ALLELOPATHY: HOPE OF HYPE?

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Introduction

Rye has been regularly used as an organic mulch (either plowed under or no-tilled in to) in a number of crop production systems where it has been shown to simultaneously increase soil organic matter and reduce erosion. When sufficient biomass is achieved, rye cover suppresses weeds by serving as a physical barrier to emergence and by inhibiting germination through reduced light transmittance and, purportedly, allelopathy.

Many previously published studies conducted to assess the allelopathic potential of rye against weeds have used young, green, living, greenhouse-grown tissue as a source of chemical extracts. Few studies have quantified the suppressive potential of rye tissue grown under natural conditions and at a number of development stages. Comparisons between studies are often difficult to make because of differences in: initial extract concentration, individual seed dose, seed size, rye developmental stage, etc. The usefulness of rye as a 'natural herbicide' would be supported if its allelopathic activity is maintained during the peak germination period of spring and/or summer annuals, like Palmer amaranth. The objective of this study was to evaluate the inhibitory effects of field grown rye, collected at different phenological stages, on both Palmer amaranth (i.e. weed control) and cotton seed (i.e. crop safety) germination.

Materials and Methods

Winter rye (Wrens Abruzzi) was grown on the UGA Ponder farm in Ty Ty, GA (2010-2011) and harvested at different 3 growth stages (tillering [V3-5], stem elongation [V6-8], and heading [V10.5]). Biomass samples were dried at 50°C for 4 day in an oven. After drying, 10 g of tissue from each sample was extracted for 24 hr in 100 ml of dH2O (1:10 wt:vol), ground in a blender, filtered and diluted to create 1, 0.5, 0.25, 0.125 and 0.0625 X strength solutions. A control (0% extract, dH2O) was also included for comparison. Five replications of 1) 25 Palmer amaranth seeds (in 2 ml of extract contained in a 47 mm diameter Petri dish on a cellulose pad) and 2) 10 cotton seeds (in 4 ml of extract contained in a 90 mm diameter Petri dish on 2 disks of Whatman filter paper) were incubated at 25-30 C for 7 days, after which germination evaluated. The entire study was replicated twice.

Results and Discussion

In general: 1) cumulative germination of both species generally decreased with increased extract concentration, relative to the non-treated control (0X); 2) younger rye tissue (V3-V5 and V6-8) was more inhibitory than more mature tissue (V 10.5); and 3) large-seeded cotton was typically less affected by rye extracts than small-seeded Palmer amaranth (Figures 1 and 2). The lowest concentration extracts (0.0625X to 0.25X) developed from rye harvested at the V3-5 and V6-8 stages actually promoted, instead of inhibited, seed germination for Palmer amaranth in this study. This phenomenon is called hormesis and is defined as a favorable response to a small/low dose/exposure to a toxin or other stressor. Greater than 50% reduction in Palmer amaranth seed germination was not observed except when extract concentrations reached the 0.5X (for V3-5 rye) or 1X (for V3-5 and V6-8 rye). Half- (0.5X) and full-strength (1X) concentrations from V10.5 rye reduced Palmer amaranth seed germination approximately 15-25%, relative to the control. Cotton seed germination was reduced between 20-80%, relative to the control, when quarter- (0.25X) to full-strength extracts were developed from rye harvested at the V3-5 and V6-8 stages. In general, extracts collected from rye that was in the process of heading (V10.5) did not reduce cotton germination at any concentration relative to the control.

Our initial results suggest that rye can be inhibitory, but only when extract concentrations are extremely high and when fresh, young tissues are used. These stages of phenological development would typically occur during the winter months in Georgia, at a time when Palmer amaranth is neither germinating nor emerging, thereby limiting the usefulness of allelopathy as a biocontrol agent. Furthermore, it is unlikely to assume, at this time, that growers would be able to macerate, solubilize, and incorporate rye tissues sufficiently in order to reach the projected concentrations necessary for the inhibition of seed germination and seedling growth and development.

Allelopathy is notoriously difficult to study and many bioassays may be limited in their abilities to accurately estimate the toxicity of plant residues. Greenhouse studies, while easy to initiate, don't account for the effects of microorganisms, plant stress, weather, and other environmental conditions that influence the production, uptake, metabolism, and degradation of allelochemicals. Conversely, it can be difficult to evaluate the activity of complex secondary plant products in field studies. Although rye is useful for managing weeds, it has not been proven, conclusively, that allelopathy, independent of physical suppression, has played a substantial role. More studies, conducted in the laboratory, as well as in the field, and under multiple growing conditions, will be required to elucidate the effectiveness of rye as an allelopathic agent for weed control.

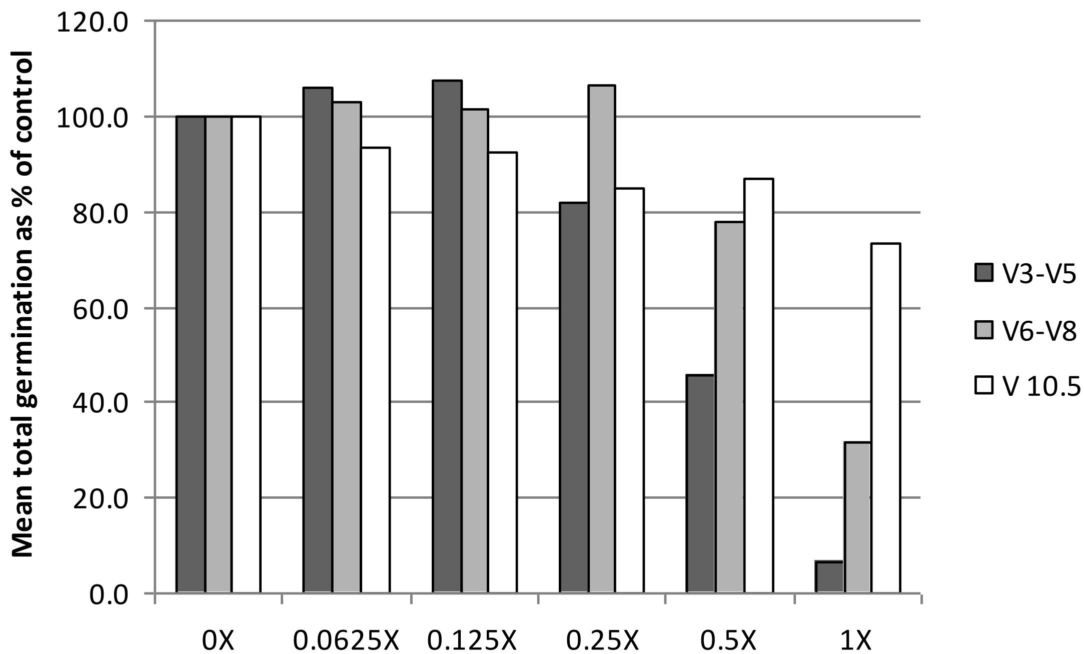

Figure 1. Palmer amaranth germination (as a percent (%) of the control) in response to varying concentrations of rye extract harvested from plants of increasing age and phenological development (V3-5, V6-8, and V10.5).

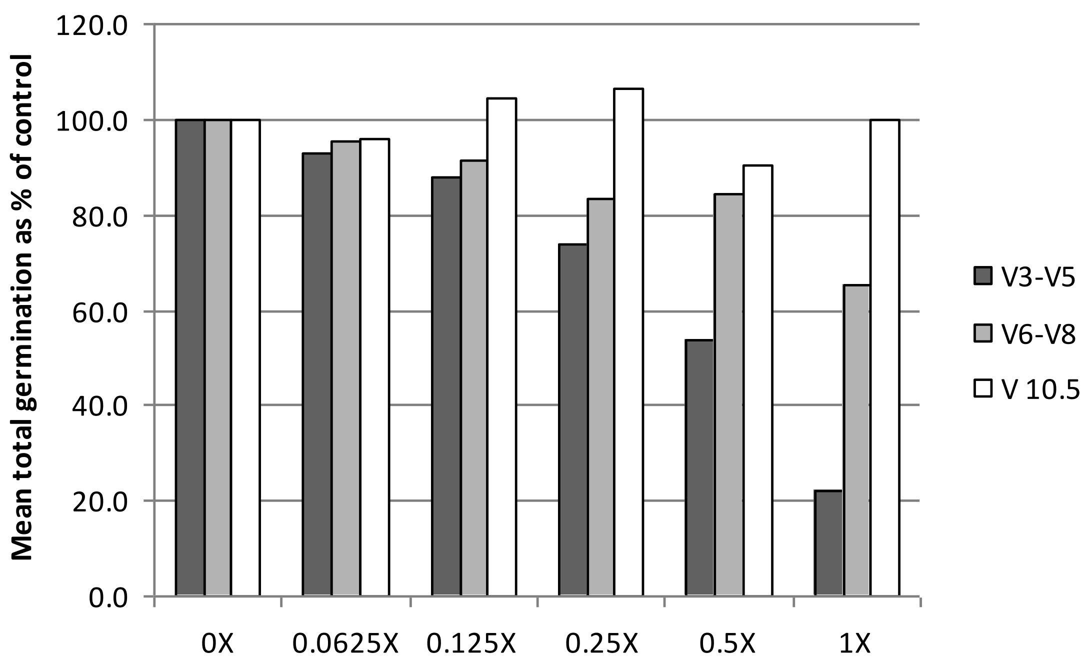

Figure 2. Cotton germination (as a percent (%) of the control) in response to varying concentrations of rye extract harvested from plants of increasing age and phenological development (V3-5, V6-8, and V10.5).