NUTRIENT MANAGEMENT ON ORGANIC VEGETABLE FARMS

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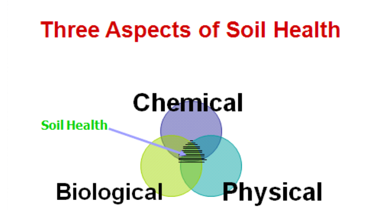
Nutrient management on organic farms is part of promoting healthy soil with good physical, biological, and chemical properties. The key to building healthy soil is organic matter management. Building up and maintaining soil organic matter contributes to nutrient management through better soil tilth and thus root exploration, enhanced biological activity which increases mineralization and nutrient availability, and greater cation exchange capacity which enhances nutrient retention. Soil organic matter also promotes an abundance of microorganisms that can stimulate root growth and help solubilize nutrients.

Managing soil nutrients, or chemistry, should not be separated from management of the physical and biological condition of soil. A good nutrient management program supports and improves all three aspects of soil health, since they are inter-related.



The main practices involved in nutrient management--and soil organic matter management--are: crop rotation, cover cropping, additions of compost and/or manure, and supplemental applications of organically approved amendments and fertilizers.

Besides maintaining soil health, the goal of a nutrient management plan should be to meet a crop's nutrient needs as economically as possible while avoiding application of excess nutrients. It can be a challenge to build up and maintain soil organic matter levels without large annual applications of nutrient-rich amendments, and that can lead to excess nutrient levels. In fact, it is not uncommon to find organic vegetable farms with very high levels of soil P and K that continue to apply large quantities of compost. These farms need to consider other methods for adding carbon and nitrogen to their soils.

It all starts with crop rotation because this provides so many benefits to a farming system. Good rotations not only help with pest management, they also benefit soil structure, and provide free nitrogen when legumes are included. Rotating with legume cover crops or forages like alfalfa, clover, hairy vetch, and field pea is especially important on farms that make (or should make) limited use of manure or compost. Legumes also help avoid excessive reliance on bagged fertility to meet crop nitrogen needs, which gets expensive and is not in keeping with the organic farming principle of optimizing on-farm inputs.

Including non-legume soil-improving crops in a rotation is also important, since they add carbon to the soil that helps maintain organic matter and soil structure. Non-legumes sown after cash crops can also 'mop up' available nutrients, preventing them from leaching, thus keeping them on the farm for future use.
Small grains like rye, oats or wheat are typically used as winter covers; summer smother crops include sorghum-Sudangrass or Japanese millet; perennial grasses are sometimes used for hay production in rotation with vegetables.

Hairy vetch plus winter rye being plowed down in early spring. The vetch, a winter-annual, can provide significant N to a subsequent crop, without taking land out of cash crop production.

The extent to which vegetable growers can rotate with legumes and other soil improving crops depends on the land they have available. Some growers try to rotate fields so they are in cash crops one year and cover crops the next year. On farms with limited land for rotation out of cash crops, soil-improving crops may take up a much smaller part of the rotation, but I recommend that at least one-quarter of your land be 'resting' in cover crops or forages at any given time. On farms where all land must be cropped for economic reasons, winter cover crops, along with occasional summer smother crops and interseedings are usually viable options.

Below are two examples of crop rotations that include legumes to provide most of the the N needed for vegetable crop production on an ongoing basis.

one year in cash crops / one year in cover crops	
Year 1	vegetables rye and hairy vetch in fall
Year 2	plow rye and hairy vetch in early summer summer smother crop to control weeds oats and hairy vetch in late summer
Year 3	plow oats and hairy vetch in late spring vegetables rye and hairy vetch in fall

two years in cash crops / two years in cover crops		
	if perennial weeds are a problem	*if perennial weeds are not a problem*
Year 1	Vegetables fall oats that winter-kill	Vegetables fall oats that winter-kill
Year 2	buckwheat in early summer rye and hairy vetch in fall	red clover and oats in spring mow oats off at head formation
Year 3	plow rye/vetch in late spring summer smother crop oats and field peas in fall	mow red clover 3 times
Year 4	disk winter-killed oats and peas vegetables	plow clover in early spring plant vegetables

Nitrogen credits from a previous crop can be estimated using the following table, adapted from the New England Vegetable Management Guide, at: www.nevegetable.org

Previous Crop Nitrogen Credit	Lbs N per acre
Grass sod	20
"Fair" clover (20-60% stand)	40
"Good" clover (60-100% stand)	60
"Fair" alfalfa (20-60% stand)	60
"Good" alfalfa (60-100% stand)	100
Sweet corn stalks	30
"Good" hairy vetch winter cover crop	100
Corn stover after grain harvest	40

Compost and manure are great for enhancing the physical condition of soil while building soil organic matter that serves as a slow-release reservoir of nutrients. But, as noted above, care must be taken with these soil amendments to avoid adding excess nutrients, especially with repeated applications over time. Research by Tom Morris at the University of Connecticut has demonstrated that it is not uncommon for organic farms to have soils that are very high in N, P, K yet they continue to add compost annually.

The nutrient content and rate of release varies among composts and manures. Fresh manures have more available nutrients than aged manures, and while mature compost is a good soil conditioner it is not a good source of short-term fertility since it contains relatively low levels of available nutrients.

Compost and manure are valuable for 'building soils' but over time…they load the soil with excess nutrients

Testing compost or manure prior to application is the only way to determine its nutrient status, pH, and salt content. It takes a little extra effort to send in a sample but the information is very useful to nutrient management since variability is so high. For example, in a survey of 20 different on-farm composts, UMass researchers found the pH to range from 5.4 to 7.9, and the total N content to vary from 8 lb to 47 lb per ton. They estimated that adding 20 tons/acre of a typical compost would add a total of 320 lb of N; however, only about 42 lb of this would likely be available to crops in year one.

Most land grant universities offer manure and compost testing at a modest cost. Alternatively, you can estimate the nutrient content using tables like the one below, but keep in mind these are only general estimates because manure properties are variable and the only way to really know their nutrient content is to have them tested.

	nutrient content lb/ton			available nutrients lb/ton in first season			
	N	P_2O_5	K_2O	N1	N2	P_2O_5	K_2O
Dairy (with bedding)	9	4	10	6	2	3	9
horse (with bedding)	14	4	14	6	3	3	13
poultry (with litter)	56	45	34	45	16	36	31
compost (from dairy manure)	12	12	26	3	2	10	23

N1= incorporated within 12 hours of application, N2 =incorporated after 1 week or more.
(Adapted from "Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops"

Organic fertilizers. There are many kinds of organic fertilizers made from plant meals, minerals, and/or animal products. The following table, adapted from the University of Maine soil testing lab, lists some common bagged fertilizers, their nutrient content, and the quantities needed to provide different amounts of available nutrients.

If you are on a certified organic farm, always be sure to check with your certifier whether the material as well as the brand of fertilizer you plan to apply is allowable.

Pounds of fertilizer/acre to provide X pounds of N per acre:

20	40	60	80	100	Sources
150	310	460	620	770	Blood meal, 13% N
500	1000	1500	2000	2500	Soy meal, 6% N (x 1.5)* also contains 2% P and 3% K_2O
220	440	670	890	1100	Fish meal, 9% N also contains 6% P_2O_5
800	1600	2400	3200	4000	Alfalfa meal, 2.5% N also contains 2% P and 2% K_2O
200	400	600	800	1000	Feather meal, 15% N (x 1.5)*
125	250	375	500	625	Chilean nitrate, 16% N cannot exceed 20% of crop's need

Pounds of fertilizer/acre to provide X pounds of P_2O_5 per acre:

20	40	60	80	100	Source
130	270	400	530	670	Bonemeal, 15% P_2O_5
270	530	800	1100	1300	Rock Phosphate 30% total P_2O_5(x 4)*
330	670	1000	1330	1670	Fish meal, 6% P_2O_5 (also contains 9% N)

Pounds of fertilizer/acre to provide X pounds of K_2O per acre:

20	40	60	80	100	Source
90	180	270	360	450	Sul-Po-Mag, 22% K_2O also contains 11% Mg
400	800	1200	1600	2000	Wood ash (dry, fine, grey) 5% K_2O, also raises pH
1000	2000	3000	4000	5000	Alfalfa meal, 2% K_2O also contains 2.5% N
8000	16000	24000	32000	40000	Greensand or Granite dust 1% K_2O (x 4)*
40	80	120	160	200	Potassium sulfate, 50% K_2O

* Application rates for some materials are multiplied to adjust for their slow to very slow release rates.

Soil organic matter. The total amount of N in the plow layer of soil is surprisingly large; it can be estimated by multiplying soil organic matter content by 1,000. Thus, a soil with 4% organic matter contains about 4,000 lbs total N per acre. However, very little of the total N is mineralized annually into the mineral forms plants can use, typically from 1% to 4% each year, depending on the soil and environmental conditions. For soil with a total of 4,000 lbs N per acre, a 1% to 4% conversion would produce 40 to 160 lbs N/acre.

The mineralization rate depends on microbial activity, which is favored by warm soils with adequate, but not excessive moisture and a pH above 6.0. On well managed soils used for vegetable production, a 2% mineralization rate is a reasonable estimate, so that 20 lbs of N/acre can be credited for each percentage of soil organic matter.

Putting it all together requires some record keeping and calculations, whether putting pencil to paper, or fingers to keyboard. It's not possible to maintain an effective nutrient management plan in your head. Soil test results and recommendations are also essential. Based on these, you start with a target level for each major nutrient and then subtract the available nutrient 'credits' contained in soil amendments and soil organic matter.

	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)
1.Recommendations:			
Nutrient credits:			
Manure			
Compost			
prior cover crop			
soil organic matter		---	---
2. Total credits:			
Total needed (1-2) =			

An example. You will be growing an acre of cabbage. The New England Vegetable Guide suggests a total of 160 lb N/acre (60 of it as a sidedress) and your soil test results show high P levels with zero P recommended and medium K levels with 130 lb K_2O/acre recommended. The field you'll be planting has 3% organic matter and a pH of 6.5, and there's a fair stand of red clover that will be turned in a week or so prior to planting as soon as you spread and promptly incorporate 5 tons/acre of dairy manure with bedding.

	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)
Recommendations:	160	0	130
Nutrient credits:			
manure – 5 T dairy	30	18	45
compost – none	0	0	0
cover crop – clover	40	0	0
organic matter 3%	60	---	---
Total credits:	130	18	45
Total needed =	30	0	85

Your fertilizer options to meet the crop's need are limited because you do not want to apply a 'blended fertilizer' that will add excess P. If this field did need some P, say 50 or 60 lb/acre, then you could apply 750 lb of pelletized bagged poultry manure (4-4-4) to provide 30 pounds each of N-P_2O_5-K_2O, then add another 45 lb of K_2O.

But that is not the case in this example, so you need to apply N and K separately. To provide 30 lb of N you could sidedress 230 lb/acre blood meal (but this might cause excess ammonia to 'burn' plants), 200 lb/acre feather meal, or 187 lb/acre Chilean nitrate (the 30 lb of total N/acre is still less than 20% of the recommended crop need.) Whatever material or combination of materials you choose, split the total application into two or even 3 sidedressings (when cultivating for weeds anyway) so as to optimize plant uptake of the applied nitrogen as the crop grows.

Potassium is a little easier to figure out in this example. To apply 85 pounds K_2O/acre, you can broadcast and incorporate 170 lb of potassium sulfate, if your soil already has sufficient magnesium. If magnesium is needed, then the equivalent amount of K would be in 386 pounds of sul-po-mag, which would also add some Mg. But don't worry about such precision when it comes to applying major nutrients; in this case 350 or 400 lb/acre would be fine. The goal is to be in a reasonable range with your nutrient applications: avoiding excesses of nutrients in the soil while meeting the needs of your crops.