EXAMINING COVER CROPS AS CARBON SOURCES FOR ANAEROBIC SOIL DISINFESTATION

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Increased adoption of protected culture systems in the Mid-Atlantic region allows for extended growing season and mitigation of adverse weather conditions, assuring higher vegetable yield and quality. Nevertheless, over time, microenvironmental conditions typical of protected culture systems, associated with limited opportunities for crop rotation, can lead to decreased soil health and emergence of soilborne pest and pathogen issues. In Pennsylvania, for instance, continuous cultivation of tomatoes under high tunnels is leading to a higher incidence of root-knot nematode infestations, which was unheard before the use of high tunnels. Maintaining soil health is critical in these production systems, and chemical fumigation or chemigation, often are not an option for small farms serving a clientele increasingly demanding agrochemical-free produce. Among the biological or non-synthetic soil management options, anaerobic soil disinfestation (ASD) is gaining interest for its ability to control a broad spectrum of pests and pathogens, as well as for its potential beneficial impact on soil fertility and crop yield. Moreover, compared to soil solarization, despite being a biological process, ASD does not require the development of high soil temperatures and can be applied only two to three weeks before planting. A key component of the ASD treatment is the availability of a low cost and easily degradable carbon (C) source. A source of labile sugar is essential to feed the soil microbial population and initiate the ASD process leading to the production of fermentation products that are suppressive of soilborne pests and pathogens. Molasses, wheat and rice bran, and crop residues have been successfully employed as a C source for ASD (Shennan et al., 2014); however, not always such materials are available at local level and their cost including transportation may be prohibitive for ASD applications. As suggested in previous studies, cover crops may constitute a low-cost alternative source of C for ASD (Butler et al., 2014), but, further research is needed to identify cover crops suitable for different pedoclimatic regions and growing seasons. Although cover crops are commonly used in the Mid-Atlantic region to enhance soil health and reduce soil erosion, limited information is available on their specific use as C sources for ASD. To this purpose a preliminary greenhouse pot study was conducted to evaluate the potential of thirteen cover crop species as C sources for ASD (Table 1). Selected species were grown in a peat-perlite mix under controlled conditions. Measured parameters included seed germination, fresh and dry biomass production at 32 and 46 days after sowing (DAS). Plant tissues were then analyzed to determine total C and nitrogen (N) content, total sugar (TS) content, and easily oxidizable carbon (EOC) content. At harvest, fresh cover crop biomass was chopped and incorporated in pots filled with soil to simulate ASD treatments and compared to untreated soil and soil amended with molasses (applied at the rate of 1.39 L m^{-2}) for the development of anaerobic conditions. After material incorporation soil was saturated with water delivered via drip irrigation and pots were sealed using totally impermeable mulch for a period of four weeks. Soil redox potential (Eh) and temperature were monitored, and after the treatment, lettuce was transplanted to assess any potential positive or negative effect on plant growth. Cover crops plant growth analysis revealed significant differences in plant biomass production between selected species. Forage radish and mustard produced the highest fresh above-ground biomass, while sunn-hemp and sorghum-sudangrass had the lowest yield, both at 32 and 46 DAS (Fig. 1). In terms of dry matter, buckwheat consistently produced the highest shoot and total plant dry biomass at both assessments. Oats and rye, along with annual rye and forage radish at 46 DAS produced the highest root biomass. At final harvest cover crops total C ranged between 42.4% in field peas and 36.7% in forage radish. C:N ratio ranged from 1:17.7 to 1:33.5 in rye and buckwheat, respectively. Buckwheat had a higher TS content compared to all the cover crops tested, while no differences were observed in terms of EOC. Cumulative Eh (ΣEh) was significantly higher in soil amended with molasses compared to soil amended with cover crops, and no differences were observed among cover crops. No effects were observed on lettuce yield. A weak and a strong positive correlation were observed between EOC-ΣEh (r=0.35; $P = 0.03$) and TS-ΣEh (r=0.91; $P < 0.0001$), respectively. Similarly, applied total C (r=0.83; $P < 0.0001$), EOC (r=0.89; $P < 0.0001$), and TS (r=0.91; $P < 0.0001$), calculated multiplying concentrations by applied dry biomass, were positively correlated with ΣEh. Results suggest that both the amount of dry biomass and total C, EOC, or TS are key to achieve good levels of anaerobicity. Among cover crops examined, buckwheat was the most suitable source of C for ASD as it germinated quickly, produced the highest dry biomass, and had the highest TS concentration generating higher anaerobicity levels. Ideally, cover crops suitable for ASD should produce large amounts of fresh biomass in short time, requiring minimum soil preparation and nutrient availability, seeds should be available at low cost, and it should be characterized by high sugar content.

Literature cited

Butler D.M., Rosskopf E.N., Kokalis-Burelle N., Albano J.P., Muramoto J. and Shennan C., 2012. Exploring warm-season cover crops as carbon sources for anaerobic soil disinfestation (ASD). Plant and Soil, 355(1-2), pp.149-165.

Shennan C., Muramoto J., Mazzola M., Momma N., Kobara Y., Lamers J., Rosskopf E.N., Burelle N.K. and Butler D. 2014. Anaerobic soil disinfestation for soil borne disease control in strawberry and vegetable systems: Current knowledge and future directions. Acta Horticulturae, 1044,165-176.

Table 1. Examined cover crop species and relative broadcast seeding rate.

Botanical family	Common name	Seed rate (kg ha^{-1})
Leguminosae	Berseem clover	22
	Cowpea	135
	Crimson clover	34
	Field pea	132
	Sunn-hemp	56
Brassicaceae	Forage radish	22
	Mustard	17
Polygonaceae	Buckwheat	101
Graminaceae	Annual ryegrass	34
	Oat	157
	Rye	179
	Sorghum-Sudangrass hybrid	56

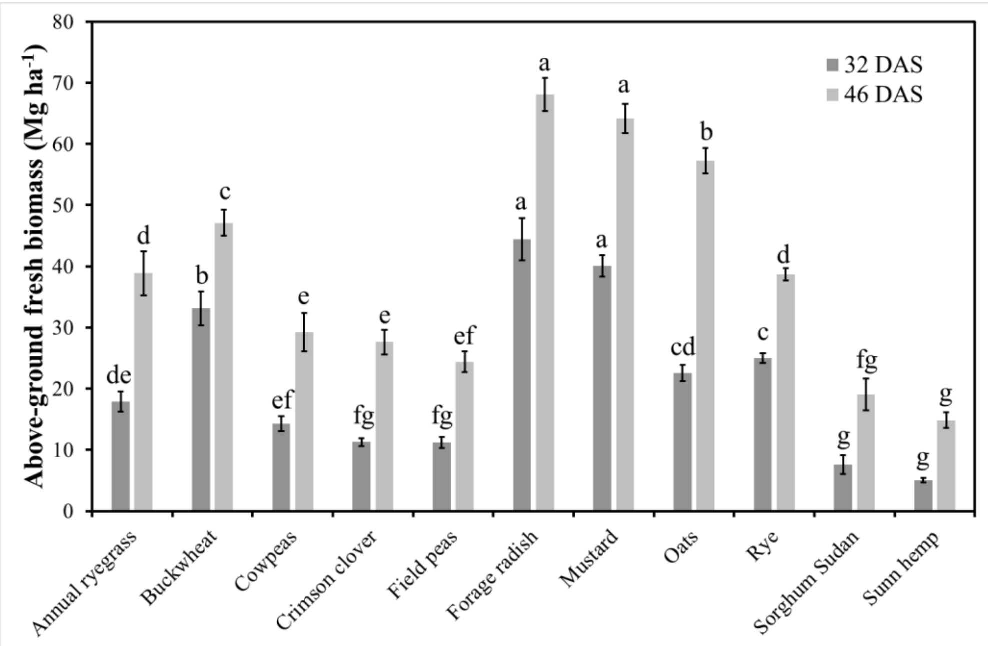

Figure 1. Above-ground fresh biomass produced by selected cover crops at 32 and 46 days after sowing.