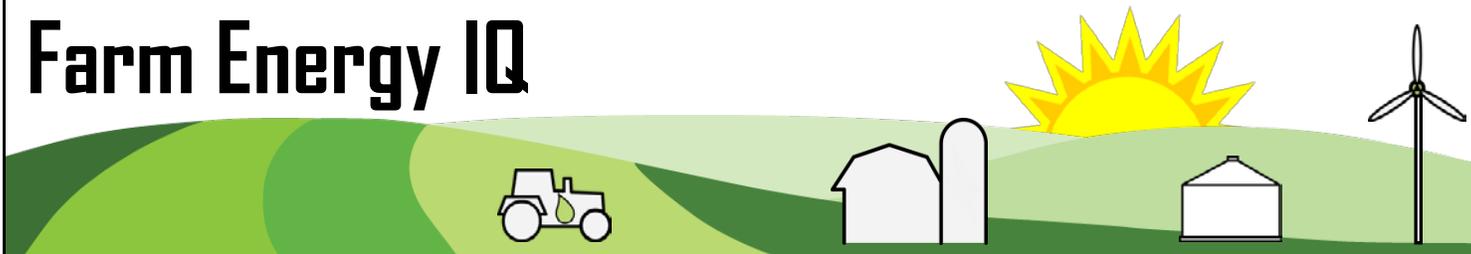


# Farm Energy IQ



## Conserving Energy in Nutrient Use and Pest Control

### INTRODUCTION

Fertilizers and pesticides are the most widely used sources of nutrients and pest control, respectively. Fertilizer and pesticides require significant energy during manufacture and use. Because of their widespread use, this fact sheet focuses on energy saving opportunities with fertilizer and pesticide. However, the principles for efficient use of fertilizer and pesticides can be applied to other inorganic or organic nutrient and pest control sources.

### ENERGY IN FERTILIZER AND PESTICIDE PRODUCTION AND USE

There are three primary ways that fertilizers and pesticides contribute to energy use in agriculture. The first is the energy used to manufacture the product, including extraction and/or synthesis of the active chemical ingredients, formulation, and packaging. The second is the energy used to transport finished the product to distributors and farms. The third is energy used in field application. The primary input to fertilizer production is natural gas for nitrogen (N) synthesis and other various fossil fuels for mining phosphorus, potassium, and other nutrients. The major ingredients in most pesticides are fossil fuel derivatives; additional natural gas and electricity are used in the manufacturing process.

Fertilizers represent more than half of the energy use in U.S. agriculture, with about 80% of that energy used in the manufacture of N from natural gas. On a per unit weight basis, pesticides require the most energy in agriculture, but on a per acre basis, they are one of the lowest energy inputs in crop production.

### ENERGY-EFFICIENT USE OF NUTRIENTS

Manufacturing efficiencies in fertilizers production have improved over the years. However, the best way to conserve energy when using fertilizer or other nutrient sources is to simply use less. After applying the proper amount of nutrients, use best practices to minimize runoff, leaching, volatilization or other losses to the environment.

To use fertilizer or other nutrient sources efficiently, soil tests are essential. The primary benefit of a soil test is to determine the amount of nutrients that the crop needs. Test the soil at least every three years by sampling each field according to known (or perceived) variations in crop yield, soil type, elevation,

and other similar characteristics. Under this system, farmers can extrapolate the data to generate a reasonably good map of soil fertility throughout the field. For larger acreage, some farmers develop electronic GPS grid maps for use in precision application techniques.

Several strategies exist for maximizing nutrient uptake efficiency, which minimizes nutrient losses. The foremost strategy is banded application at planting or side dressing for later applications. Disadvantages of banded applications are increased time, labor, and machinery inputs. However, careful planning of banded applications can reduce inputs to an acceptable level, particularly if the operation is combined with another, such as when a sidedresser is mounted on a cultivator. Because soil fertility benefits are mostly realized during plant growth, it is best to time fertilizer applications so that the effects on soil fertility are highest during the essential plant growth stage, rather than before the growing season starts.



Sidedressing during the growing season is one of the best ways to accomplish this. The strategy can be extended from timing during the growing season, to timing during rotations. That is, apply fertilizers during the year when crops with the highest nutrient needs are grown, so that crops with lower nutrient needs can use the residuals next season. So in a corn-soybean rotation, apply fertilizers during a corn season rather than to soybeans directly. This strategy also saves an application trip.

Another important strategy for using less manufactured fertilizer is replacing fertilizer with legumes, green manure crops or livestock manures. Various types of legumes can leave from 40 to 100 lb of fixed nitrogen in the soil when topgrowth is plowed under; alfalfa is among the best crop for this purpose. Soybeans can leave as much as 40 lb per acre, but it is usually less in northern climates. Table 1 (see next page) from the Penn State University Agronomy Guide provides estimates of nitrogen from various legume sources. Your state's Cooperative Extension Service can be consulted for more localized estimates.

An additional benefit of legumes, cover crops, and manure is the residual organic matter will act not only as a source, but also as a storehouse of residual nutrients. No-till cropping systems can also offer some benefits in this regard.

**Table 1. Residual Nitrogen Contributions from Legumes**

| Previous crop                                 | Percent stand | High-productivity fields                 | Moderate-productivity fields | Low-productivity fields |
|---|---------------|--|------------------------------|-------------------------|
| First year after alfalfa                      |               | Nitrogen credit (lb/acre)                |                              |                         |
|   | > 50          | 120                                      | 110                          | 80                      |
|   | 25-49         | 80                                       | 70                           | 60                      |
|   | < 25          | 40                                       | 40                           | 40                      |
| First year after clover or trefoil            |               |  |                              |                         |
|   | > 50          | 90                                       | 80                           | 60                      |
|   | 25-49         | 60                                       | 60                           | 50                      |
|   | < 25          | 40                                       | 40                           | 40                      |
| First year after soybeans harvested for grain |               | 1 lb N/bu soybean produced previous year |                              |                         |

Credit: adapted from Penn State Agronomy Guide

It is extremely important to test soil when switching nutrient strategies, especially if livestock manure use is planned. Manure tests are also an important tool that allow you to add only amounts needed by the crop, preventing an oversupply of nitrogen and phosphorus that may cause environmental and other problems. The Penn State Agronomy Guide and other state's Cooperative Extension publications offer detail on manure use practices.

Any nutrient application strategy is highly dependent on soil pH, which must be tested frequently because uptake of macronutrients is reduced at a pH of 6.5 or below. With conventional tillage, a reading should be taken within the top 7-in. of soil. In no-till systems, readings should be taken within the top 3 in. of soil and at a 3 to 6-in. depth. Soils managed with no-till practices are susceptible to acidification on the top layer due to decomposition of residues and surface N application, which must be managed appropriately to reduce waste in fertilizer and pesticide application.

## APPLYING NUTRIENTS EFFICIENTLY

In addition to using the proper nutrients at the appropriate time, applying nutrients efficiently is also important to minimize energy consumption for fertilization. A critical factor in accomplishing this is consideration of the relative mobility of the nutrients to be applied. Some nutrients, such as N, are highly mobile in soil, and thus must be applied as needed for optimal crop growth. Solid manures should be applied before planting and incorporated to allow slow nutrient release over the growing season and to reduce run-off and volatilization. Liquid manures can be incorporated after planting if equipment is available. Other nutrients like phosphorus (P) and potassium (K) are less mobile in soil so, if adequate

levels are found during a soil test, levels will remain acceptable for one or more growing seasons. While P and K don't easily leach or volatilize like N, they do move with soil. Therefore, minimizing soil erosion is essential for all nutrient conservation. In irrigated crops, fertigation—in which fertilizer is distributed through irrigation water—reduces energy consumption by reducing the number of trips over the fields and applying more efficiently to meet crop needs. Finally, when applying any type of nutrients, application equipment should be calibrated regularly to supply the proper amounts needed.

## ENERGY-EFFICIENT USE OF PESTICIDES AND PEST CONTROL METHODS

The most important principles in energy-efficient use of pesticides are Integrated Pest Management (IPM) and good soil fertility management. When crop-specific nutrient recommendations are followed, crops have the best chance of outcompeting pests and will be less susceptible to disease and infestation that are brought on by stress.

Once soil fertility concerns are adequately addressed, you can consider energy conservation in pesticide use. Energy use associated with pesticides includes the manufacture, formulation, and packaging; transportation to and around the farm; and energy use in crop/field application. Modern advances in biochemistry and pesticide development have greatly reduced energy inputs in pesticide manufacture and, in general, newer pesticides require less energy to produce, package, and transport per unit of active ingredient used per acre. Herbicides, which account for between 40 and 50% of pesticides used (by weight) in U.S. agriculture, are the primary contributor to energy use in overall pesticide manufacture. Glyphosate, the most widely used pesticide in the U.S., requires more energy per pound of active ingredient than most pesticides. However, the breadth of the spectrum of plants controlled usually results in lower total energy consumption because it reduces the need to apply several different herbicides. While pest control efficacy is of utmost importance, best practices for conserving energy in the manufacture, distribution, and application of pesticides can also contribute to optimal plant growth, minimal crop damage, and reduced cost inputs. Publications provide energy comparisons of various pesticides (for example, see Helsel, 2006).

In reducing energy inputs to transportation and storage of pesticides, the farmer can most effectively control the energy used to transport the pesticides within the farm. Since many pesticides require heat energy during winter storage, keeping small quantities of pesticide through the winter is generally not energy efficient. Except where large amounts of usable pesticides remain from the previous season, it is best to let dealers and manufacturers store pesticides over the winter. As far as transportation in the field, the general principles of efficient field operations apply. As much as possible, reduce turning time, unnecessary engine horsepower and RPM, and extra passes. In addition, it is beneficial to reduce water in spray mixtures to the minimum acceptable level. Low-volume spray technology reduces the water needed to spray efficiently, meaning fewer trips to the mixing area and less weight to transport within the field.

## MANAGEMENT PRACTICES TO REDUCE PESTICIDE USE

Strategies for reducing pesticide use through comprehensive ecosystem management are known as Integrated Pest Management (IPM). IPM involves managing plant health and lifecycle, balancing biological predators and controls, and using resistant varieties and pesticide inputs. IPM can reduce pesticide use by up to half, particularly in crops which typically require heavy pesticide use. A good IPM

plan starts by quantifying the economic impact of pests, and setting minimum pesticide inputs accordingly. The plan also takes into consideration population levels of beneficial life forms including insects, fungi, and plants, and will define pesticide use practices that maximize target pest control while minimizing damage to beneficial life forms. IPM also relies on precise data on pest populations at specific times and places. Consult staff from your local county Cooperative Extension offices for further information.

With the current popularity of organic cropping systems, many farmers ask if using mechanical cultivation for weed control uses less energy than herbicide application. A detailed calculation (see *Helsel 2006*) of these two practices show similar energy inputs, so the choice of which strategy to use depends more on efficacy, labor, equipment, and time flexibility than the method. Mechanical cultivation may lead to environmental benefits on farms surrounded by protected ecosystems or neighbors with “chemical” concerns. Chemical weed control often leads to environmental benefits in highly erodible fields, and uses less machinery and labor. Varieties of common field crops are available which make use of genetic-based biopesticides, resulting in lower energy inputs than is typical in current chemical pest control. Several of these varieties have, in addition to several biopesticide traits, resistance to one or more herbicides as well, creating the possibility for less spray trips throughout the growing season. As with nutrient application, pest control application equipment should be calibrated regularly.

## REFERENCES:

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