TITLE: Evaluation of occurrence of glyphosate resistant Russian thistle (Salsola tragus) in Northeastern Oregon

RESEARCH LEADER: Judit Barroso

COOPERATORS: Larry Lutcher

SUMMARY:

The first year of the project has been very successful. The project was written to investigate the reason(s) for poor glyphosate performance observed by growers in recent years. Reduced efficacy can be attributed to dust, water stress, or generally poor growing conditions during application as often occur in post-harvest herbicide applications. Objective 2 was conceived to improve Russian thistle glyphosate control in a post-harvest application. In objective 1, studies were undertaken to determine if the poor control could be due to glyphosate resistance in Russian thistle populations. Results from objective 1 confirmed glyphosate resistance in some Oregon Russian thistle populations. Plant mortality at recommended glyphosate doses for the resistant populations was less than 30% three weeks after treatment. Based on the findings of this project so far (Obj. 1 and 2), a glyphosate treatment to control Russian thistle post-harvest is not always successful.

OBJECTIVES:

1) Determine the occurrence of glyphosate-resistant Russian thistle populations in Northeastern Oregon
2) Evaluate the effect of post-harvest glyphosate application on Russian thistle plant biomass, seed production, and seed germination considering two application times.

PROCEDURES:

Objective 1

In February 2016, on fallow fields of Umatilla, Morrow, and Sherman Counties, Larry Lutcher and my technician Jennifer Gourlie helped me collect eleven populations of Russian thistle (Figure 1 and 2). Each population consisted of at least ten Russian thistle plants randomly gathered and labelled for later processing (population identifier is provided in Figure 2).
The seed was threshed and cleaned at the Columbia Basin Agricultural Research Center (CBARC) at Pendleton, OR. Seeds from each population were bulked. Half of the populations were tested at CBARC and the other half were tested at OSU campus (Corvallis, OR) due to limited greenhouse space at CBARC.

Before initiating the study, a germination test was conducted on each population. All of the populations had at least 60% germination.

The protocols were set the same in both greenhouses (CBARC and campus). The experimental design was a randomized complete block (blocked by population) with treatments replicated six times. Ten seeds were seeded per pot and thinned before treatment to four plants per pot.

At seedling state (5 - 6 leaves stage), the populations were treated with 0, 3.75, 7.5, 15, 30, 60, and 120 oz/ac of Gly Star original®. The recommended dose for that product varies between 24 and 32 oz/ac depending on weed height. Herbicide treatments were applied to plants at the five-leaf stage using a compressed air, greenhouse cabinet sprayer delivering 10 gal/ac at CBARC and 15 gal/ac in Corvallis. Evaluation was conducted 3 weeks after treatment. Live plants per pot were counted, clipped, and placed in paper bags. The samples were dried in an oven at 50°C for at least 48 h and then weighed. The studies were repeated.
The response of relative dry biomass per plant (calculated as percent of the untreated control plants per population) and percentage of live plants per pot (y) to the herbicide doses (x) were analyzed with dose-response curves.

Analysis of variance indicated no effect of experiment per population; therefore, data from the two experiments per population in each greenhouse were combined for analysis of relative dry biomass per plant and percentage of live plants per pot.

The relative dry biomass per plant and percentage of live plants per pot showed a log-logistic response to increasing glyphosate doses (Figures 3 and 4). With the recommended glyphosate dose, eight populations were controlled but not three of them (MC1, MC2, and MC5) for the variables studied (Figures 3 and 4). Based on the $I_{50}$ values (which is the dose that causes an inhibition of 50% with respect to the untreated control) of these three populations, the R/S ratio ($I_{50}$ of a resistant (R) biotype divided by the $I_{50}$ of a susceptible (S) biotype) was between 2.4 and 4.0 for the relative dry biomass per plant and between 2.8 and 3.6 for the percentage of live plants per pot. These results confirm glyphosate resistance in these three Russian thistle populations.

Some pictures of a susceptible versus resistance population can be found in Figures 5 and 6.

Figure 2: Location in Sherman, Morrow and Umatilla Counties of the collected populations
Figure 3. Dose-response curves of relative Russian thistle dry biomass per plant 3 weeks after treatment; a) Populations tested at CBARC, and b) Populations tested at OSU-campus. Points indicate mean of the experimental data and lines fitted models. Results from each location are shown separately because the herbicide effect in the control population, UC1 – tested in both sites, was significantly different.
Figure 4. Dose-response curves of percentage of Russian thistle live plants per pot 3 weeks after treatment. Points indicate mean of the experimental data and lines fitted models. Results from both locations are shown together because the herbicide effect in the population control (UC1 – present in both greenhouses) was not significantly different.

Figure 5. Random distribution of the 42 pots of: a) the susceptible population UC1 and b) the resistant population MC1.
Figure 6. Photos of the seven treatments 0 oz/ac (white label), 3.75 oz/ac (yellow label), 7.5 oz/ac (blue label), 15 oz/ac (green label), 30 oz/ac (pink label), 60 oz/ac (orange label), and 120 oz/ac (red label) sprayed on a) a susceptible population in Umatilla County and b) a resistant population in Morrow County.

**Objective 2:**

In April 2016, we established two field experiments, one in Moro (CBARC-M) and the other in Pendleton (CBARC-P). The experiment at CBARC-P was in conventional soil management (with tillage) and the experiment at CBARC-M was in no-till land. The experiments were a split-split plot design with three repetitions where the main factor (plots) was the application time (2 weeks after harvest (2WAH), or 4 weeks after harvest (4WAH)), the second factor (sub-plots) was the glyphosate rate (0X, 1X, 2X, and 4X) and the third factor (sub-sub-plots) the different Russian thistle populations (Figure 7). The Russian thistle populations UC1, UC2, MC1, and MC2 were seeded right before the crop seeding.
Post-harvest glyphosate treatments were done in mid-and late August corresponding with 2WAH and 4WAH.

However, this objective was based on the hypothesis that the cause of low herbicide efficacy post-harvest was not due to an evolved herbicide resistance. When we established the Russian thistle populations, we did not know that MC1 and MC2 were resistant populations.

These experiments were destroyed in early September to avoid the spread of the resistance. Before their destruction, we evaluated plant mortality and confirmed that recommended doses do
not control susceptible Russian thistle populations post-harvest. Growers cannot distinguish between susceptible and resistant Russian thistle populations after a post-harvest treatment, unless they are using four times the recommended dose (Figure 8). Post-harvest is not the right time to scout fields looking for resistant populations (demonstrated susceptible population in the greenhouse may behave as resistant after a post-harvest application (Figure 8)).

Figure 8. Comparison of percentage of live Russian thistle plants after a glyphosate treatment at seedling stage (color bars (green and red)) and post-harvest (gray bars (darker gray - 2 weeks after harvest (WAH) and lighter gray - 4 WAH)) treatment with different herbicide rates (X = 30 oz/ac): a) for a susceptible population (UC2) and b) for a resistant population (MC1).
SIGNIFICANT ACCOMPLISHMENTS TO DATE:

Results from this project confirmed of glyphosate resistance in some Russian thistle populations in Oregon.

A scientific paper titled “Identification of glyphosate resistance in Salsola tragus in Northeastern Oregon” submitted to Pest Management Science Journal that ranks 11 in the Agronomy Category of SCI journals has been recently accepted and is in press (DOI:10.1002/ps.4525). Soon it will be available on-line and it will be published in a special number of the journal about glyphosate.


A longer extension paper on the same subject is in review for the Crops and Soils Magazine (Washington). If it is accepted, it will be published in March 2017.

We have given several talks on this important finding in different conferences, workshops and, meetings to inform growers in the state and in the region:


Note: Agricultural Research Foundation has been properly mentioned in all the publications and presentations as the funding organization that supported this research with the exception of the Oregon Wheat Magazine that we forgot. We apologize for that.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM: None

FUTURE FUNDING POSSIBILITIES:

A project titled “Cooperative tumbleweed management to preserve no-till and reduce the spread of herbicide resistance” has been submitted to WesternSARE. We are collaborating with Drs. Stewart Wuest and Dan Long (USDA-ARS) and several growers from Morrow County.