AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
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TITLE: Expansion of Scouringrush (*Equisetum hyemale*): Control in Winter Wheat & Chemical Fallow Cropping Systems

RESEARCH LEADERS:

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SUMMARY:

Scouringrushes (*Equisetum hyemale* L.; *E.* x*ferrissii* Clute; *E. laevigatum* L.) are ancient perennial seedless vascular plants historically associated with wetlands, low-lying roadsides or field margins with more plant available water. There has been little research conducted on scouringrush species in the context of agricultural production because traditional farming practices confined them to field margins and roadside depressions. An increasing amount of dryland winter wheat (*Triticum aestivum* L.) hectares in the inland Pacific Northwest have replaced summer tilled-fallow rotations with chemical fallow. Where chemical fallow rotations have become the standard practice, scouringrush has expanded out of its historical habitat into production fields and established at high enough densities to cause concern from growers. Research was conducted to identify control options that fit chemical fallow cropping systems, evaluate the magnitude of crop interference by scouringrush, and address how soil pH affects scouringrush growth and establishment, as soil acidification is another agronomic issue caused by intensive wheat production in the Pacific Northwest. Field studies located in Reardan, WA, and near The Dalles, OR, were established in commercial wheat production fields that evaluated 10 herbicide treatments for efficacy on scouringrush. An additional factor in the trials was to determine if pre-herbicide mowing affected herbicide efficacy. At both locations pre-herbicide mowing had no effect on efficacy and only chlorsulfuron plus MCPA-ester controlled scouringrush though the subsequent winter wheat rotation. A third herbicide trial determined that triclopyr or increased rates of chlorsulfuron plus 2,4-D and dicamba or asulam were able to effectively control scouringrush seven and 10 months after treatment at a non-crop site in eastern Oregon. Under field conditions wheat yield reductions were correlated with increasing scouringrush density, but in a controlled study scouringrush density had no effect on winter wheat development or grain yield. Disagreement between these results is hypothesized to be a function of nutrient deficiencies within production fields. Results from three greenhouse studies showed that scouringrush biomass production increased as soil pH increased from ≈4.6 to ≈8.0 and that scouringrush was able to establish and survive in soil pH conditions that are unsuitable for winter wheat production.

OBJECTIVES:

1. Screen herbicides for scouringrush control in eastern Oregon and eastern Washington dryland winter wheat-chemical fallow cropping systems and non-crop areas.

2. Quantify the effect scouringrush density has on winter wheat yield.

3. Determine the effect soil pH has on growth and establishment of scouringrush.

PROCEDURES:

Summer Fallow Prior to Winter Wheat Seeding:

Ten herbicide treatments were applied on 9/9/2015 to a chemical-fallow field near The Dalles, OR, containing a stand of scouringrush with nearly uniform density. The field is under the management of Charlie Remington. Winter wheat (ORCF-101) was seeded at 88 kg/hectare 29 days after treatment. Plots were organized in a randomized split-plot design where half of each plot was mowed with a flail mower before herbicide application. The mowing treatment was added to determine its effects, if any, on herbicide efficacy. Visual control of scouring rush ratings were taken at 14 and 48 days after treatment. Scouringrush shoots/meter of row were recorded in late spring 2016. Grain yields were recorded in summer 2016. This herbicide screening is a repetition of treatments applied one-year prior by Washington State University (Dr. Drew Lyon) in Reardan, WA.

Rhizome fragments from the Reardan, WA site were taken from each mowed and unmowed plot and grown in a greenhouse to determine if herbicide treatments were effective at controlling rhizomes. Stem counts were taken on the greenhouse-grown plants on 2-week intervals for 154 days. This process was repeated for the site near The Dalles, OR in the spring of 2016.

Non-Crop:

Six herbicide treatments were applied to a stand of scouringrush growing parallel to a road/fence-line near The Dalles, OR on 10/8/2015. Herbicides included in the trial were either not labeled for use in winter wheat or applied at higher rates than could be used in a wheat crop. Plots were organized in a randomized complete block design. Visual control ratings were taken 20 days after treatment. Scouringrush shoots/50cm^2 were quantified in late spring 2016.

Scouringrush Density and Winter Wheat Yield:

Scouringrush (*Equisetum x ferrissii*) rhizomes were collected from both of the herbicide evaluation sights near The Dalles, OR and transported to Oregon State University. Rhizomes were washed and cut into segments containing 1 node. Rhizome fragments were planted at increasing densities into 17-liter Sterilite tubs containing Metro-Mix professional growing mix with 85 g/m^3 Osmocote (14-14-14) fertilizer. Scouringrush rhizome density treatments were 0, 1, 2, 4, 8, 16, 32, 64, and 100 fragments per 17-liter tub. After 7 days , 'Goetze' winter wheat was planted into the same tubs at 108 seeds per m^2. On 11/20/2015, after 8 days in a greenhouse, tubs with winter wheat and scouringrush were placed outside and grown though wheat maturity. Tubs were organized in a randomized complete block design. Beginning in the spring of 2016, tiller number, wheat height, and scouringrush shoot number were quantified. In the summer of 2016, wheat was hand threshed and yields were quantified.

Effects of Soil pH on Scouringrush Growth and Establishment:

Acid Soil: Soil collected at the Hyslop Field Lab near Corvallis, OR (pH: 4.6) was amended with calcium carbonate $CaCO_3$ to reach soil pH targets of 5.1, 5.6, 6.6 and 7.6. After a 28-day soil incubation period 2 scouringrush rhizome fragments were weighed then planted into amended soils. After 1 year, total fresh-weight biomass was recorded and soil pH treatments were analyzed by percent fresh-weight increase.

Alkaline Soil: Soil collected from Madras, OR (pH 8.1) was amended with sulfuric acid (H_2SO_4). Knowing that 1 unit of sulfur (S) will neutralize 3 units of $CaCO_3$, and assuming that the Madras soil contains 5% $CaCO_3$, a rate of sulfuric acid was calculated to acidify an alkaline soil of pH 8.1 to neutral. Three doses of H_2SO_4 were used; the calculated neutralizing dose, 1.5x the neutralizing dose, and 2x the neutralizing dose. All acid treatments were sub-irrigated into pots containing soil with the exception of the 2x dose. The 2x dose had an initial neutralizing dose sub-irrigated and a subsequent neutralizing H_2SO_4 treatment injected at the surface of pots 28 days later. Soils were allowed to dry then mixed in plastic tubs and repotted to eliminate the possibility of stratified pH zones within pots. Scouringrush rhizomes were then weighed and planted into amended soils. The experimental design and analysis were similar to the initial acid soil study described above.

SIGNIFICANT ACCOMPLISHMENTS:

Blake Kerbs graduated with MS degree in the Dept. of CSS in 2016 having completed this work. His thesis and data are available. Efforts are underway to publish his work in journal format.

Techniques were developed and refined for transporting scouringrush rhizome fragments from the field and propagating them in a greenhouse setting.

Sites with adequate uniformity, density, and area were identified for current and future scouringrush field studies. Chlorsulfuron plus MCPA-ester was the only treatment that resulted in nearly 100% control of scouringrush through wheat harvest. Pre-herbicide mowing had no effect on efficacy. All herbicide treatments had no effect on wheat yield at either location; including where chlorsulfuron plus MCPA-ester reduced smooth scouringrush stem density to > 2 stems m row^{-1} from nearly 50 stems m row^{-1} at Reardan, WA, and intermediate scouringrush to 0 stems m row^{-1} from nearly 20 stems m row^{-1} at The Dalles, OR. Results from these trials suggest chlorsulfuron plus MCPA-ester would be a commercially acceptable treatment for smooth and intermediate scouringrush control in winter wheat-chemical fallow cropping systems.

In the non-crop trial, intermediate scouringrush treated with halosulfuron plus 2,4-D and dicamba or triclopyr was controlled 71 and 100%, respectively, 20 days after treatment. However 10 months after treatment, plots where halosulfuron plus 2,4-D and dicamba or triclopyr were applied had 23 and 25 stems 60 cm2, respectively. Where chlorsulfuron plus 2,4-D and dicamba and chlorsulfuron plus asulam was applied, visual control of intermediate scouringrush was rated as 60% and 40%, respectively. Ten months after treatment chlorsulfuron plus 2,4-D and dicamba and chlorsulfuron plus asulam were found to have 11 and 0.3 stems 60 cm2, respectively. Results suggest the initial response of intermediate scouringrush stems turning dark black 20 days after herbicide application is an inadequate method to predict complete control, and herbicide treatments containing chlorsulfuron and triclopyr were most effective in controlling intermediate scouringrush 10 months after treatment.

An additive competition study was used wherein winter wheat was seeded into 17 L pots containing 0, 1, 2, 4, 8, 16, 32, 64 or 100 intermediate scouringrush (*Equisetum* x *ferrissii* Clute) rhizome fragments. The study was terminated at wheat maturity. Total aboveground biomass, grain yield, height, tiller number, and spike number were regressed against the total number of scouringrush stems per pot. Due to inconsistent establishment by scouringrush, data were reclassified into either a high or low density group for regression analysis. To supplement data from the potted wheat experiment, yield data from trials assessing herbicide efficacy on scouringrush in The Dalles, OR (2015) and Reardan, WA (2014) were analyzed. For field experiments, winter wheat plot yields were regressed against the average number of scouringrush stems m row^{-1} measured in the plot. Low r^2 values indicated quantifying scouringrush density through stem number was not ideal. However, regression lines from the controlled potted wheat experiment have slopes near zero, which suggested scouringrush is a weak or non-competitor with winter wheat. Regression lines from field studies in Reardan and The Dalles have slopes of $\approx$-10 and $\approx$-30 respectively, suggesting there was a correlation between low yielding areas and scouringrush density. Although these results are preliminary, there is evidence suggesting negative yield responses currently attributed to scouringrush infestations could be in part the result of nutrient deficiency, as other species within the genus *Equisetum* lack the ability to respond to nitrogen and have been associated with nitrogen deficient field plots in agronomy trials.

Methods for amending the pH of small volumes of soil were developed. . An acidic soil collected near Corvallis, Oregon, was amended with calcium carbonate, and an alkaline soil collected near Madras, Oregon, was amended with sulfuric acid with the goal of creating a matching soil pH range for the two soils. After soils were amended, scouringrush rhizome fragments were planted and grown in a greenhouse for 344 days. Total above and belowground dry biomass was then measured and whole plant tissue samples were analyzed for 13 different nutrient concentrations. Scouringrush had a similar biomass response to soil pH when grown in both soil types. Total biomass production increased as soil pH increased from ≈4.6 to ≈8.0. Scouringrush was able to survive in acidic soil conditions (pH ≈4.1) with plant tissue concentrations of iron, manganese, and aluminum known to cause toxicity in a majority of crop plants (9916 mg kg^{-1} iron, 781 mg kg^{-1} manganese and 5000 mg kg^{-1} aluminum). Soil acidity was found to negatively impact scouringrush, but the plants were able to establish under conditions that would be unsuitable for winter wheat or other cereal grain crop production.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM: None

FUTURE FUNDING POSSIBILITIES: TBD