Enhancing soil health with cover crops

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Soil health is generally synonymous with soil quality and refers to the capacity of a soil to sustain biological productivity, maintain environmental quality and promote plant health. Soils are complicated ecosystems, and discussions of soil health must consider the links between soil functions and soil-based ecosystem services, such as crop production, erosion control, pest and disease control, and biodiversity conservation.

While improving soil health or quality is not a new concept, it has received increased attention by growers, researchers and conservation agencies as a method to sustainably and economically improve crop production. The majority of research and information regarding soil health was developed for annual crops other than Florida citrus. Benchmarks for determining soil health are still in development, especially for Florida citrus production systems. However, there are indications that improving soil health, particularly through cover crops, may provide multiple benefits to citrus management and production.

WHY SOIL HEALTH IS IMPORTANT

Healthy soils typically have improved water-holding capacity, nutrient availability and microbial activity compared to soils with poor health or quality. These traits of healthy soils can influence root growth and nutrient uptake by the tree. This is particularly important for Florida citrus affected by huanglongbing (HLB) or citrus greening, as HLB can significantly impact root growth and nutrient and water uptake. The increased microbial activity and diversity associated with healthy soils may also impact citrus root growth by contributing to increased nutrient availability and potentially increasing the number and types of microbes that can promote root growth.

One of the key components to healthy soils is the amount of soil organic matter (SOM). This critical component of soils is made from the decomposition of plant material and microbes and contributes to some of the main components of a healthy soil: water-holding capacity and microbial activity. The majority of Florida citrus soils have extremely low SOM content. Increasing SOM can be challenging due to the climate and existing soil conditions. Methods to improve soil health, and SOM, in particular, include reducing soil disturbance, keeping soil

covered and maintaining living roots in the soil throughout the year.

HOW COVER CROPS HELP

Cover crops are one of the ways to improve soil health that utilize all of the methods mentioned above. Having plants in the ground year-round prevents erosion and can limit weed growth and the frequency of herbicide application. The leaf litter and roots of cover crops also contribute to SOM as they decompose and provide resources for microbial activity. In addition, using cover crops in citrus may improve soil-plant-microbe interactions by gradually increasing the abundance and diversity of soil microbes involved in soil nutrient cycling and many of the traits critical for a healthy soil.

FIRST-YEAR FIELD TRIAL FINDINGS

Preliminary data from ongoing field trials indicate that planting cover crops in the row middles can impact soil health. Three-year field trials were established in two commercial citrus groves (A and B) in South Florida (Immokalee) in 2019. This study is examining two cover crop mixes in combination with or without eco-mowing, a practice that directs clippings under the tree canopy, and a grower-standard control.

Cover crops are being planted approximately two times per year. The two cover crop mixes are identical, but mix 2 does not include any nitrogen-fixing cover crops (e.g., sunn hemp and clovers). Non-legumes in the trial include daikon radish, winter rye, browntop millet, dove millet and buckwheat. Trees in both groves are Valencia on Swingle, are over 20 years old and have similar management.

In both groves after only one year of planting cover crops, SOM increased in the row middles that were planted with cover crops compared to the grower-standard control (Figure 1). The legumes in mix 1 appeared to have a greater beneficial effect on nitrogen cycling compared to mix 2, as soil concentrations of ammonium and nitrate were higher in those soils. Legumes, through a symbiotic relationship with specific microbes, can fix nitrogen from the atmosphere and add it to the soil, likely contributing to this greater soil nitrogen.

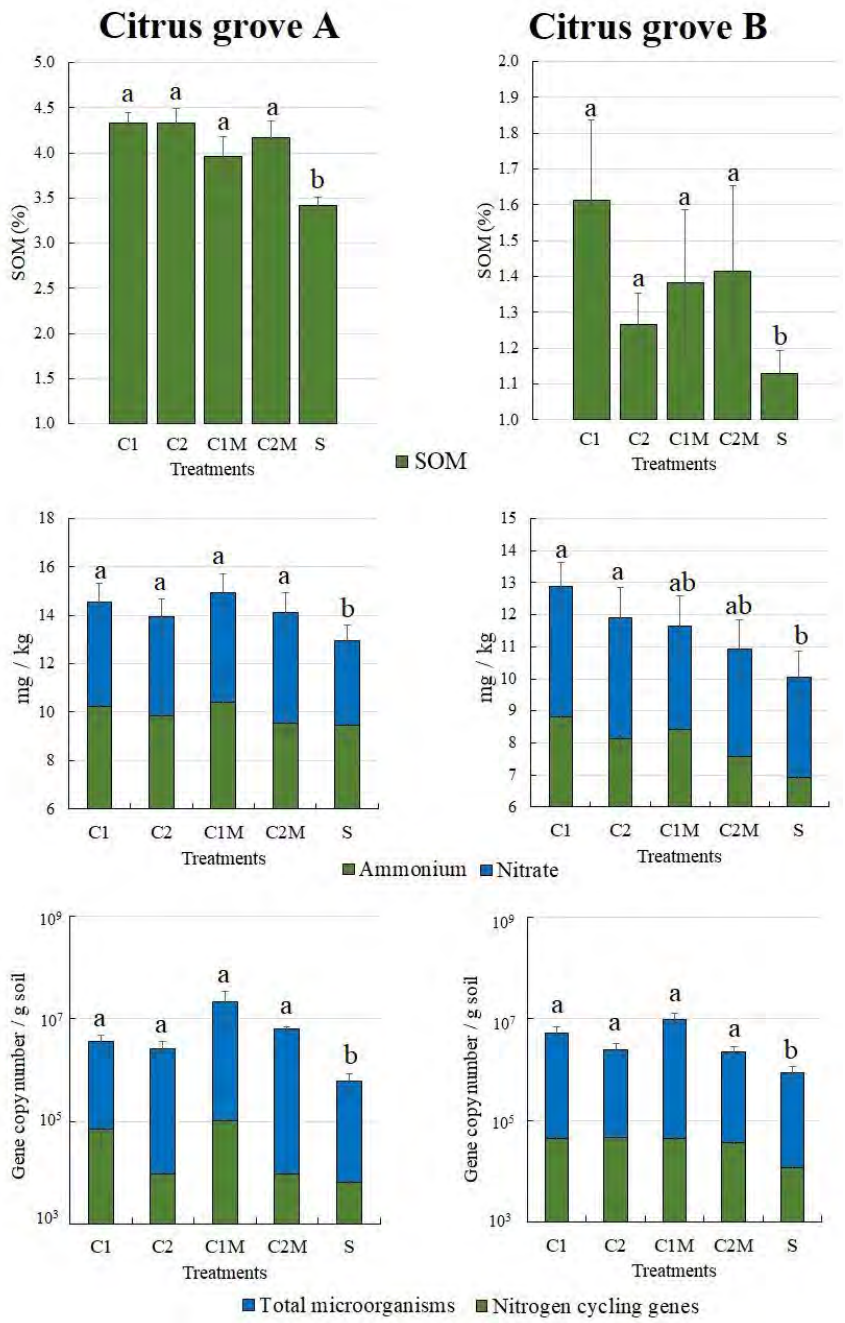

Figure 1. Effect of cover crops on soil organic matter, soil ammonium and nitrate concentration, and total abundance of microorganisms and nitrogen cycling genes in a grower-standard control (S) and mixtures of non-legumes and legumes (mix 1; C1) and non-legumes (mix 2; C2) cover crops in a commercial citrus grove in South Florida. Eco-mowing treatments are denoted with "M." Soil samples were taken 12 months after cover-crop planting. Letters indicate significant differences.

Although there is not a specific level of microbial abundance that equates a "healthy" soil, increases in SOM and soil nutrients in the trials were accompanied by increases in the abundance of soil microorganisms (Figure 1). Using molecular biology techniques, researchers detected a greater number of genes, which serve as a proxy for different soil microbes, involved in soil nitrogen transformations in the cover crop treatments compared to the grower-standard control (Figure 1).

In citrus, cover crops can be planted only in the row middles or trunk-to-trunk (Figure 2, page 24). Even if cover crops are only planted in the row middles, improvements to soil health may still provide benefits to the trees, as citrus roots extend into the row middles. In the trials, cover crops

Photos by Sarah Strauss

Figure 2. Cover crops can be planted in the row middles (A) or trunk-to-trunk (B) in citrus groves.

were not planted under the tree canopy. However, increases in SOM and microbial abundances were still found under the tree canopy that were similar to what was found in the row middles.

Preliminary data also indicate that cover crops can have a significant influence on weed management. See "Row-middle weed management methods" in the September 2020 issue of Citrus Industry magazine for more information.

Generally, the initial results suggest that: 1) improvements in soil nutrient cycling in citrus row middles due to cover crops can be observed after only one year of treatment, and 2) cover crops promote microbial gene abundance, which is linked to improved soil health. However, while the overall patterns in changes to soil nutrients and microbes are similar in both groves, some differences between locations can be seen. As the study continues, researchers hope to better understand what might be contributing to these differences between the locations (e.g., fertilizer and herbicide applications or climatic conditions).

COVER CROP CONSIDERATIONS

The majority of research on the benefits and impacts of cover crops to agroecosystems has focused on annual cash crops. Therefore, their effect on soil health in perennial fruit systems, including citrus, remains largely unknown. There are many questions about the best mixes of cover crop species and the timing of planting, as well as how these combinations may impact soil nutrient cycling and water storage. The appropriate cover crop mix will largely depend on grove needs (e.g., increase SOM or weed management), location (e.g., soil characteristics or weather) and soil management practices.

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In the citrus trials, there was better cover crop germination and reduced weed pressure when cover crops were mowed before the next round was planted. The potential impact on tree nutrition due to changes in soil nutrients from cover crops is still being examined. After one year of the trials, significant differences in fruit quality, tree growth and production were not seen. However, because of Florida's low SOM (often only 1 percent or less) and unique climate, increasing SOM and soil nutrients is expected to be a long-term process. It may take several years for increases in soil health to translate to increases in tree health and productivity.

Some considerations to keep in mind are capital investments in a planter (e.g., no-till planter), seed costs, labor and time needed to learn effective management of this system. Because of the many environmental benefits, some conservation programs (including those offered by Natural Resources Conservation Service) offer cost-share opportunities that can help offset some of the initial management costs.

Cover crop adoption may seem risky since there is no clear guidance on cover crop management in citrus, and much of the benefits and costs will vary by grove due to differences in weather and soil characteristics. The field trials are expected to address some of these questions as it appears that cover crops may be extremely beneficial to Florida citrus production through improvements to soil health.

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