

## The influence of nitrogen and phosphorus concentrations on the allelopathic effects of *Festuca rubra ssp. commutata*

Dominic P. Petrella, Florence Sessoms, Jon M. Trappe, and Eric Watkins  
 Department of Horticultural Science, University of Minnesota, St. Paul MN

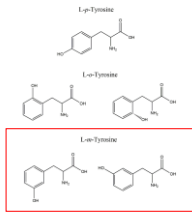
## Question

Fine fescues require lower amounts of fertilizer, could reduced nutrient levels alter allelopathic effects?

**Objective:** Determine if nitrogen and phosphorus alter allelopathic effects and allelochemical accumulation in Chewings fescue

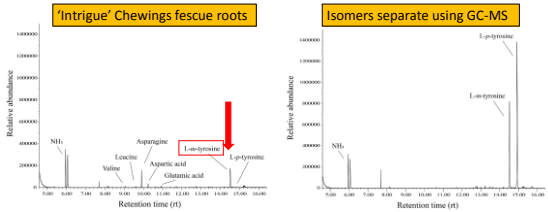
## Allelopathy in fine fescues

- **Allelopathy** is the synthesis and release of specialized, *phytotoxic*, metabolites into the environment
- Fine fescues are allelopathic (Bertin et al., 2009)
- Allelopathy is potentially due to L-m-tyrosine (Bertin et al., 2007)
  - Very potent
  - "Large" quantities exuded by roots of Chewings fescue cv. 'Intrigue'
  - Direct observations of allelopathic fine fescues are still lacking
  - L-m-tyrosine is rapidly degraded by microbes (Kaur et al., 2009)
- Environmental conditions alter allelopathic effects



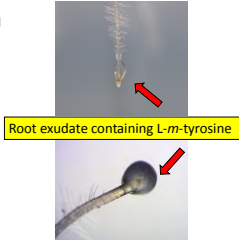
## L-m-tyrosine in Chewings fescue roots

L-m-tyrosine is the most abundant free amino acid in Chewings fescue cv 'Intrigue' roots

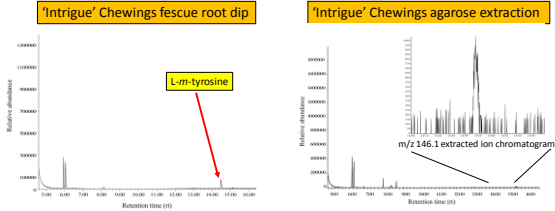


## What is the direct impact of growing fescues near weeds?

- After L-m-tyrosine discovery, little attention was paid to the **direct effects** of growing fescues near weeds
  - Are there other important metabolites?
  - Does neighbor competition influence allelopathy?
  - Would nitrogen and phosphorus influence allelopathic interactions?
- Direct effects are difficult to evaluate
  - Allelopathy and competition co-exist
  - We are reducing competitive effects through manipulating nutrient concentrations
  - Evaluate morphological changes attributed specifically to allelopathy



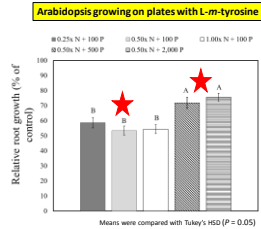
## Is L-m-tyrosine exuded by Chewings fescue roots?



L-m-tyrosine is produced and exuded, but do nutrient levels alters its effects?

## Nutrient fertility and L-m-tyrosine effects

- Would higher N or P allow weeds to overcome L-m-tyrosine effects?
  - *Arabidopsis thaliana* 'Col-0'
- 0 or 0.37  $\mu\text{M}$  L-m-tyrosine ( $\text{IC}_{50} = 0.249 \mu\text{M}$ )
- Five nutrient treatments on agar plates
  - (1) 0.25x (2) 0.50x, or (3) 1.00x N (15 mM N) + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
  - (4) 0.50x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
  - (5) 0.50x N + 2,000  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
- Measured root growth for 7 d post germination
- L-m-tyrosine significantly reduced AT root, no matter nutrient concentration
  - More N did not reduce severity
  - Increased phosphorus compensated
  - Effects of L-m-tyrosine could not be overcome with more nutrients



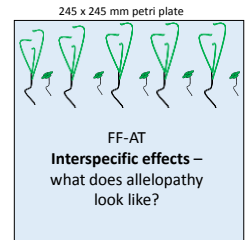
## Chewings fescue - Arabidopsis direct effects

### Fertility treatments evaluated:

1. 0.25x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
2. 0.50x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
3. 1.00x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
4. 0.25x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
5. 0.50x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
6. 1.00x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$

### Treatment structure

1. Arabidopsis seedlings (AT) alone (decreased neighbor interference) – Control
  2. Arabidopsis seedlings with older Arabidopsis (AT-AT)
  3. Arabidopsis seedlings with Chewings fescue cv. 'Intrigue' (FF-AT)
- 6 plates per treatment with 5 AT seedlings per plate
  - Measured root growth for 9 d post AT germination
  - Experiments have not been repeated



## Chewings fescue - Arabidopsis direct effects

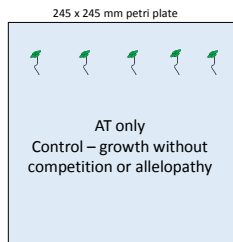
### Do these fertility treatments alter direct effects?

### Fertility treatments evaluated:

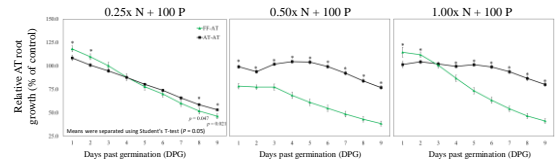
1. 0.25x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
2. 0.50x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
3. 1.00x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
4. 0.25x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
5. 0.50x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
6. 1.00x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$

### Treatment structure

1. Arabidopsis seedlings (AT) alone (decreased neighbor interference) – Control



## Effects of nitrogen under low phosphorous



- AT seedlings exhibited similar rates of inhibition no matter the species grown with
- AT and FF produce similar competitive effects
- More N removed some competition
- AT still suppressed AT seedling growth, indicating phosphorus may be limiting
- Increased N did not alleviate FF suppression on AT seedlings
- With FF, full strength N results in improved AT seedling root growth for 2 d – nitrogen effect?
- 100  $\mu\text{M}$  Phosphorus is limiting

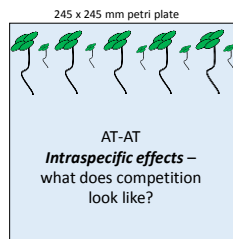
## Chewings fescue - Arabidopsis direct effects

### Fertility treatments evaluated:

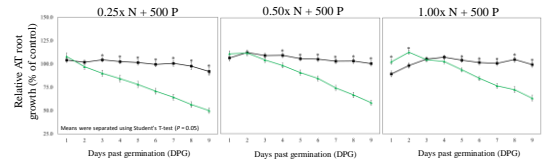
1. 0.25x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
2. 0.50x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
3. 1.00x N + 100  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
4. 0.25x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
5. 0.50x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$
6. 1.00x N + 500  $\mu\text{M}$   $\text{KH}_2\text{PO}_4$

### Treatment structure

1. Arabidopsis seedlings (AT) alone (decreased neighbor interference) – Control
2. Arabidopsis seedlings with older Arabidopsis (AT-AT)



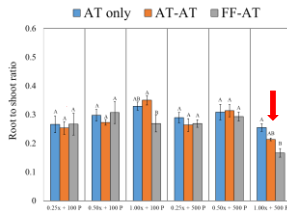
## Effects of nitrogen under increased phosphorous



- Increased P led to no competition between AT and AT seedlings
- AT seedlings grown with FF show similar response to lower P experiment
- Increased N did not alleviate FF suppression on AT seedlings
- Slopes of FF-AT similar to previous
- Magnitude of suppression was only slightly increased
- Full strength N results in drastically increased AT seedling root growth for 2 d – nitrogen effect?
- Phosphorus does not seem to be limiting

### Arabidopsis morphological changes

- Changes in the root to shoot ratio (R:S) can indicate nutrient stress (Hermanns et al., 2006; Gruber et al., 2013)
  - Nitrogen and phosphorus stress increase R:S
  - Roots are larger relative to shoots
- Low N and P decreased root and shoot growth similarly to AT only
- 0.50x + 100 P slightly increased R:S, indicating increased nutrient stress with unbalanced N and P
- Full N with low P was similar, but FF-AT was quite reduced
- Higher phosphorous treatments were similar
- Full N + increased P reduced R:S of FF-AT
- R:S data indicate potentially insignificant nutrient competition with FF plants

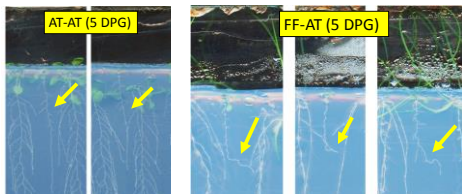


### Conclusions and future steps

- Methods for L-m-tyrosine quantification were improved
  - Need to determine if concentrations are changing under various nutrient treatments
- Moderate amounts of nitrogen (7.5 mM N) and moderate phosphorus (500 μM) increase allelopathic effects while minimizing competitive effects
  - Use shoot derived Arabidopsis N and P starvation genetic markers to accurately determine levels of nutrient competition
  - What impact do even higher levels of phosphorus have on the growth of Arabidopsis with Chewings fescue?
- Measure lateral root length as another means of morphological assessment
- Abnormal agravitropism indicates allelopathy over competition
- These effects are not due to L-m-tyrosine and may be due to another metabolite or synergy with another metabolite

### Arabidopsis morphological changes

Abnormal gravitropism was observed with FF-AT treatments



Agravitropic growth was only observed with higher levels of phosphorus

### Acknowledgements

This project was supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Specialty Crops Research Initiative under award number 2017-51181-27222



#### Department of Horticultural Science

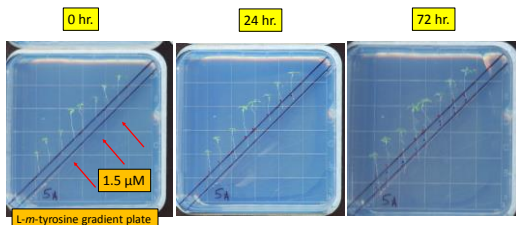
Adrian Hegeman  
Jerry Cohen  
Jayanti Suresh

#### Turfgrass science research group

Brian Horgan  
Andy Hollman  
Kris Moncada  
Chase Straw  
Dan Sandor

Garett Heineck  
Nicole Mihelich  
Yinjie Qiu  
Dominic Christenson  
David Herrera  
Ryan Schwab

### Do Arabidopsis roots avoid L-m-tyrosine?



This agravitropism is not due to L-m-tyrosine