Choosing a soil amendment

by Vijay Cuddeford

"A CLOAK OF LOOSE, SOFT MATERIAL, HELD TO THE EARTH'S HARD SURFACE BY GRAVITY, IS ALL THAT LIES BETWEEN LIFE AND LIFELESSNESS." [1]

In addition to well-designed crop rotations and green manures, organic farmers rely on non-synthetic fertilizers and soil amendments to provide nutrients to crops. A fertilizer is usually defined as a material that improves the supply of available nutrients in the soil. In contrast, a soil amendment is a material that influences plant growth indirectly via improvements in the soil's physical condition, such as soil structure, tilth and water infiltration. But of course the two classifications are not mutually exclusive—fertilizers can improve soil properties, and soil amendments can increase fertility.

Simply substituting alternative inputs for conventional inputs does little to increase overall sustainability.

It's important that organic growers don't overestimate the contributions of organic fertilizers and soil amendments. Many other factors affect nutrient availability, particularly farming practices such as crop rotation and tillage practices. Also, site-related variables affect nutrient availability, such as slope, soil texture, soil temperature and rainfall amounts. In general, the nutrients provided by fertilizers and soil amendments exert significant influence on crop growth only if levels of soil moisture, porosity, and acidity are relatively normal.

Simply substituting alternative inputs for conventional inputs does little to increase overall sustainability. A good general policy is to minimize the use of off-farm inputs. Try using your own compost, then test for deficiencies. Nutrient imbalances can then be addressed by fertilizers and soil amendments. That being said, there is much to learn about the various types of fertilizers and soil amendments.

When you are considering buying a soil amendment or fertilizer, consider the current soil quality and the plant needs. Assess the nutrient status, the physical characteristics and tilth of the soil. Current nutrient status relates directly to previous years' fertility: it does not reset itself to zero at the beginning of each growing season, so account for the carryover from fertilizer, manure and incorporation of residues. Use your own observations in conjunction with lab analyses of soil samples or leaf and petiole samples from growing crops. Knowing which products are allowed by organic certification standards is critically important for organic growers. Another point to keep in mind is that, while some materials may well be biologically effective, their use may not be economical—the benefits may be outweighed by the cost. It is important for farmers to do product evaluations within the context of their own farm operations. While on-farm research trials take some effort, they are not difficult to perform.

The Canadian National Standard for Organic Agriculture (1999) [2] ***allows the use of the following:***

- alfalfa pellets
- biodynamic preparations
- basalt
- blood meal (R): composted blood meal from organically raised livestock
- biotite
- bone meal (R): composted bone meal from organically raised livestock
- borax
- chelates (R)
- clay (bentonite, perlite)
- compost (R)
- egg shell meal
- elemental sulphur (R)
- epsom salts (magnesium sulfate)
- feldspars
- fish emulsions/meal (R)
- granite
- greensand
- gypsum (mined calcium sulfate)
- keiserite
- langbeinite (Sul-Po-Mag)
- limestone (calcitic or dolomitic)
- manure, fresh, from organic sources (R)
- mica
- oyster shells
- peat moss
- potassium sulfate (mined)
- rock phosphate
- sawdust/wood chips
- seaweed and seaweed products
- sodium molybdate (R)
- sulfates of zinc or iron (R)
- wood ash (R)
- zeolite

R = use has some restrictions; check with certifying bodies for details.

Sources of nitrogen

Manure and compost: Manure provides both organic matter and nutrients. But most nutrients in raw manure are soluble and unstable, and can be easily lost due to surface runoff or leaching. In organic production, manure is almost always composted before being applied to the soil. The use of raw manure is only allowed under certain conditions, and the practice is discouraged in general.

A good general policy is to minimize the use of off-farm inputs.

Composting stabilizes nutrients, and allows them to be released slowly, minimizing losses. Good quality compost also contains more humus than manure does. And, unlike raw manure, compost can be used at almost any rate without burning plants. Composting reduces the bulk of raw organic materials—especially manure with high moisture content. Off-farm sources of compost must be approved by the certifying body. Purchased composts can be expensive. Farmers or gardeners with on-farm or nearby sources of manure and compostable materials can cut costs dramatically.

Blood meal: Kiln dried blood meal is dried slaughterhouse waste, a source of nitrogen and trace minerals. It contains about 12% nitrogen. Unless used carefully, blood meal can burn plants with ammonia, lose much of its nitrogen through volatilization, or encourage fungal growth. If necessary, use 1–3 lbs. per 100 sq. ft. before planting, or side dress later in the season. Because of the possibility of transmission of bovine spongiform encephalopathy (BSE) or mad cow disease, certifying agencies restrict or prohibit the use of some blood meal products. To be safe, always refer to your certification standards, or check with your certifying agency before using a new soil amendment.

Fish products: Fish meal and fish emulsion are rich in nitrogen, with fish meal containing about 10% nitrogen and 6% phosphate. Some fish emulsions include chemical fertilizers, so check labels (also, be suspicious of any product with more than 5% nitrogen). Fish products provide nutrients to plants without improving soil quality. Consequently, these products should not be relied upon as a major source of nutrients. Rather, they should be used only at critical times when an extra boost of nutrients is needed (e.g. starting seedlings in flats or after transplanting).

Choosing a phosphate source

Natural phosphate sources, because of their slow release, are often promoted on the basis of total, rather than available, phosphate. But neither total nor available phosphate are good predictors of performance in a natural system—hence the importance of developing good powers of observation through on-farm experimentation. One general guideline is that phosphates are released more quickly in moderately acid soils than in neutral or alkaline soils.

Colloidal phosphate consists of clay particles surrounded by natural phosphate. Total phosphate is around 20% and available phosphate about 2–3%. If added to livestock manure, acids in the manure dissolve much of the total phosphate while the phosphate stabilizes the nitrogen in the manure. Alternatively, add 20–50 pounds of colloidal phosphate to one ton (2 cubic yards) of manure when composting.

Rock phosphates are commonly derived from ancient marine deposits, and are less available than colloidal phosphates. Total phosphate is around 30%, with 1–2% available phosphate. While used in the same way as colloidal phosphate, it may be worthwhile to pay for soil tests to determine how effectively the phosphate moves

into manure or soil. It can be a worse or better buy than colloidal phosphate, depending on conditions and circumstances.

Hard-rock phosphates are usually derived from volcanic deposits and consist almost totally of the mineral apatite. While apatite contains about 40% total phosphate, it is largely unavailable. Although an application of hard-rock phosphate is expensive, it is sometimes the best way to supply phosphorous. Phosphate fertilizers derived from mined rock phosphate contain varying levels of heavy metals, including cadmium, depending on where they are mined. Cadmium is a probable human carcinogen when inhaled, so check the cadmium content before purchasing.

Bone meal: Bone meal is often steamed and ground for quick uptake. It is particularly useful early in the season for promoting strong root systems and later assisting with fruit and flower production. Bone meal contains about 27% total phosphate, nearly all in an available form. Certifying agencies restrict or prohibit the use of bone meal products due to concerns over BSE (mad cow disease).

To be safe, always refer to your certification standards, or check with your certifying agency before using a new soil amendment.

Choosing a potassium (potash) source

As with phosphate, there are a variety of sources of potassium, with differing availability and nutrient value. There is a difference between pure potassium and potash, with the potash number being 1.2 times higher than potassium for the same amount of nutrient.

Mined potassium sulfate is allowed in organic farming, and is extracted by an evaporation process lasting three years.

Langbeinite goes from mine to field with minimal processing. It is quite soluble and high in salt, so careful use is required. However, the high potash content (22%) does allow for good plant response from relatively modest application rates. It is a natural source of sulphur and magnesium as well, and application will not alter soil pH. Sul-Po-Mag and K-Mag are two well-known brand names.

Sources of other nutrients and minerals

Agricultural limestone: Limestone is commonly used to increase the pH (sweeten the soil), and add calcium and/or magnesium. Dolomite limestone is roughly half magnesium carbonate and half calcium carbonate, and provides both calcium and magnesium. Calcitic limestone is pure calcium carbonate. Plants usually need more calcium than magnesium; so, it may be wise to use a mixture (e.g. 1/3 dolomite lime and 2/3 calcitic lime), depending on the levels of calcium and magnesium in the soil.

Gypsum: Gypsum is a naturally-occurring form of calcium sulfate, containing about 23% available calcium and 18% sulphur. Because it is relatively soluble, gypsum can leach below the zone of incorporation to improve soil calcium and diminish aluminum toxicity in some acid soils. If you have clay soil, and your soil accumulates sodium (which causes it to collapse and become hard to work), gypsum will help. Because calcium is the only element that will kick the sodium ions off of the cation exchange sites, adding gypsum under an application of mulch and letting the earthworms work it in may solve the sodium problem. Use only mined gypsum—other sources contain glues and other potential toxins. Note that gypsum contains small amounts of naturally occurring crystalline silica which is considered to be a carcinogen.

Shellfish products: Oyster shell lime contains 40–50% calcium carbonate, plus a balance of other nutrients and micronutrients, and nitrogen from the muscles left on the shells. It raises the soil pH, corrects calcium deficiencies and is faster acting than limestone. Crab waste contains 10–15% chitin, a substance that has demonstrated ability to suppress nematodes. For gardens, use at a rate of 5 lbs per 100 sq. ft.

Greensand and other rock dusts: These materials are rich sources of micronutrients such as calcium, magnesium, sulphur, boron, copper, iron, manganese and zinc. The nutrients in greensand and other rock dusts are made more available to plants if the rock dusts are applied along with compost, or while incorporating a green manure or cover crop. The increased biological activity stimulated by the legume plowdown or compost, produces organic acids which helps increase the availability of both macro- and micronutrients.

Greensand is mined from deposits that were originally part of the ocean floor. It contains about 7% total potash, which is very slowly made available, along with iron, magnesium, silica and about 30 other trace minerals. Greensand is also useful for loosening heavy soils.

Certain kinds of mica, particularly biotite (black mica), contain

several percent total potash, which is relatively available in microbially active environments. If pure biotite can be obtained at a reasonable price, it may be cost-effective and useful.

While particular rock dusts and powders may be effective in one location, it is hard to generalize to other areas. Additionally, there is very little product consistency from one batch to another. Keep in mind that greensand and other rock dusts are expensive, which may limit their use to high-value horticultural operations.

Kelp meal and other seaweed products: Most kelp products are derived from dried raw *Ascophyllum nodosum* seaweed. They contain about 1% nitrogen, a trace of phosphorous, and 2% potash, along with magnesium, sulphur, and numerous trace elements, including natural plant hormones. Products can be applied directly to soil or added to the compost pile. Soil application rates for kelp meal commonly range from 150 to 250 lbs/acre for pastures, forages and small grains. Two hundred to 400 lbs/acre are advised for corn, horticultural crops, and gardens. The high price may limit the use of kelp meal to high-value crops.

Concentrated extracts of kelp or other seaweeds are sometimes used as foliar sprays. While not high in nutrient levels, these sprays act as a tonic, providing a broad array of micronutrients and other trace elements. They may also strengthen resistance to pests, diseases, frost and drought, as well as improving soil tilth. Kelp and other sea plants contain relatively concentrated amounts of plant auxins, growth regulators and stimulants, such as indole-3-acetic acid (IAA), gibberellic acid and cytokinins. While most kelp products are allowed in organic production, some commercial products contain kelp mixed with synthetic fertilizers and other banned substances, and are therefore not allowed in organic production.

Zeolites: Zeolites are mined alumino-silicates, useful not for their plant nutrient status, but because they enhance the performance of fertilizers by making them resistant to leaching, immobilization and gaseous losses. They are particularly useful in reducing leaching in sandy soils. One study applied 4 to 8 tons of zeolite per acre and found yield increases of 14% for wheat, 19–55% for eggplants, 63% for carrots and 13–38% for apples. They are widely used in eastern European and Japanese agriculture.

Inoculants

Mycorrhizal fungi colonize plant roots, dramatically increasing the root absorptive area, resulting in increased water and nutrient uptake. Once colonized, there is no need to re-inoculate; the fungus becomes a permanent part of the root system. Plants with mycorrhizal roots use fertilizer more efficiently and are more tolerant to drought, high salts, soil compaction, nematodes, diseases, heavy metals and organic toxins. Although high rates of synthetic phosphate fertilizer suppress mycorrhizae, they perform well after applications of organic fertilizers or rock phosphate.

Rhizobia: These bacteria colonize the roots of legumes, forming nodules which fix atmospheric nitrogen into useable plant nutrients. Each species works only with certain legumes. Rhizobia are not very active in cold soil, and inoculation is necessary to maximize their effects. You can use a powdered rhizobia inoculant to coat seeds or you can mix the powder into the soil before transplanting. To meet organic standards, use only non-genetically engineered rhizobia.

Conclusion

While soil amendments and organic fertilizers are not a panacea, the wise use of these products will pay off. Observations of crop and soil quality, regular soil tests and careful record-keeping will allow farmers and gardeners to assess the value of using soil amendments.

8

Vijay Cuddeford, a freelance writer and researcher from Brampton, Ontario, specializes in sustainable pest management, agriculture, biotechnology and the environmental impact of agricultural practices.

Recommended reading

Building Soils for Better Crops (2nd Ed.). F. Magdoff & H. van Es. Sustainable Agriculture Network, Burlington, Vermont. 2000.

How to Conduct Research on your Farm or Ranch. D. Anderson, M. Honeyman, J. Luna and V. Berton. Sustainable Agriculture Network. University of Vermont, Burlington, Vermont. 1999.

Organic Field Crop Handbook (2nd Ed.) J. Wallace (Ed.). Canadian Organic Growers, Ottawa, Ontario. 2001.

Sustainable Soil Management: Soil System Guide. P. Sullivan. Appropriate Technology Transfer for Rural Areas (ATTRA), Fayetteville, Arizona. 1999. <www.attra.org/attra-pub/soilmgt.html>.

Footnotes:

[1] *Soils of the Desert*. Fuller, W.H. Southwest University of Arizona Press. 1975.

[2] *National Standard for Organic Agriculture*. Canadian General Standards Board. Ottawa, Ontario. 1999.