

**Frass 101: Knowns and unknowns of plant-soil interactions**

Livestock and Poultry Environmental Learning Community, August 15, 2025

Amanda Ashworth, Ph.D. – USDA, Agricultural Research Service, Acting Research Leader, Soil Scientist  
 Helen Amorim, Ph.D. – Postdoc Fellow




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**The MINiStock Grand Challenge**

Model for INsect Inclusion in Sustainable Agriculture

- 40 ARS Scientists
- >20 Research Units
- 19 Locations
- 12 National Programs



[www.ars.usda.gov/oc/utm/insect-meal-a-grand-challenge/](http://www.ars.usda.gov/oc/utm/insect-meal-a-grand-challenge/)



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**Our Team**

Diverse portfolio of ARS expertise  
 Entomology, molecular and microbiology, animal science, chemistry...

7 working groups that build upon existing research conducting by ARS researchers

Mission: Enhance a circular economy through research solutions needed to facilitate insect upcycling of organic waste into sustainable protein and other value-added products.





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### Insect agriculture for circular systems

- Insect protein can be produced using <0.02% of the water required for an equivalent volume of soybean meal, and up to 500x the yield per acre of soybean.
- An insect farmer producing 2 tons frass/week (3% N and 5% P<sub>2</sub>O<sub>5</sub> = 3,300 kg N and 5,600 kg P<sub>2</sub>O<sub>5</sub> yr<sup>-1</sup> and displace 9,500 kg of ammonium nitrate and 20,000 kg of rock phosphate).
- The insect protein industry has over 300 companies worldwide and 21 in the US, and it continues to show economic promise as the global insect protein market was valued at \$600 million in 2023 and is expected to reach \$16 billion by 2033.
- Frass unknowns:
  - Frass quality based on insect/feed.
  - Fertilizer rates per cropping system (based on frass physiochemical properties)
  - Market prices for fertilizer
  - Understanding secondary benefits



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### 1. Frass physiochemical properties vs. other manure sources

**Objective:** assess chemical properties and potential nutrient supply of insect frass from varying rearing conditions compared with poultry litter

**Experimental setup:** commercial and laboratory frass (USDA-ARS National Biological Control Laboratory) and poultry litter (AR and NC)

**Frass composition**

- ✓ 2-times more C and N than poultry litter
- ✓ Up to 15-times more soluble reactive P
- ✓ No heavy metals
- ✓ Pathogens linked to wet feed source/waste



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### 2. Frass quality as affected by species and feed source

**Research question:** how does feed source and insect species affect frass chemical quality?

**Experimental setup:** insects fed various feed sources

- BSF-W:** agricultural waste
- BSF-D:** modified Gainesville diet + wasted fruits, vegetables, and grains
- Cricket-D:** Mazuri® standard cricket diet
- Mealworm-W:** post-consumer waste (wheat bran, rice hulls, fruits and vegetables)

**Data collection:** frass chemical properties and major foodborne pathogens



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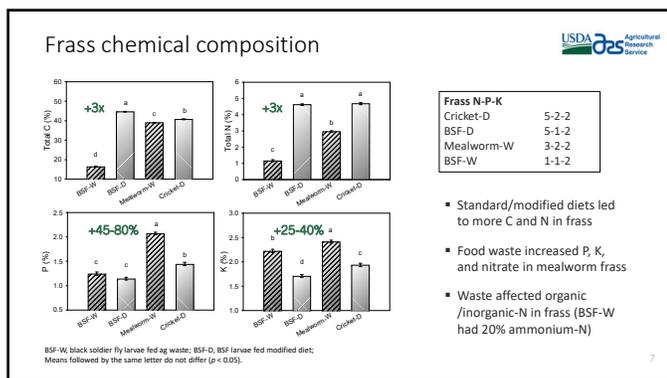
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### 3. Frass improvements in soil and plant health

**Objective:** investigate frass improvements on soil health, forage yields and quality compared to poultry litter and synthetic fertilizers

**Experimental setup:** bermudagrass plots on a silt loam soil receiving fertilizers (late May 2022 and 2023)

- Ammonium nitrate (AN; 67 kg ha<sup>-1</sup>)
- Poultry litter (PL; 3.4 Mg ha<sup>-1</sup>) ~ 2% N
- Low *T. molitor* frass rate (LF; 3.4 Mg ha<sup>-1</sup>) ~ 3% N
- High *T. molitor* frass rate (HF; 6.8 Mg ha<sup>-1</sup>)
- Control (CT; no fertilizer)

**Data collection:** soil properties (0-15 cm depth; 2022-2024), soil health indices, and forage mass and quality (Spring-Summer 2022 and 2023)

Ashworth et al. Insect frass fertilizer as soil amendment for improved forage and soil health in circular systems. Sci Rep 15, 2024 (2025). <https://doi.org/10.1038/s41598-025-01717-9>

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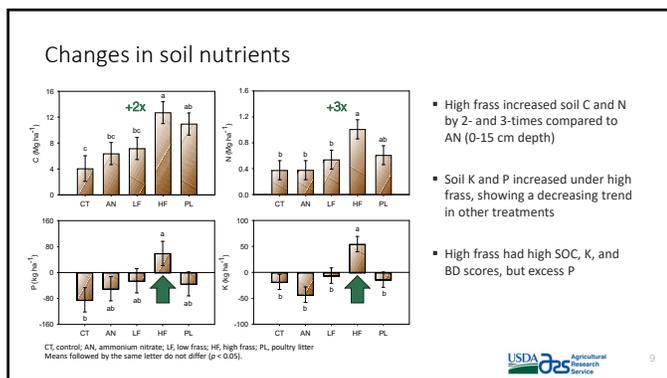
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### 4. Frass fertilizer in organic systems

**Research question:** how frass improves soil health, crop yields and quality, plant growth and resistance to stress in organic row crop systems?

**Experimental setup:** soybean plots on a 5% slope, irrigated and dryland, and switchgrass receiving organic fertilizers

- Poultry litter (PL; 5.6 Mg ha<sup>-1</sup>) ~ 2% N
- Low *H. illucens* frass rate (LF; 5.6 Mg ha<sup>-1</sup>) ~ 1% N
- High *H. illucens* frass rate (HF; 11.2 Mg ha<sup>-1</sup>)
- Control (CT; no fertilizer)

**Data collection:** soil physicochemical properties and enzymes (chitinase), plant height, leaf greenness, leaf damage at 30, 60, and 90 days after planting, crop yields and nutritional value



Amorim et al., submitted to Journal of Environmental Quality



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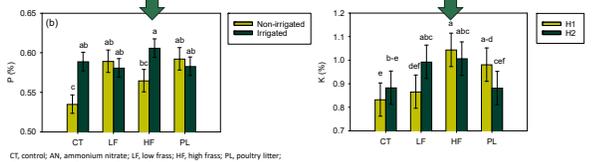
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### Crop yields and plant nutrition

- High frass increased P in soybean grain by 13% and K in pasture crops by 25% relative to the control;
- Owing to similar yields, low frass had 2-4 greater nutrient use efficiency than PL.



CT, control; AN, ammonium nitrate; LF, low frass; HF, high frass; PL, poultry litter; Means followed by the same letter do not differ ( $p < 0.05$ ).



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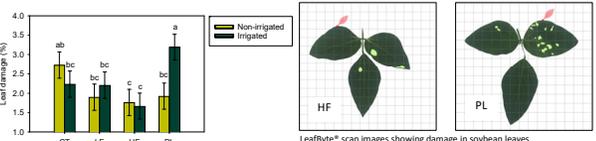
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### Leaf damage

- Soybean leaves under high frass-dryland plots had 37% less damage than the control, and 48% less damage than PL under irrigated conditions



CT, control; AN, ammonium nitrate; LF, low frass; HF, high frass; PL, poultry litter; Means followed by the same letter do not differ ( $p < 0.05$ ).



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Thank you!  
[Amanda.Ashworth@usda.gov](mailto:Amanda.Ashworth@usda.gov)



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