Horticulture

EXTENSION
UtahStateUniversity

extension.usu.edu

September 2016 Horticulture/Fruit/2016-04

Improving Organic Peach Orchard Fertility with Nitrogen-Fixing Ground Covers in Capitol Reef National Park: A Case Study

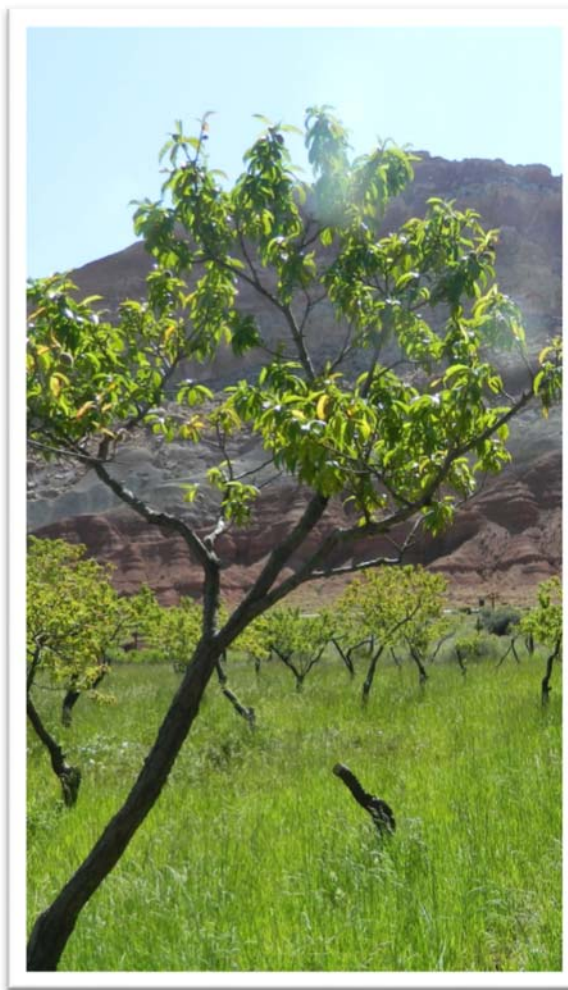
Esther Thomsen, Research Assistant
Diane Alston, Entomologist
Jennifer Reeve, Soil Scientist
Grant Cardon, Soil Scientist
Brent Black, Horticulturist

History

The orchards in Fruita, Utah, were first established in the early 1880s by Mormon pioneers. The valley became famous for its cultivation of fruit through the 1950s. Acquired by the National Park Service during the 1960s, and named Capitol Reef National Park (CRNP), the district was listed on the National Register of Historic Places in 1997. Today, Fruita's orchards are not primarily managed for fruit production, but rather for historical accuracy and tree longevity. Orchards in CRNP are preserved first and foremost to illustrate Fruita's cultural heritage.

Due to the emphasis on historical accuracy in managing the orchards, interesting challenges have presented themselves for park rangers and academics alike. For example, deer fencing is prohibited around orchards, which historically had no fencing; and since early settlers used flood irrigation, that is the only type of irrigation allowed for use today. In addition, animals are not allowed to be harmed or relocated since it is a National Park, even when trees or fruit are being damaged.

A USDA organic research grant provided funding for Utah State University researchers to collaborate with CRNP orchard managers to explore options to improve tree health and fruit quality using organic management techniques while maintaining historical and cultural mandates of the National Park Service.



Project Goals

One of the ongoing dilemmas for the CRNP orchard manager was providing adequate nutrition to the trees organically with only a small-allotted budget for tree maintenance. Organic fertilizers are not always expensive, however, shipment costs to remote locations can add up. The CRNP orchard manager and the USU research team decided to try nitrogen-fixing legumes on-site to affordably supply some of the nitrogen needs to trees. Alfalfa was chosen, as it is an historic feature of the landscape, hence an approved plant by the park service.

The goals of the team at the Carrell Peach Orchard in CRNP were to:

1) Discover how orchard plantings of alfalfa affect soil nitrogen levels and soil quality.

2) Assess the interaction and competition between alfalfa, grass, weeds, and peach trees.

3) Determine the influence of understory alfalfa plantings on insect and mite populations, both pest and beneficial species.

Implementation

In May 2012, a 25 ft by 92 ft section of the orchard was tilled and planted with alfalfa. Soil and tree leaf tissue samples, vegetation biomass, density and percent cover were taken in early spring and late summer of 2013, 2014 and late spring of 2015. Insect counts were also taken during these times, brushed from peach leaves, swept with a net from the orchard floor, and collected from soil samples via Berlese funnel tests. Test results were compared to samples taken from the control plot in an established perennial grass cover. However, the influence of local wildlife on the alfalfa had not been considered: yellow-bellied marmots heavily grazed the alfalfa. Therefore, in late summer 2013 a third treatment was established, alfalfa inter-seeded into the perennial grass cover using a no-till drill.

Results

Legumes

The legumes produced more foliage in the inter-seeded (alfalfa-grass) plots where their growth was hidden between tall blades of grass. Otherwise, the yellow-bellied marmots consumed most of the alfalfa plant matter (Figs. 1, 2 and 3).

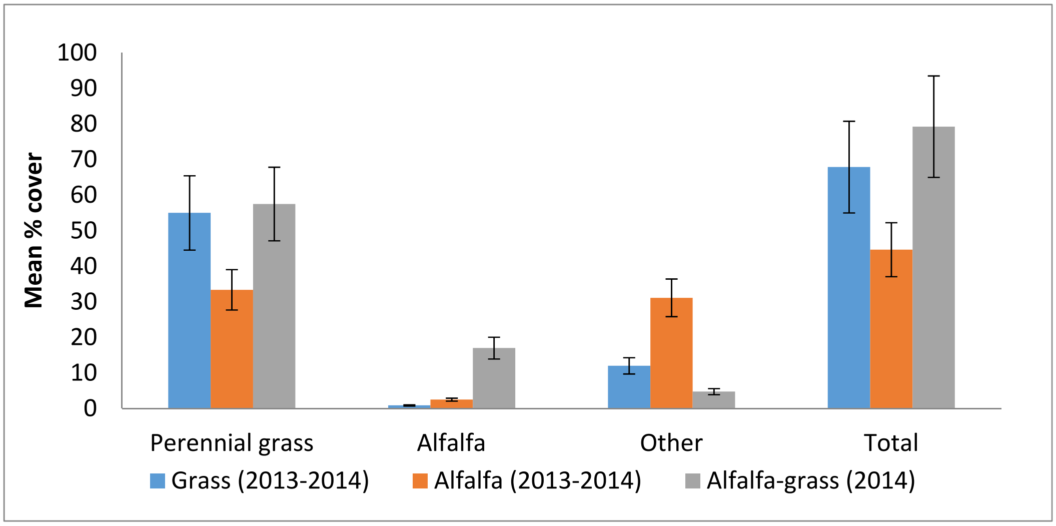


Figure 1. Average percent plant cover (grass, alfalfa, other, or total) in a 1.5 x 1.5 ft grid placed in four locations in each plot during summer sampling in 2013-2015. Alfalfa plots were seeded in spring 2012, and alfalfa inter-seeded into perennial grass in summer 2013.

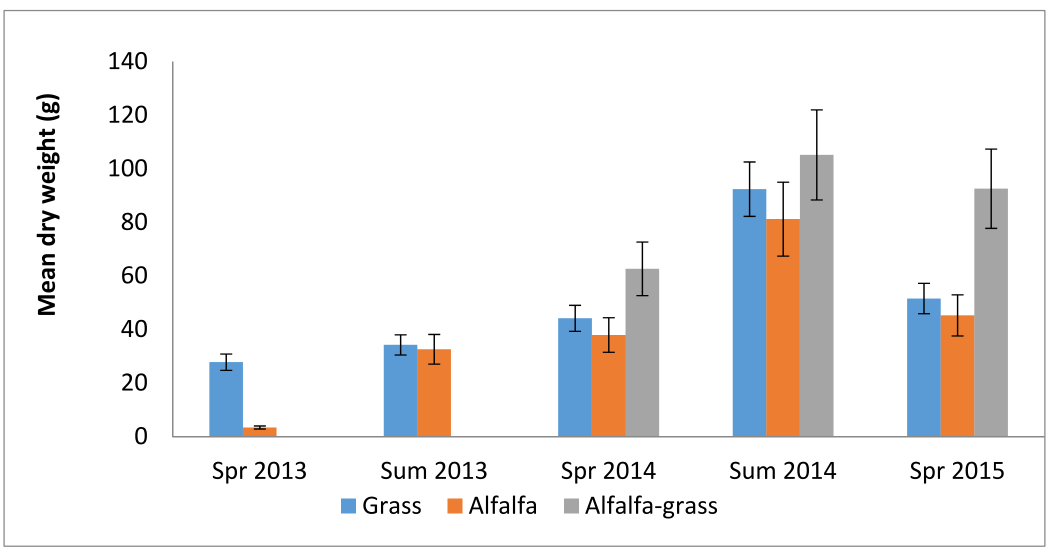


Figure 2. Average weight of total vegetation (dried) collected from a 1.5 x 1.5 ft grid placed in four locations in each plot from 2013-2015. Alfalfa plots were seeded in spring 2012, and alfalfa inter-seeded into perennial grass plots in summer 2013.

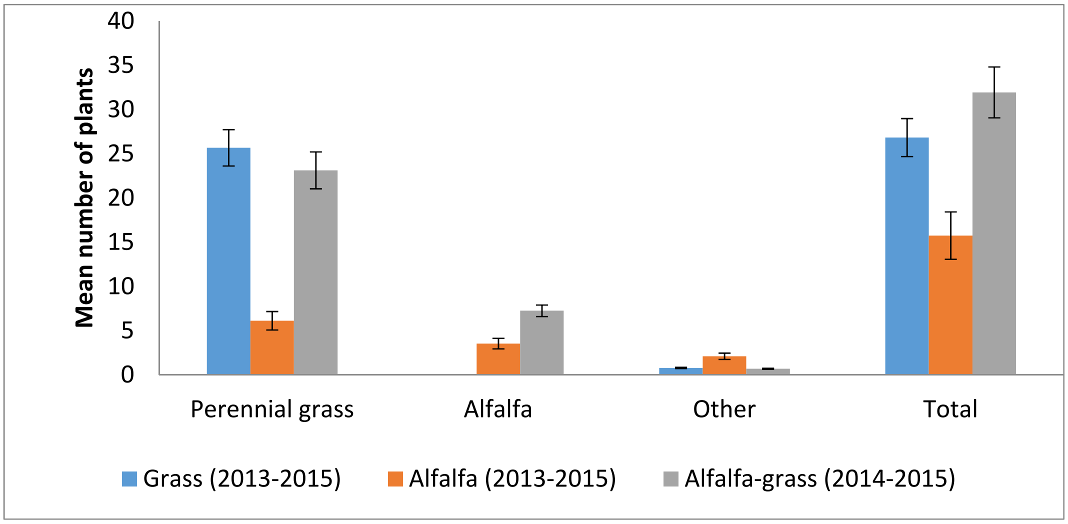


Figure 3. Plant density by species in a 0.5 x 0.5 ft grid placed in eight different locations in each plot during spring sampling in 2013-2015.

Soil Nitrogen

Total available soil nitrogen is shown in Fig. 4. Despite heavy grazing by marmots in the alfalfa plots, there was still a noticeable increase in soil nitrogen compared to the grass-only plots. This increase in available nitrogen was likely caused by tillage, which released otherwise unavailable nitrogen in the soil through the breakdown of perennial grass roots, clippings and larger soil organisms. By 2014, available soil nitrogen was reduced in the plots on average, but was still greater in the alfalfa and the alfalfa-grass plots than in the perennial grass plots. In June 2015, available nitrogen was low or undetectable, but greatest in the alfalfa-grass treatment. This suggests the potential for inter-seeded legumes to increase soil N even when present in relatively low proportions.

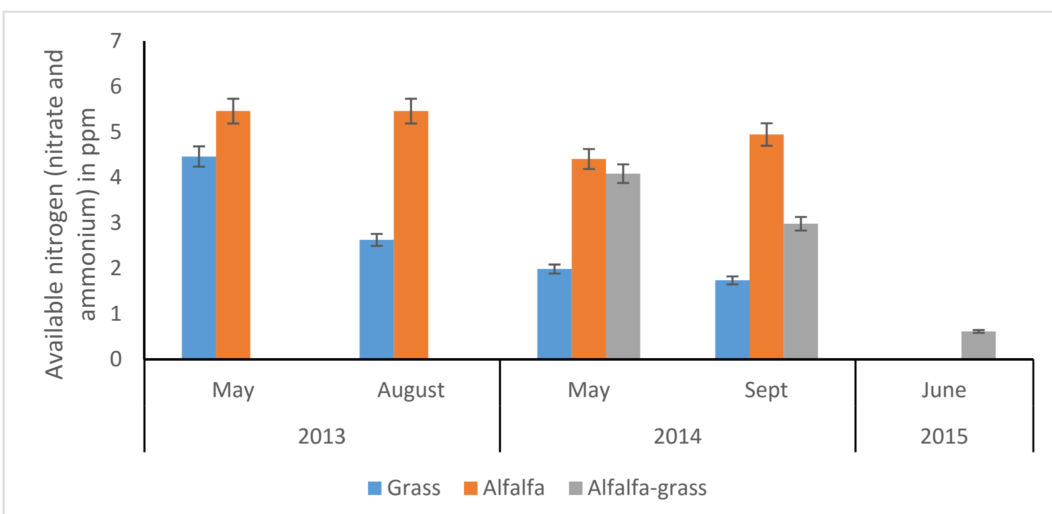


Figure 4. Available nitrogen (nitrate and ammonium) in ppm in grass, alfalfa and alfalfa-grass plots from 2013-2015.

Soil Phosphorus
The effects of ground cover treatments on soil phosphorus are shown in Fig. 5. In the first two years there were marginal to no differences in soil phosphorus; however, by 2015, the alfalfa-grass treatment had significantly less phosphorus. This difference may have been due to greater biomass of alfalfa and grass in the plots, consuming more phosphorus (Figs. 1, 2 and 3). Alternatively, it may have been due to natural variability since this difference was not apparent in other years, however, the inter-seeded alfalfa was not planted until summer of 2013 and may have required some time to influence phosphorus levels.

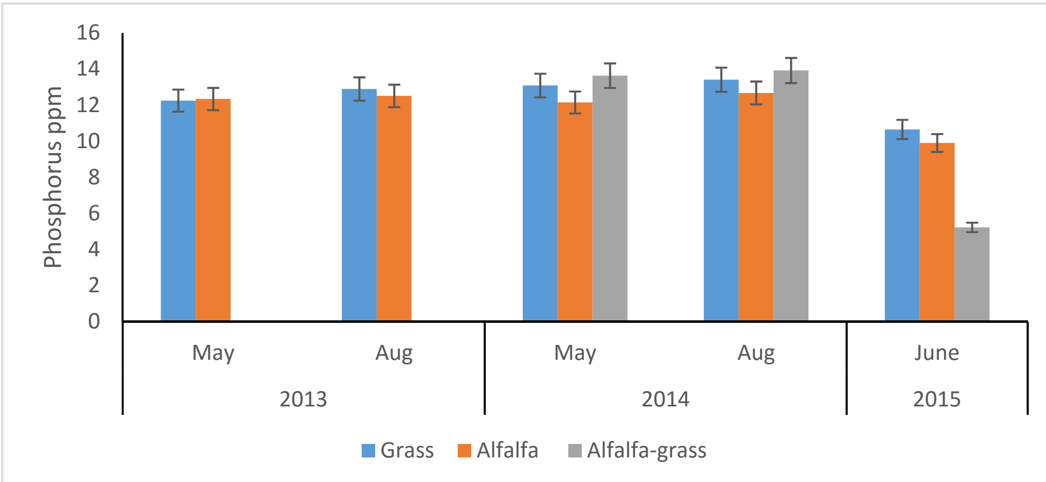


Figure 5. Phosphorus in ppm for grass, alfalfa and alfalfa-grass plots from 2013-2015.

Leaf Tissue Nutrients
Leaf tissue test results revealed deficiencies in nitrogen, calcium, iron and manganese in the peach trees of the Carrell orchard (Figs. 6 and 7; minimum normal values shown on the right). The alfalfa plantings were insufficient, at least in the short-term, to alleviate nitrogen deficiency. To resolve the deficiencies in calcium, iron and manganese, foliar sprays would be the best nutritional amendment.

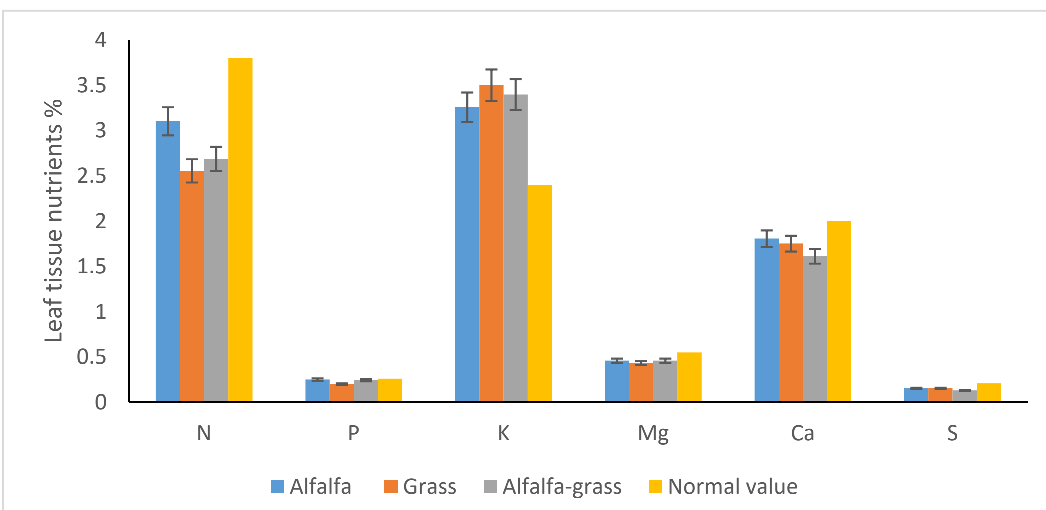


Figure 6. Macronutrient percent levels for peach leaves in the Carrell Orchard, from the alfalfa, grass and alfalfa-grass plots, in May 2014. Minimum normal values are shown on the right. N = nitrogen, P = phosphorus, K = potassium, Mg = magnesium, Ca = calcium, and S = sulfur.

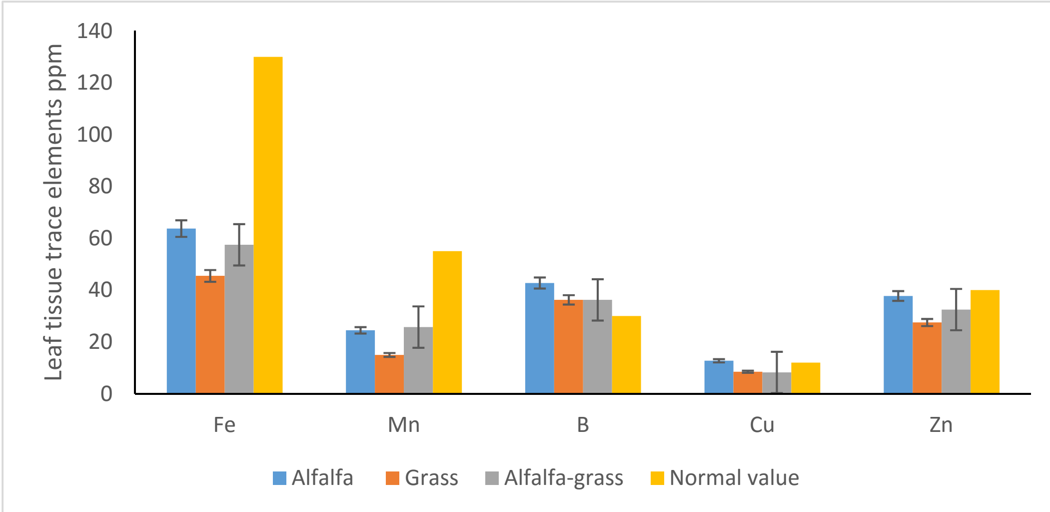


Figure 7. Micronutrient levels in ppm for peach leaves in the Carrell Orchard from the alfalfa, grass and alfalfa-grass plots, in May 2014. Minimum normal values are shown on the right. Fe = iron, Mn – manganese, B = boron, Cu = copper, and Zn = zinc.

Soil Microbial Biomass

Microbial biomass provides an indication of nutrient retention and turnover in the soil (Fig. 8). In 2013, the tilled alfalfa plots had greater microbial biomass than the grass plots, likely caused by the breakdown of soil aggregates and a release of otherwise unavailable organic matter, nitrate and ammonium. In September 2014, alfalfa-grass plots had significantly higher respiration rates than alfalfa or grass alone. However, by 2015, microbial biomass levels declined substantially in all plots with modestly higher levels in alfalfa-grass plots. Nitrogen fixation by alfalfa in the inter-planted legumes is the likely reason for the increased microbial activity, and indicates the potential for soil health improvements over time.

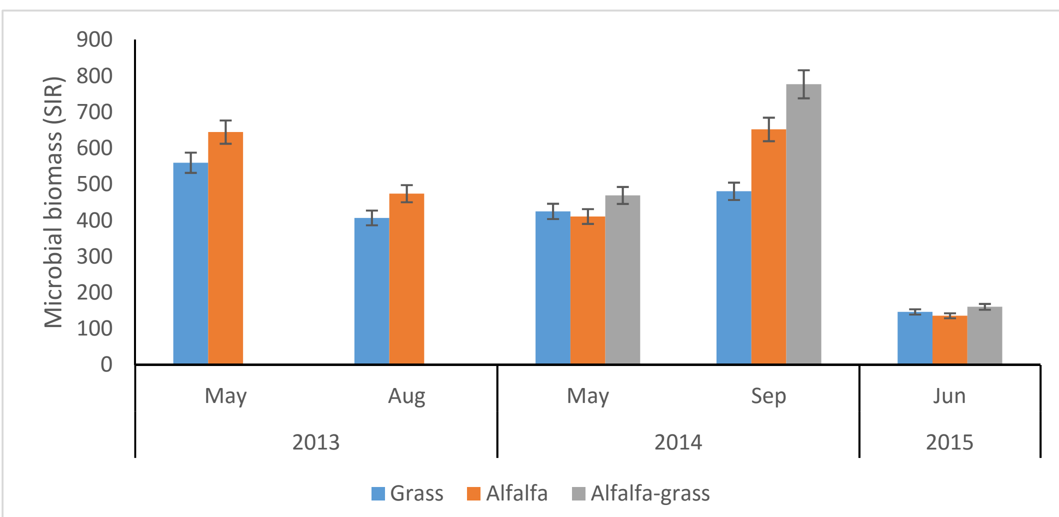


Figure 8. Microbial biomass measured by substrate-induced respiration in grass, alfalfa and alfalfa grass plots for spring and summer samples from 2013-2015.

Arthropods

Thrips, spider mites, aphids, and alfalfa weevil larvae were the dominant herbivores (plant-feeders) on ground vegetation, while springtails (collembola) and orbatid and flat mites were the most abundant detritivores (decomposers). There were few differences in arthropod abundance or diversity among the ground cover types; however, arthropod abundance tended to be lowest on ground cover vegetation and peach tree leaves in inter-planted alfalfa-grass plots (Figs. 9 and 10). The alfalfa plots had a greater density and diversity of weeds as a result of the tillage activity which may have encouraged a higher abundance of some herbivores and detritivores.

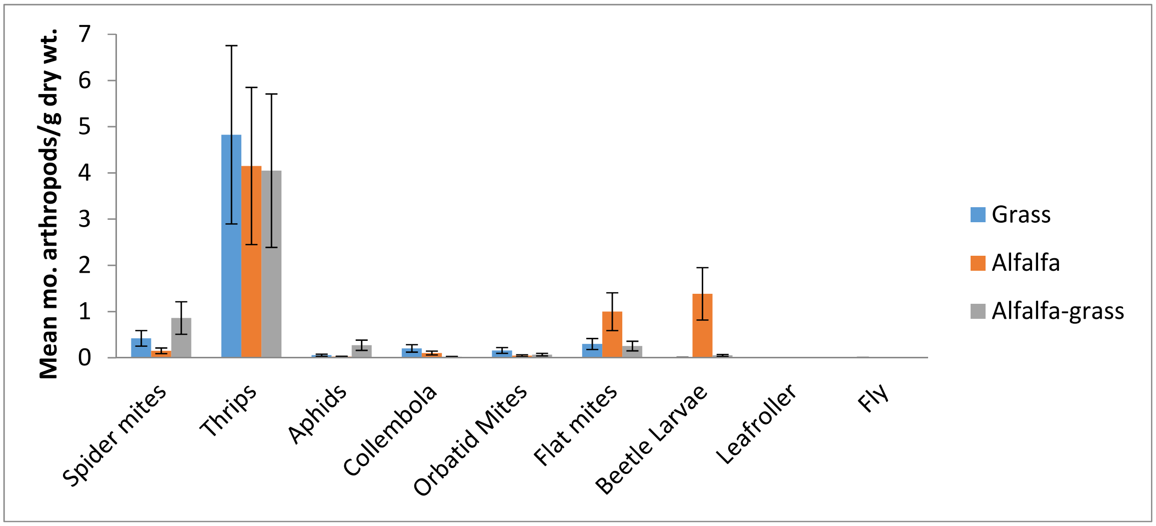


Figure 9. Arthropod numbers per gram dry weight of ground cover vegetation in the springs of 2013-2015.

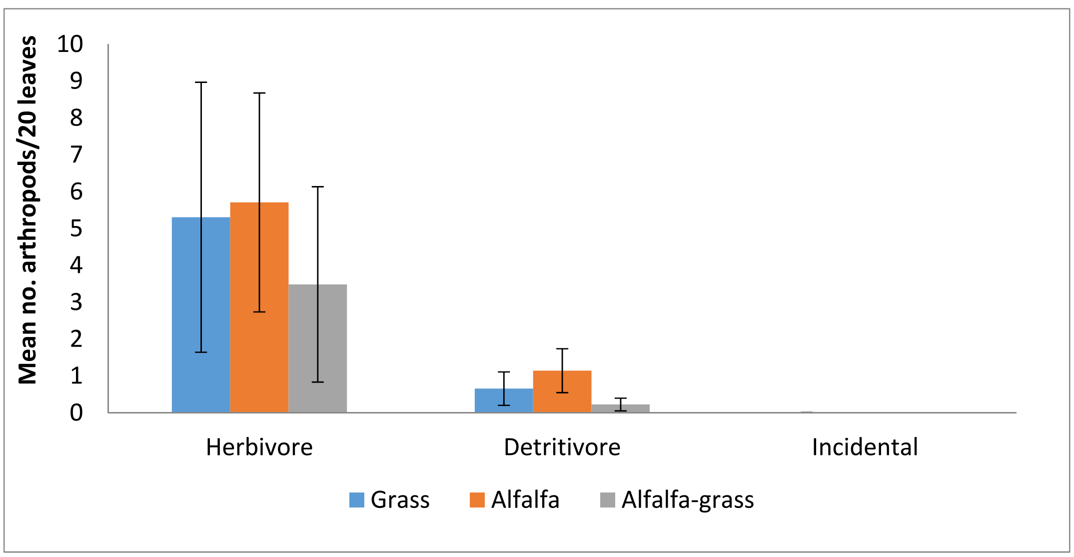


Figure 10. Arthropod numbers per 20 peach leaves in the Carrell orchard in the alfalfa, grass and alfalfa-grass plots from springs of 2013-2015.

Conclusions

Despite heavy grazing from marmots, and greatly reduced presence of alfalfa plants in the tilled plots, tillage and planting legumes still appeared to benefit available soil nitrogen in the short-term when compared to undisturbed grass plots. In regards to a longer-term solution, inter-seeding legumes into perennial grass may be a viable option to increase soil nitrogen available to fruit trees. Yet, legumes alone did not alleviate all of the deficiencies found in the peach trees in the Carrell Orchard. The trees would benefit from receiving foliar sprays of calcium, iron, and manganese, in addition to nitrogen in the form of compost or other organic fertilizers. Plant cover only modestly influenced arthropod species and abundance: tillage seemed to increase the abundance and variety of arthropods in the peach trees. This may have been caused by invasion of weeds into tilled plots and lack of competition from the alfalfa due to heavy grazing by marmots. CRNP has recently been given permission to begin applying manure compost to increase soil nitrogen, phosphorus and tree health. Gradually, soil nitrogen availability and soil health should improve. Despite limited resources and constraints in wildlife management, this study demonstrated that soil health and quality could be improved with plantings of inter-seeded legumes while not perturbing the arthropod abundance and diversity in orchard trees, which could cause pest outbreaks. This strategy shows promise for alleviating soil N deficiencies in the long-term and reducing the need for purchased inputs.

This project was supported by a grant from the USDA Organic Research and Education Initiative (OREI), Utah State University Extension, and the Utah Agricultural Experiment Station.

Related Fact Sheets

Preparing Garden Soil:
https://extension.usu.edu/files/publications/factsheet/HG_H_01.pdf

Soil Testing Guide for Home Gardens:
https://extension.usu.edu/files/publications/factsheet/HG_H_05.pdf

Understanding your Soil Test Report:
http://extension.usu.edu/files/publications/publication/AG_Soils_2008-01pr.pdf

Preparing and Improving Garden Soil:
https://extension.usu.edu/files/publications/factsheet/pub__8066784.pdf

References

Cooperband, L. 2002. Building Soil Organic Matter with Organic Amendments. Center for Integrated Agricultural Systems, College of Agriculture and Life Sciences, University of Wisconsin Madison.

Hartwig, N. L., and H.U. Ammon. 2002. Cover crops in living mulches. 50th anniversary invited article. Weed Sci. 50: 688Ð699.

Hoagland, L., L. Carpenter-Boggs, D. Granatstein, M. Mazzola, J. Smith, F. Peryea, and J.P. Reganold. 2008. Orchard floor management effects on nitrogen fertility and soil biological activity in a newly established organic apple orchard. Biol. Fert. Soils 45:11-18.

Hogue, E.J., J.A. Cline, G. Neilsen, and D. Neilsen. 2010. Growth and yield responses to mulches and cover crops under low potassium conditions in drip irrigated apple orchards on coarse soils. HortScience 45:1866-1871.

Kuhn, B.F. and H.L., Pedersen. 2009. Cover crop and mulching effects on yield and fruit quality in un-sprayed organic apple Production. European J. Horticulture Sci.74:247-253.

Neilsen, G.H., and Hogue, E.J. 1992. Long-term effects of orchard soil management on tree vigor and extractable soil nutrients. Can. J. Soil Sci. 72:617-621.

Nunez-Elisea, R., Cahn, H., Caldeira, L. and Seavert, C.F. 2005. Polypropylene row covers greatly enhance growth and production of fourth-leaf sweet cherry trees. HortScience 40:1129. Abstract only.

Provin, T., L. and Pitt, J., L. 2005. Phosphorus; Too Much and Plants Suffer. Texas Cooperative Factsheet. Agricultural Communications. The Texas A&M University System.

Reeve, J., B. Black, C. Ransom, M. Culumber, T. Lindstrom, D. Alston, and A. Tebeau, 2013. Developing Organic Stone-Fruit Production Options for Utah and the Intermountain West United States.

Sanchez, E.E., A. Giayetto, L. Cichon, D. Fernandez, M.C. Aruani, and M. Cuetti. 2006. Linking soil properties and nematode community composition: Effects of soil management on soil food webs. Nematol 8:703-715.

Sideman, E. 2007. Providing Nitrogen to Crops. MOFG Fact Sheet #8.

Stefanelli, D., R.J. Zoppolo, R.L. Perry, and R. Weibel. 2009. Organic orchard floor management systems for apple effect on rootstock performance in the midwestern United States. HortScience 44:263-267.

Swift, C.E. 2009. Fertilizing Fruit Trees. Colorado State University Extension Fact Sheet no. 7.612.