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Nutrient Management Strategies for Organic Vegetable Production

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Organic vegetable production can be profitable for growers in Utah looking to supply local markets. Much of Utah has short growing seasons (<150 days frost-free) with hot, dry summers and cold winters. Organic growers must work within these constraints to generate sufficient soil fertility using cover crops, composts, and targeted use of commercial organic fertilizers. This fact sheet explores nutrient management techniques used at the Utah State University (USU) Student Organic Farm (Student Farm) located in Cache County. In operation since 2008, the Student Farm was certified organic in 2011.

The Student Farm operates on one acre of land, and each year, with students intensively farming one-half an acre to grow a range of cool- and warm-season vegetables for its community-supported agriculture (CSA) members. The other half-acre is used to grow cover crops to improve soil conditions and fertility. Students use two high tunnels for season extension of leafy greens, tomatoes, and peppers. The vegetables and cover crops rotation maximize yields, utilize farm space efficiently, and generate or recycle most nutrients on the farm. Efficient nutrient management is achieved by focusing on cover crop management, compost additions, and targeted side dressing with commercially available, concentrated organic nutrients where necessary.

Cover Crop Strategies

Cover crops reduce soil erosion, suppress weeds, add organic matter to the soil, help stabilize the soil, and increase soil biological activity. Nitrogen (N)-fixing cover crops like hairy vetch also add considerable N to the soil if managed correctly. Due to Utah's limited growing season, the timing of fall cover crops planting is critical as cover crops do not grow during the winter. The Student Farm relies on cover crops planted in early September to allow some cover crop growth before winter, with resumed plant growth in the spring before termination. If winter cover crops are planted too late, they mature and flower before they produce sufficient biomass in the spring (Figure 1).

Cool-season cover crops suited to Utah's climate include alfalfa, various clovers, hairy vetch, and winter grasses like wheat and rye. At the Student Farm, students rotate various cover crops so fields have a cover crop growing in 18 out of every 24 months. Each growing season, students plant a half-acre to cover crops and farm the other half with vegetables (Table 1).

Table 1.

USU Student Farm Cover Crop and Vegetable Crop Rotation, with Cool and Warm Season Vegetables Grown Every Other Year on Half of the Farm Acreage

½ of acreage; non-cropped

April	May	June	July	August	September	October
Terminate Winter Wheat (WW) cover crop by June		Plant Buckwheat in late June and terminate by mid-Aug			Plant Hairy Vetch (HV) /Winter Wheat (WW) in early Sept after compost application	
Terminate HV/WW 2 wks. before planting	Cool season vegetables: Staggered planting schedule depending on crop needs					Plant WW mid-Oct
Terminate HV/WW 2 wks. before planting		Warm season vegetables: Staggered planting schedule depending on crop needs				Plant WW mid-Oct

Figure 1. Hairy vetch and winter wheat planted in early September (back) vs. mid-October (front). Crops were planted at 100 lb. seed per acre (70% vetch and 30% wheat). Photo was taken late May of the next year. Planting dates are common to Cache County and may differ depending on location and climate differences.

Figure 2. Hairy vetch/winter wheat cover crop before mowing and incorporation in late May. It is important to terminate the cover crops before seed set to prevent self-seeding.

This rotation helps maximize on-farm N-fixation and limits the need to purchase off-farm inputs (compost and feather meal). A mixture of hairy vetch and winter wheat is planted in early September after compost application. Sections of the cover crops are mowed and incorporated as needed over the following spring to early summer depending on the needs of cool or warm season vegetables. Hairy vetch grows fast and fixes lots of nitrogen (Figure 2). Data collected on the Student Farm shows that hairy vetch can produce 160–225 pounds of N per acre under Utah growing conditions when inoculated and planted by mid-September. Winter wheat is added to the mixture because it establishes quickly, helps prevent erosion, and scavenges nutrients over the winter months. Certified organic winter wheat is inexpensive and locally available, but winter rye also works well. High seeding rates help prevent fall and spring weed growth and cover crops are planted at 70 lbs. hairy vetch and 30 lbs. winter wheat per acre.

In field sections where vegetable harvest continues through September, only winter wheat is planted, usually by early to mid-October. Hairy vetch is omitted from this planting due to high seed costs and low vetch biomass production when planted too late. In areas with early summer vegetable harvest, a fast-growing summer cover crop like buckwheat (Figure 3) is planted in June for summer weed control, soil protection and to increase soil organic matter. Buckwheat is incorporated in late August to allow for timely planting of the hairy vetch/winter wheat cover crops. There are many ways to rotate cover crops with vegetable crops within the constraints of Utah's short growing season. If more land is required for vegetables, use these other cover crop rotations. Tables 2 and 3 provide some suggestions for how to integrate cover crops into vegetable production. Some adjustments on the planting dates may be required for other production areas in Utah.

Figure 3. The summer buckwheat cover crop is mowed at flowering and then incorporation before fall seeding of the hairy vetch/winter wheat mix.

Table 2.

Alternative Cover Crops and Vegetable Crop Rotation, with Cool and Warm Season Vegetables Grown Two Out of Three Years on Various Sections of a Farm

April	May	June	July	August	September	October
Terminate HV/WW 2 wks. before planting	Cool season vegetables: Staggered planting schedule depending on needs				Plant HV/WW in early Sept after compost application	
Terminate HV/WW 2 wks. before planting	Warm season vegetables: Staggered planting schedule depending on crop needs					Plant WW mid-Oct
Terminate WW 2 wks. before planting	Plant Buckwheat in late June and terminate by mid-Aug				Plant HV/WW in early Sept after compost application	
Terminate HV/WW 2 wks. before planting	Cool season vegetables: Staggered planting schedule depending on needs				Plant HV/WW in early Sept after compost application	

Table 3.
Alternative Cover Crop and Vegetable Crop Rotation, with Cool and Warm Season Vegetables Grown Every Year on a Farm

<table>
<tr><th>April</th><th>May</th><th>June</th><th>July</th><th>August</th><th>September</th><th>October</th></tr>
<tr><td>Terminate WW 2 wks. before planting</td><td colspan="4">Cool season vegetables: Staggered planting schedule</td><td colspan="2">Plant HV/WW in early Sept after compost application</td></tr>
<tr><td colspan="2">Terminate HV/WW 2 wks. before planting</td><td colspan="4">Warm season vegetables: Staggered planting schedule</td><td>Plant WW by mid Oct</td></tr>
<tr><td>Terminate WW 2 wks. before planting</td><td colspan="4">Cool season vegetables: Staggered planting schedule</td><td colspan="2">Plant HV/WW in early Sept after compost application</td></tr>
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For example, a quick-maturing, warm season vegetable like snap beans can be substituted for buckwheat, provided the beans are harvested in time for a mid-September vetch/wheat cover crop. Alternatively, warm season and cool season vegetables could be offset on the farm to provide windows for cover crops. The key is finding space for the early planted hairy vetch/winter wheat mix, which grows the most biomass and fixes the most nitrogen.

Compost

Nitrogen-fixing cover crops can provide the majority of farm N needs when managed correctly. Cover crops can also recycle nutrients from deeper in the soil profile and prevent nutrient loss over the winter months from leaching and erosion. However, cover crops do not provide new inputs of most essential nutrients such as phosphorus (P), potassium (K), and trace elements. Hence, compost forms the foundation of soil fertility improvement on many organic farms. Compost adds much organic matter and nutrients to soil, but when compost additions are only used to address crop N needs, eventually excessive soil phosphorus (P) and salts build up in the soil. This is because compost typically contains significantly more P than is required for plant growth relative to a plant's N needs. To avoid this problem, add compost to target P needs instead of N. To meet the plant's N needs, use nitrogen-fixing cover crops (legumes) or side dress with nitrogen rich organic fertilizers (such as feather meal).

Composts are made from manures or plant-based materials. Manure composts are high in N, P, and trace elements. These nutrients are useful for amending depleted soils, especially if the soil is low in P. However, for farms not raising animals, purchasing manure compost can cost more than purely plant-based composts. Additional rules also apply to the use of manure-based composts. The USDA National Organic Program (https://www.ams.usda.gov/rules-regulations/organic/handbook) safety standards require composting manure at temperatures between 131° F and 170° F for 15 days using a windrow composting system. The composting materials must be turned at least five times and then adequately cured. Producers must apply manure-based composts not meeting these standards 120 days before crop harvest for crops directly touching the ground (meaning almost all vegetables) or 90 days prior to harvest for aboveground crops (like sweet corn). These timelines help prevent bacterial disease contamination of the produce. In Utah's short growing season, any non-compliant manure compost must be applied the previous year.

Plant-based composts are easier to produce and may cost less, but are also lower in most nutrients than manure composts. While the

National Organic Program (NOP) manure handling and application rules do not apply to plant-based composts, like the manure composting procedures, plant compost should be brought up to temperature, turned regularly, and hold that temperature to kill plant pathogens and weeds. Both manure- and plant-based composts pose potential weed introduction risks if not composted correctly. The Student Farm uses manure-based compost but does not compost it according to the USDA NOP standards. Therefore, the Student Farm applies manure compost just prior to planting the fall cover crops to meet the 120-day restriction rule. Cover crops are mowed and incorporated in the spring two weeks prior to planting vegetables. Fall application of compost allows the nutrients to mineralize, making them more readily available for the vegetable crop growing season. However, it is essential to apply it in conjunction with a winter cover crop to avoid winter loss of nutrients contained in the compost.

Space-Constrained Organic Vegetable Production

Many farms may not have the land or economic resources to grow cover crops for all or part of the season. If cover crops are not an option, N-rich organic fertilizers can supply additional N needs. This is a more expensive approach than using compost alone, but provides a complement to compost when soil tests reveal high soil P levels and/or excessive salts. Organic N fertilizers like feather meal and bone meal are also more readily available for plant uptake. The Student Farm side dresses with feather meal to provide extra N for high-demanding crops like cabbage and broccoli. For short season crops like lettuce grown multiple times per season, this also works well. Table 4 lists typical organic fertilizers, comparing them by nutrient content, cost per pound of material, and cost per pound of N.

Table 4.

Nitrogen-rich Organic Fertilizers Listed by Nutrient Content and Cost per Pound N

Product	N	P	K	Dollars per pound material	Dollars per pound N
Feather meal	13	0	0	0.43	3.27
Blood meal	12	0	0	0.63	5.23
Corn gluten meal	8	0	0	1.33	16.67
Cotton seed meal	5	2	1.5	1.06	21.2
Fish fertilizer	7	7	2	1.81	25.95
Alfalfa hay meal	3	1	2	0.12	4.07
Alfalfa hay, bailed	3	0.5	2	0.13	4.29
Composted chicken manure	3	2	1	0.12	3.92
Composted steer manure	2	0.5	0.5	0.06	2.98
Composted yard waste	1	1	1	0.02	2.35
Bagged composted yard waste	1	1	1	0.05	4.76

Note. Percent nutrient contents were sourced from guaranteed analyses on commercial products from the Oregon State University fertilizer calculator (https://smallfarms.oregonstate.edu/calculator) or from analyses conducted at Utah State University. Prices are representative only and were obtained from local suppliers in Logan, Utah (June 2020) and may vary depending on product purchased.

Other Nutrient Management Techniques

Plastic mulches are commonly used to reduce weed proliferation, lessen the competition between crops and weeds for nutrients, and warm the soil for better early growth. Mulches also improve water use efficiency, which reduces

nutrient leaching in the soil, thus reducing fertilizer costs. The Student Farm uses plastic mulches with squash to keep the soil warm while seeds germinate, increase soil N mineralization, reduce weeds and weeding times, and keep the soil moist. Plastic mulches do require the use of specialized, expensive equipment like a plastic layer and tractor to install; therefore, plastic mulch may not provide a solution for every farm. Organic mulches like straw, cardboard, or wood chips can provide similar benefits, but depending on availability, can also be expensive, may suppress soil temperatures, and could introduce weeds.

Tilling is commonly used to loosen the soil, incorporate compost or plant residues, and prepare the soil for planting. Tillage helps reduce weed pressure and increases the availability of soil nutrients. Despite these benefits, excessive tillage harms soil structure, causes hard pans to form, may increase clumps in wet soils, increases the likelihood of surface crusting, and contributes to the loss of soil organic matter. Tillage lowers soil organic matter content and the activity of earthworms and other beneficial organisms compared to soils in less disturbed areas. Due to these concerns, limit tilling wherever possible. The Student Farm only tills before planting to incorporate composts or cover crops and prepare the seed beds for vegetables. Interns then limit tillage to using a wheel hoe to reduce weed pressure throughout the growing season.

Summary

Sustainable nutrient management on organic vegetable farms requires applying various strategies to improve or maintain soil fertility. Using a combination of cover crops, compost and supplemental, concentrated organic fertilizers, soil health is enhanced, soil nutrients conserved and recycled, and crop productivity improved. The approaches here have proven successful on the USU Student Organic Farm and illustrate one approach to solving nutrient needs in an organic production system.

Additional Reading and Resources

Cardon, G., Kotuby-Amacher, J., Hole, P., & Koenig, R. (2008). Understanding your soil test report. *Utah State University*. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1825&context=extension_curall

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