

Title: A disruptive soil amendment for soybean production: growing organically with insect frass

Author

- AMORIM, HELEN C. - University Of Arkansas
- Ashworth, Amanda
- Ducey, Thomas
- BREWER-GUNSAULIS, VALERIE - Tyson Foods
- DRESCHER, GERSON - University Of Arkansas
- Owens, Phillip
- PATTERSON, ALANA - Tyson Foods
- DE BLASIS, GIOVANNA - Protix Bv
- VAN STRAATAN, IRIS - Protix Bv

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Interpretive Summary:

Technical Abstract: Insect frass – the main by-product of insect rearing for animal feed – is a mixture of excreta and exuviae, enriched in macronutrients and a promising soil amendment and plant growth promoter. However, a lack of basic agronomic information prevents frass' widespread use by regional farmers. Here, we assessed impacts of black soldier fly [BSF; *Hermetia illucens* L. (Diptera: Stratiomyidae)] larvae frass on soil health, crop growth and quality, and plant resistance to stress compared to poultry litter in organic systems. Irrigated and non-irrigated soybean (*Glycine max* L. Merr.) received either poultry litter (PL; 5.6 Mg ha⁻¹), low (LF) and high (HF) frass rates (5.6 and 11.2 Mg ha⁻¹, respectively), or unamended control (CT). In general, soil fertility and biological health (0-15

cm) were unaffected by soil amendments ($p < 0.05$); yet, HF-irrigated soybeans had 7% higher P content in grains than non-irrigated, and 13% greater P content than the non-irrigated control ($p < 0.05$), demonstrating frass performance as a soil amendment varies with irrigation conditions. HF reduced soybean leaf damage by 35% and 48% relative to the non-irrigated control and irrigated-PL plots ($p < 0.05$), illustrating frass potential as a natural pesticide. LF had 2-4 times greater nutrient use efficiency than HF and PL, owing to similar yields and much lower nutrient inputs. This study is the first to showcase the multiple benefits of frass to plant protection and grain nutritional value under field conditions. These findings pave the way for frass use as an organic fertilizer and biostimulant and support waste management of a fast-growing, sustainable industry.