The Allelopathic Potential of Hairy Vetch, Fall Rye and Winter Wheat in a Silty Clay Loam Soil

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Introduction

Allelopathy is the chemical effect of one plant on another (including microorganisms) through the release of chemicals into the environment[1]. This effect is usually a form of amensalism, where one plant is inhibited while the other plant is unaffected. However, allelopathy may also manifest as a neutral/positive (stimulatory) interaction in some situations[1,2,3].

In agriculture, allelopathy is an additional weed management tool that when used in conjunction with other weed management strategies can be part of an integrated weed management approach. Unfortunately, little information on the allelopathic potential of crop species and their effect on common weeds is available in western Canada.

Preliminary research indicated that the allelopathic potential of hairy vetch, fall rye, and winter wheat aboveground biomass had a greater effect on canola, kochia, lamb's quarters, wheat, and wild oat when compared to belowground biomass[3]. For this reason, this study focused on aboveground biomass.

The objectives of this study where to examine the allelopathic effects of aqueous extracts of aboveground biomass of hairy vetch, fall rye, and winter wheat at two different developmental stages on the germination and radicle elongation of canola, kochia, lamb's quarters, wheat, and wild oat in a soil system; and to compare the chemical composition of these extracts.

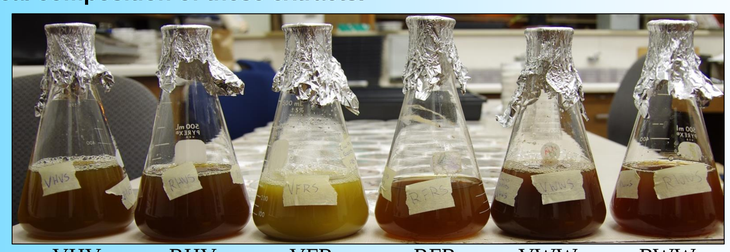

Figure 1 Vegetative stage hairy vetch (VHV), reproductive stage hairy vetch (RHV), vegetative stage fall rye (VFR), reproductive stage fall rye (RFR) vegetative stage winter wheat (VWW), and reproductive stage winter wheat (RWW) aboveground biomass aqueous extracts used to imbibe weed seeds in germination assays.

Methods

Canola, kochia, lamb's quarters, wheat, and wild oat seeds were imbibed in six aqueous extracts of both vegetative and reproductive stage aboveground biomass of hairy vetch, fall rye, and winter wheat in petri dishes on filter paper, or filled with 15g sieved (2mm) silty clay loam soil.

Aqueous extracts (10g dw / 100mL)

- Vegetative stage hairy vetch shoot (VHV)
- Reproductive stage hairy vetch shoot (RHV)
- Vegetative stage fall rye shoot (VFR)
- Reproductive stage fall rye shoot (RFR)
- Vegetative stage winter wheat shoot (VWW)
- Reproductive stage winter wheat shoot (RWW)

Controls

1. Distilled water control
   - ***account for dormancy and viability of seed***
2. Osmotic controls
   - di water + Mannitol
   - adjusted to same osmotic potential as each corresponding extract (271 - 383 mmol·kg^{-1})
   - **discern allelopathic from osmotic effects**

Medium

1. Filter Paper
   - P8-creped, 9.0cm diameter (Fisherbrand)
2. Silty Clay Loam Soil (15.0g)
   - homogenized, sieved (2mm)
   - 0 - 6" topsoil
   - 3.4% OM
   - pH 7.1
   - CEC 15.3 meq

Measurements

1. Germination
   - final count of germinated seedlings
   - corrected for osmotic effect (average -13%)
   - expressed as % of di water control
2. Radicle length
   - digital scan of 3 representative seedlings
   - measured using Assess 2.0 program[4]
   - corrected for osmotic effect (average -43%)
   - expressed as % of di water control
3. Chemical analysis of each extract
   - High Performance Liquid Chromatography (HPLC)

Statistical analysis

- SAS mixed model ANOVA of germination and radicle length relative to the di water control and corrected for osmotic effect[5]
- Principal component analysis of HPLC peak area (UV light absorbance and fluorescence emission) for each extract to **identify unique peaks and/or chemical concentrations**

Results

Germination

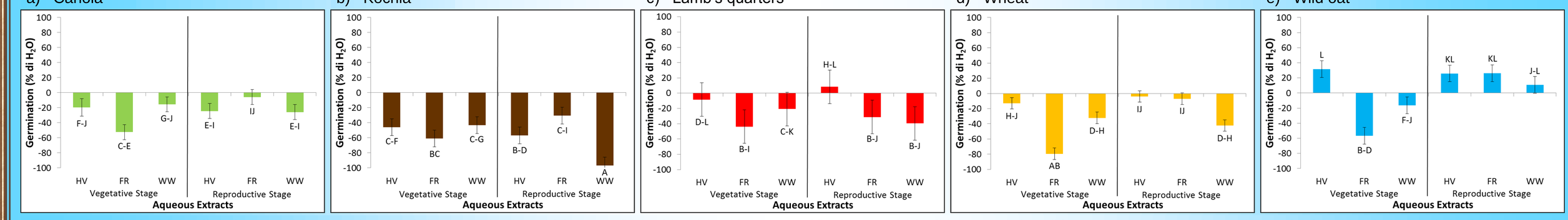

Figure 2 Allelochemical effect (corrected for osmotic potential) on germination of (a) canola (b) kochia (c) lamb's quarters (d) wheat, and (e) wild oat seeds in soil in response to vegetative and reproductive stage hairy vetch (HV), fall rye (FR) and winter wheat (WW) extracts relative to the di water control. Different letters above bars indicate statistically significant differences as determined by Fisher's protected LSD. Error bars indicate +/- one standard error.

Radicle Length

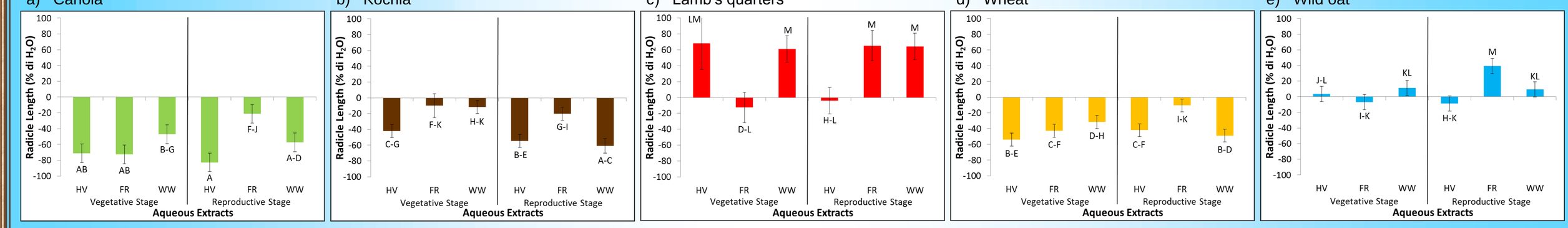

Figure 3 Allelochemical effect (corrected for osmotic potential) on radicle length of (a) canola (b) kochia (c) lamb's quarters (d) wheat, and (e) wild oat seeds in soil in response to vegetative and reproductive stage hairy vetch (HV), fall rye (FR) and winter wheat (WW) extracts relative to the di water control. Different letters above bars indicate statistically significant differences as determined by Fisher's protected LSD. Error bars indicate +/- one standard error.

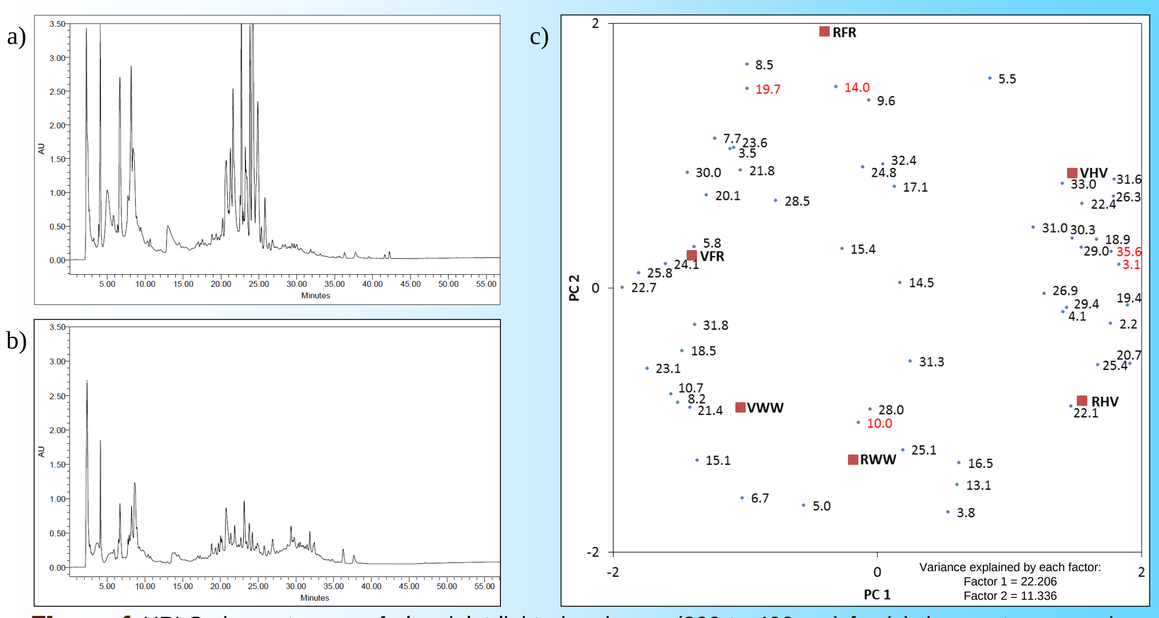

Figure 4 HPLC chromatogram of ultraviolet light absorbance (200 to 400 nm) for (a) the most suppressive extract (vegetative stage fall rye) and (b) the least suppressive extract (reproductive stage fall rye) during HPLC analysis. (c) Principal component analyses displaying the relationship between aqueous extracts and area of each peak observed within extracts. HPLC peaks are labeled with retention time (minutes). Peaks unique to allelopathic species are highlighted in red.

Key Findings

- Vegetative stage extracts resulted in the greatest allelopathic inhibition of both germination and radicle elongation of weed species when compared to reproductive stage extracts in soil (Fig. 2, 3).
- The vegetative stage fall rye extract resulted in the greatest allelopathic inhibition of germination and radicle elongation while the reproductive stage fall rye extract resulted in the least allelopathic inhibition (Fig. 2, 3).
- All weed species showed some degree of allelopathic inhibition of germination, however, radical elongation of lamb's quarters and wild oat was not inhibited by an allelochemical effect (Fig. 3c, e). Wild oat germination was allelochemically stimulated by both the vegetative and reproductive stage hairy vetch as well as the reproductive stage fall rye extracts (Fig. 2e), while wild oat radicle elongation was allelochemically stimulated by the reproductive fall rye extract (Fig. 3e). Lamb's quarters radicle elongation was allelochemically stimulated by all extracts except the vegetative stage fall rye and reproductive stage hairy vetch extracts (Fig. 3c). The allelopathic stimulation of lamb's quarters and wild oat warrants further investigation.
- When comparing between assay medium (soil or filter paper), it was evident that the soil medium reduced the allelochemical effects caused by all extracts on average by about 65% relative to the di water control (data not shown).
- Principle component analysis was used to investigate the compositional relationship among the extracts and revealed that the differences between extracts were greater among allelopathic species than between developmental stages within species (Fig. 4). This result, in addition to lower HPLC peak areas in reproductive tissue suggests that differences in chemical concentration rather than chemical composition were responsible for the effects observed between vegetative and reproductive developmental stages. HPLC analysis revealed peaks unique to each species (Fig. 4). Further investigation of peak identification is necessary.
- This research indicates that the allelopathic effects among plants are complex and dependent on allelopathic species, stage, medium, and model weed species. The utilization of allelopathic species can be a strategic component of an integrated weed management system targeting problematic weed species in western Canada.

References:

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