Proof of Concept for Growing Lettuce and Carrot in a Biobased Mulch System

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Introduction

- Organic weed management is challenging in direct-seeded, high-density plantings of vegetable crops and hand-weeding is still commonplace.
- Plastic and biobased mulch films can increase specialty crop yields by >30% compared to bare soil (Figure 1), but are not typically used for high-density plantings.
- Many biomulch products provide similar performance as polyethylene plastic film, but are significantly more expensive; thus, **we need to explore ways to add value to biobased mulch**.
- **One idea:** If crop roots can penetrate and grow through a biomulch membrane then we could seed and establish vegetables directly on top of the mulch without creating individual planting holes that would jeopardize the integrity of the membrane (Figure 2).
- We are proposing a novel biomulch system for direct-seeded, high-density vegetable plantings where growers will:
  1. Make a raised bed and lay a crop-root-permeable biomulch membrane
  2. Plant seeds directly on top of the biomulch
  3. Top-dress with a locally available, certified compost
  4. Manage crops with usual cultural practices, but without any additional weed management
  5. Use biomulch removal to concurrently remove crops from the field (as crop roots will be entangled in the membrane) – or harvest as normal and leave biomulch in the field

Our objectives were to: 1) determine the potential for two direct-seeded, high-density planting vegetable crops to germinate on and grow through prototype biobased mulch membranes, and 2) measure crop growth changes and yield in response to the prototype mulches.

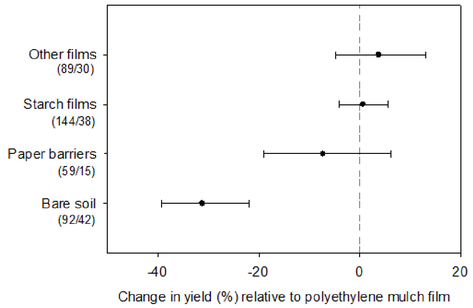

Figure 1. Mean change in crop yield as influenced by bare soil and biobased mulch type including starch-based films, paper mulch barriers, and other polymer films (relative to polyethylene mulch film) as determined via meta-analysis. Numbers below y-axis labels indicate the number of observations and studies (left/right, respectively) contributing to each mean. Error bars represent 95% confidence intervals determined via bootstrapping.

Figure 2. Weed competition during carrot establishment with (left) and without a biomulch membrane. Dominant weed species are *Amaranthus* and *Setaria* spp.

Methods

- We conducted a greenhouse pot trial with five replicate pots of a 3 x 2 factorial combination of treatments for separate lettuce and carrot trials (Figure 3).
- The first factor was 'mulch' and included two types of prototype biobased mulch (a 100% polylactic acid biofabric [PLA] and a PLA [37% by weight] + soybean meal [63% by weight] biofabric [SOY+PLA]) and a no mulch control (Figure 4).
- The second factor was 'top-dressing' and included compost or a soil mix.
- Mulches were cut in a circle to fit within the top of each pot, and seeds were placed on top of wetted mulch. Top-dressings were applied to a depth of 1 cm and pots were watered to field capacity.
- Each pot was fertilized 2x/wk beginning 4 wks after seeding.
- Lettuce heads and carrot roots were harvested and weighed fresh 64 days after planting.

Figure 3. Greenhouse arrangement of treatment factors and crops.

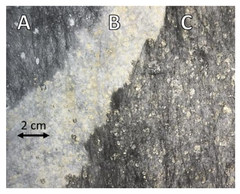

Figure 4. A bird's eye view of a deconstructed piece of PLA/soy biomulch including: A) spunbond PLA fibers in the bottom layer; B) meltblown PLA sheet with embedded soy in the middle layer; and C) spunbond PLA fibers in the top layer.

Results and Discussion

- Averaged across top-dressing treatments, PLA+SOY mulch increased lettuce yield in comparison with PLA mulch and the no mulch control (Figure 5).
- Carrot yield followed a similar trend, where the PLA+SOY mulch seemed to perform best; however, differences from PLA (p=0.095) and the no mulch control (p=0.27) were not significant.
- Embedded soybean meal in biomulch may have: 1) served as a starter fertilizer for the young crops, and 2) increased pore size for root growth through the PLA matrix (through biodegradation of soy and adjacent PLA polymers).
- Although total carrot yield was not negatively affected by biomulch, some visible root constriction and resulting aesthetic changes (Figure 6) could reduce the fresh market value for this crop.
- Biomulch mass loss (biodegradation during crop growth) was greatest when PLA+SOY mulch was combined with the compost top-dressing treatment (38.7% ±2.2%; ±one SE), followed by PLA with compost (27.1% ±2.2%) and PLA + SOY with soil mix top-dressing (25.2% ±2.2%), and lowest in PLA with soil mix top-dressing (4.1% ±2.2%).
- Differences in biomulch degradation can be explained by C:N of mulch and top-dressings.

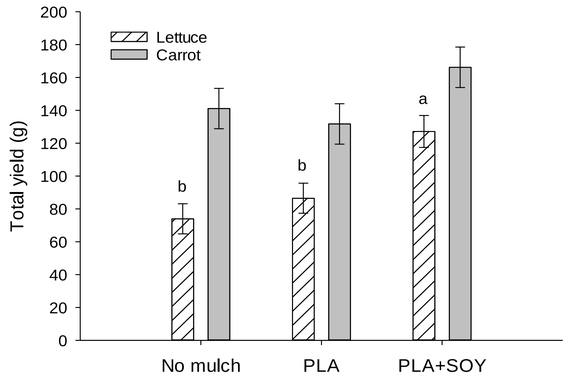

Figure 5. Fresh lettuce (g/plant) and carrot (g/pot) yield as influenced by the type of biomulch barrier beneath the seeded crop. PLA+SOY = polylactic acid based mulch + soybean meal particles; PLA = polylactic acid based biofabric mulch.

Figure 6. Harvested carrots (left) and lettuce (middle), and lettuce root architecture (right) after direct-seeding onto the PLA (carrot) or PLA+SOY (lettuce) biofabric mulch.

Conclusions and Next Steps

Figure 7. Visual observations from field trials in 2020 including pelleted spinach seed on top of SOY+PLA biomulch (left), compost top-dressing placed on top of carrot seed (middle left), carrots growing on and through PLA biomulch 35 days after planting (middle right), and matted-row strawberry plants producing runners on top of PLA (top right) and SOY+PLA biomulch (bottom right).

- Results of greenhouse study successfully demonstrated proof of concept for seeding high density vegetable crops on top of a permeable biobased mulch membrane.
- Next steps (currently in progress) in the development of this biomulch-based cropping system include field-scale research to assess agronomic performance, potential for reduced incidence of plant and human pathogens, and profitability compared to the current mulch-free status quo in spinach, lettuce, carrot, and matted-row strawberry production (Figure 7).

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