

Pest Type
W, Weed, G-BYRW7, G-WedStg = Weed or volunteer crop
Crop Code
TRZAS, BCER, Triticum aestivum (spring), = US
Part Rated
PLANT = plant
Rating Unit
% = percent

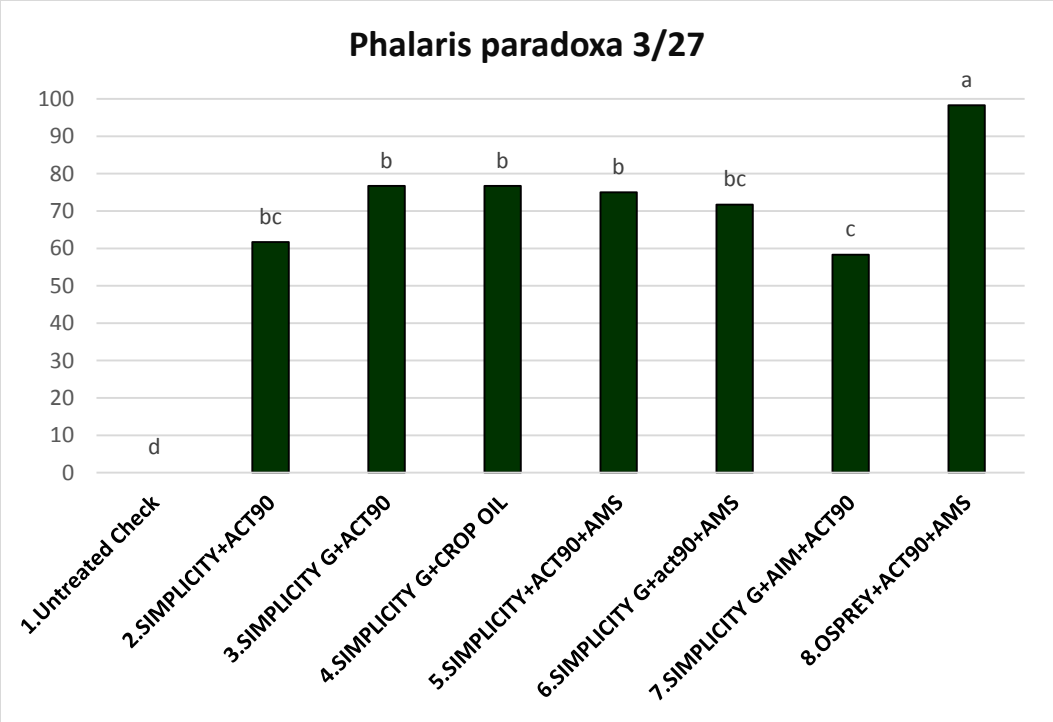

Figure 2. Efficacy of pyroxulam on Hood Canarygrass *(Phalaris paradoxa)*. March 27, 2018.

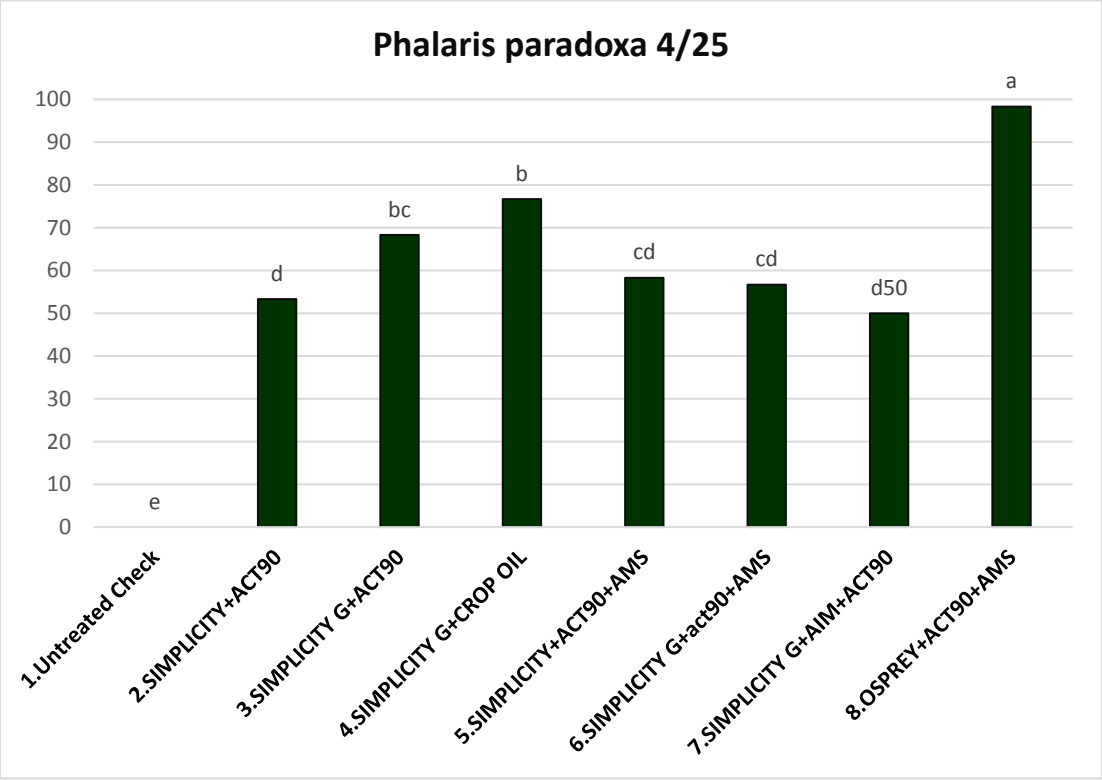

Figure 3. Efficacy of pyroxulam on Hood Canarygrass (Phalaris paradoxa). April 25, 2018.

This trial was conducted at the University of Arizona Yuma Agriculture Center in 2017-18. Durum wheat was planted into a field containing a known population of Hood canarygrass. Two formulations of simplicity and combinations of adjuvants were include in this trial along with Osprey at the recommended rate. Evaluations were made on March 27 and April 25. Visual estimates of control ranged from 50% to 76% with Simplicity and were 98.3 % from Osprey. The levels of control for simplicity were not high enough to satisfy most growers. This leaves only Osprey if Hood canarygrass ever becomes a widespread problem in Arizona wheat.

Osprey (mesosulfuron) has been registered in Arizona wheat for several years, control most annual grasses, and some broadleaf weeds. Many growers have been reluctant to use it because it has a 10-month plantback restriction to most crops grown in Arizona except cotton, which is only 90 days. This plant back interval is especially troublesome for vegetable growers. A trial (Tables 4-5) (Figure 4) was conducted to determine if lower rates of Osprey could still be effective and possibly reduce this time requirement.

**Table 4. Mesosulfuron Rate Evaluation and Assessment Data Summary**

| | | | | | | |
|---|---|---|---|---|---|---|
| Pest Scientific Name | | | | Phalaris parad> | | |
| Pest Name | | | | Hood canarygra> | | |
| Rating Date | | | | Mar-2-2018 | | |
| Rating Type | | | | % control | | |
| Trt No. | Treatment Name | Rate | Rate Unit | Plot | 3 | |
| 1 | Osprey | 1.0 | oz/a | 101 | 10.0 | |
| | | | | 205 | 10.0 | |
| | | | | 301 | 10.0 | |
| | | | | 405 | 10.0 | |
| Mean = | | | | 10.0 | | |
| 2 | Osprey | 2.0 | oz/a | 102 | 10.0 | |
| | | | | 204 | 80.0 | |
| | | | | 303 | 80.0 | |
| | | | | 403 | 80.0 | |
| Mean = | | | | | 62.5 | |
| 3 | Osprey | 3.0 | oz/a | 103 | 90.0 | |
| | | | | 202 | 95.0 | |
| | | | | 305 | 90.0 | |
| | | | | 402 | 90.0 | |
| Mean = | | | | 91.3 | | |
| 4 | Osprey | 4.0 | oz/a | 104 | 95.0 | |
| | | | | 201 | 95.0 | |
| | | | | 302 | 90.0 | |
| | | | | 404 | 90.0 | |
| Mean = | | | | 92.5 | | |
| 5 | Untreated Check | | | 105 | 0.0 | |
| | | | | 203 | 0.0 | |
| | | | | 304 | 0.0 | |
| | | | | 401 | 0.0 | |
| Mean = | | | | 0.0 | | |

Pest Type
W, Weed, G-BYRW7, G-WedStg = Weed or volunteer crop
Pest Code
, Phalaris paradoxa, = US
Crop Code

Rating Unit
% = percent

**Table 5. Mesosulfuron Rate Evalution AOV Means Table**

| | |
|---|---|
| Trial ID: | Osprey Rate Evaluation |
| Location: | Yuma, Arizona |
| Investigator: | Barry Tickes |
| Sponsor Contact: | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pest Type | | | | W Weed | | |
| Pest Code | | | | | | |
| Pest Scientific Name | | | | Phalaris parad> | | |
| Pest Name | | | | Hood canarygra> | | - |
| BBCH Scale | | | | BVHF | | |
| Rating Date | | | | Mar-2-2018 | | |
| Rating Type | | | | control | | |
| Rating Unit | | | | % | | |
| Number of Subsamples | | | | 1 | | |
| Trt No. | Treatment Name | Rate | Rate Unit | 3 | | |
| 4 | Osprey | 4.0 | oz/a | 92.5 | a | |
| 3 | Osprey | 3.0 | oz/a | 91.3 | a | |
| 2 | Osprey | 2.0 | oz/a | 62.5 | b | |
| 1 | Osprey | 1.0 | oz/a | 10.0 | c | |
| 5 | Untreated Check | | | 0.0 | c | |

| | |
|---|---|
| Replicate F | 0.950 |
| Replicate Prob(F) | 0.4473 |
| Treatment F | 30.973 |
| Treatment Prob(F) | 0.0001 |

Means followed by same letter do not significantly differ (P=.05, LSD)

Pest Type
W, Weed, G-BYRW7, G-WedStg = Weed or volunteer crop
Pest Code
, Phalaris paradoxa, = US
Crop Code

Rating Unit
% = percent

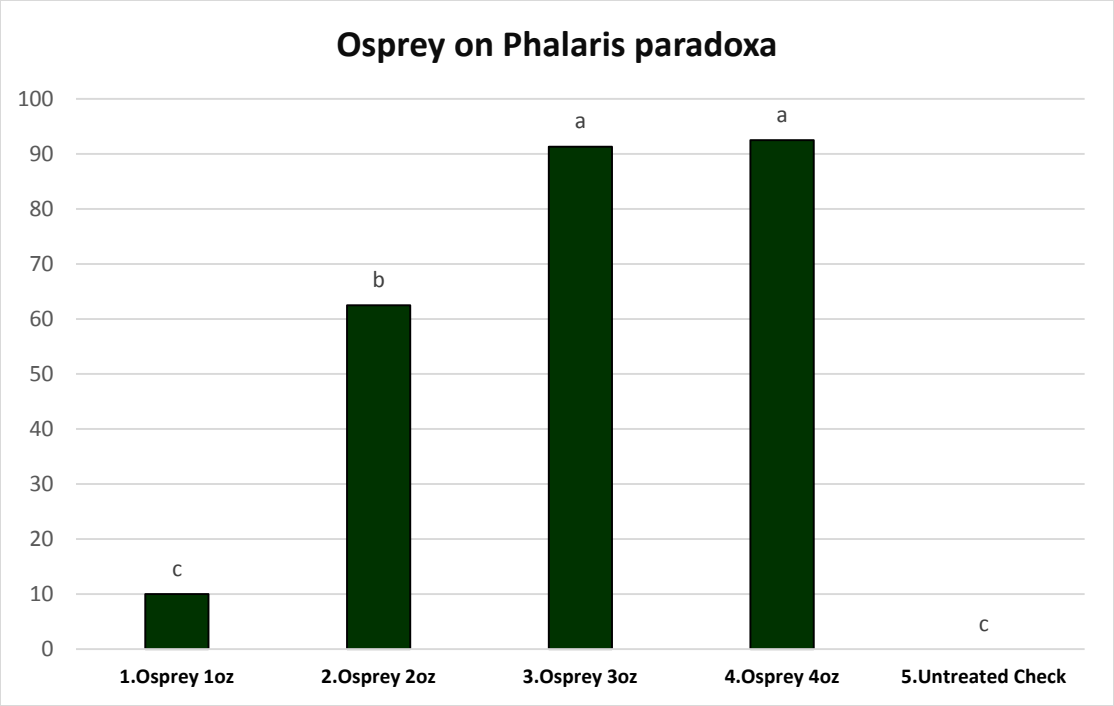


Figure 4. Mesosulfuron rates comparison for the control of hood canarygrass *(Phalaris paradoxa)*.

This trial was established at the University of Arizona Yuma Agriculture Center during the 2017-18 growing season. The recommended use rate is 4.75 oz. with a methylated seed oil adjuvant. The trial included 1.0, 2.0, 3.0 and 4.0 oz. of Osprey and an untreated check. Durum wheat was planted into a known population of Hood canarygrass. Acceptable levels of control were only reached at the 3 and 4 oz. rates. Reducing the use rate by 1.0 oz. (25%) may reduce the plantback requirement a little but more work will be required.

**Potential Herbicide Resistance in Littleseed canarygrass *(Phalaris minor)* in Arizona**

Littleseed canarygrass that is resistant to several of the ACCase herbicides has been found in in other countries including Mexico, Pakistan, South Africa, Israel, Iran, India and Australia. It has been found in the U.S. as close as the Imperial Valley, CA. There have been few complaints of poor control anywhere in Arizona and it has not been suspected. Where poor control has occurred,

it has commonly been traced back to inadequate use rates or application timing. A trial was conducted in the 2017-18 (Table 5-6 and figure 5) growing season to determine if the commonly used wheat herbicides for this weed were still effective.

**A**

## Table 5. Evaluation of Commonly Used Herbicides for Canarygrass Control

Canarygrass Parker Experiment

Trial ID: Protocol ID:
Location: Study Director:
Project ID: Investigator: Barry Tickes

| Trt No. | Treatment Name | Rate | Rate Unit | | | |
|---|---|---|---|---|---|---|
| Pest Scientific Name | | | | Sisimbrium irio | Poa annua | Phalaris spp |
| Pest Name | | | | **London Rocket** | **Blue grass** | **Canarygrass** |
| Crop Scientific Name | | | | Triticum spp | Triticum spp | Triticum spp |
| Crop Name | | | | Wheat | Wheat | Wheat |
| Crop Variety | | | | Orita | Orita | Orita |
| Rating Date | | | | Mar-15-2018 | Mar-15-2018 | Mar-15-2018 |
| Number of Subsamples | | | | 1 | 1 | 1 |
| | | | | 1 | 2 | 3 |
| 1 | Simplicity | 6.75 | floz | 95.0 | 80.0 | 95.0 |
| | +Act0.5% | | | 95.0 | 85.0 | 90.0 |
| | | | | 90.0 | 80.0 | 90.0 |
| Mean = | | | | 93.3 | 81.7 | 91.7 |
| 2 | Osprey | 4.75 | floz | 90.0 | 80.0 | 95.0 |
| | +Act 0.5% | | | 95.0 | 90.0 | 95.0 |
| | | | | 90.0 | 75.0 | 90.0 |
| Mean = | | | | 91.7 | 81.7 | 93.3 |
| 3 | Tacoma | 0.66 | floz | 90.0 | 75.0 | 95.0 |
| | | | | 85.0 | 75.0 | 95.0 |
| | | | | 95.0 | 65.0 | 85.0 |
| Mean = | | | | 90.0 | 71.7 | 91.7 |
| 4 | Discover | 12.8 | floz | 95.0 | 50.0 | 90.0 |
| | | | | 90.0 | 50.0 | 90.0 |
| | | | | 90.0 | 65.0 | 85.0 |
| Mean = | | | | 91.7 | 55.0 | 88.3 |
| 5 | Untreated | | | 0.0 | 0.0 | 0.0 |
| | | | | 0.0 | 0.0 | 0.0 |
| | | | | 0.0 | 0.0 | 0.0 |
| Mean = | | | | 0.0 | 0.0 | 0.0 |

**Table 6. Evaluation of Commonly Used Herbicides for Canarygrass Control Analysis of Variance**

Canarygrass Parker Experiment

Trial ID: Protocol ID:
Location: Study Director:
Project ID: Investigator: Barry Tickes
Rating date Mar 15, 2018

| Pest Scientific Name | S.irio | Poa annua | Phalaris spp |
|---|---|---|---|
| Pest Name | L.Rocket | Blue grass | Canarygrass |
| Crop Name | Wheat | Wheat | Wheat |
| Crop Variety | Orita | Orita | Orita |
| Number of Subsamples | 1 | 1 | 1 |

| Trt No. | Treatment Name | Rate | Rate Unit | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Simplicity+Act 0.5% | 6.75 | fl oz/a | 93.3 | a | 81.7 | a | 91.7 | ab |
| 2 | Osprey+Act 0.5% | 4.75 | fl oz/a | 91.7 | a | 81.7 | a | 93.3 | a |
| 4 | Discover+.25Hasten | 12.8 | fl oz/a | 91.7 | a | 55.0 | b | 88.3 | b |
| 3 | Tacoma | .66 | fl oz/a | 90.0 | a | 71.7 | a | 91.7 | ab |
| 5 | Untreated Check | | | 0.0 | b | 0.0 | c | 0.0 | c |

| | | | |
|---|---|---|---|
| Replicate F | 0.138 | 0.375 | 6.000 |
| Replicate Prob(F) | 0.8732 | 0.6988 | 0.0256 |
| Treatment F | 417.586 | 87.750 | 858.143 |
| Treatment Prob(F) | 0.0001 | 0.0001 | 0.0001 |

Means followed by same letter do not significantly differ (P=.05, LSD)

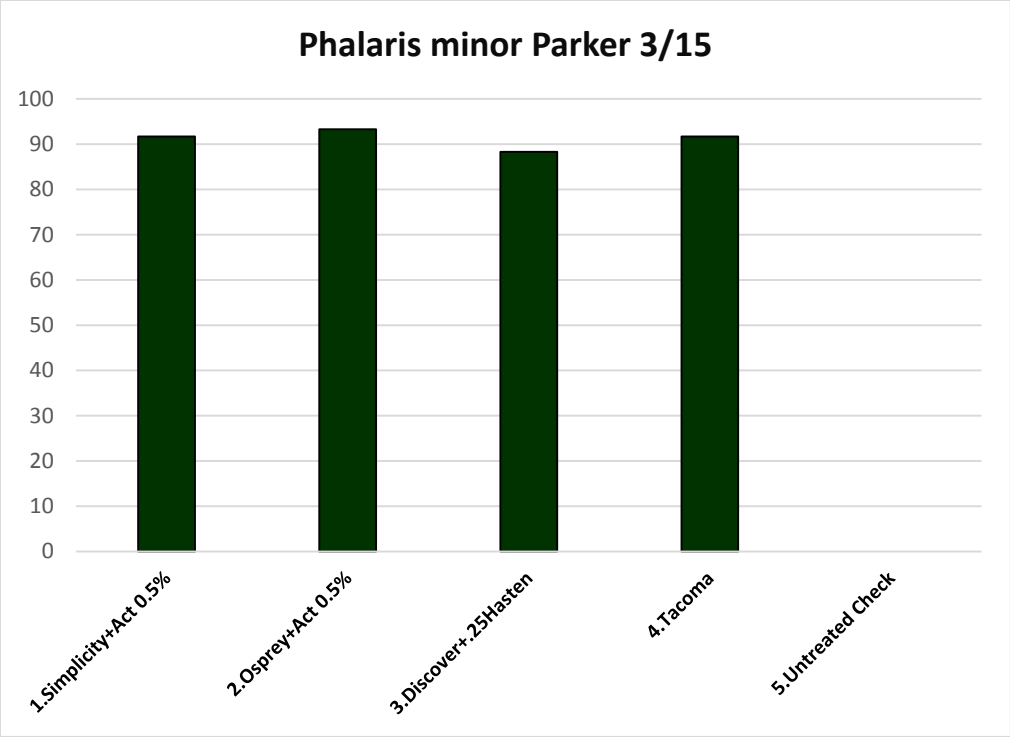

Figure 5. Comparison of commonly used herbicides for littleseed canarygrass control.

This trial was conducted in the Parker Valley, AZ. near the California border. The four most commonly used herbicides were used at the recommended use rate. These included the ACCase inhibitors and two ALS inhibitors. Visual estimates of littleseed canarygrass control ranged from 88% to 93%. These are the same levels of control that we have measured in several previous trials and coincides with grower experience.

**Conclusions**

Weed shifts commonly occur over time in response to herbicide use and grower practices. Wild oat was the primary grass weed in Arizona grown wheat for many years and it has now been replaced by Littleseed canarygrass (*Philaris minor*). Seed longevity of this weed is very long and it is an annual problem. Herbicides are available, however, that keep it in check. There has been some concern over the detection of an herbicide resistant biotype of littleseed canarygrass in the

Imperial Valley, CA and the identification Hood canarygrass in the Gila Valley, AZ. that had not previously been known to occur in the area. This project was conducted to address these two concerns.

A trial was conducted to evaluate if Littleseed canarygrass was still sensitive to the four herbicides most commonly used to control it. This included two ALS inhibitors and Two ACCase inhibitors. Canarygrass was controlled with all of these herbicides at the same levels that they have been in the past. We will need to continue to monitor individual populations that are not controlled as they occur.

Trials were also controlled to evaluate the sensitivity of Hood canarygrass to seven grass herbicides that normally are effective on Littleseed canarygrass. Five of these are registered on wheat. Only one, Osprey, was effective. It appears to be resistant to the ACCase inhibitor herbicides and is difficult to determine where this population came from but our observations indicate that it has remained confined to where it was found.

## Acknowledgment

This project was supported by the Arizona Grain Council. This support is greatly appreciated