



Fertilizers and Energy¹

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Commercial fertilizers are by far the largest users of energy in production agriculture. Approximately 1/3 of the energy used to grow foodstuffs is consumed in the form of fertilizers. Floridians apply approximately 2 million tons of fertilizers each year. The energy used to manufacture this quantity of fertilizers is equivalent to that contained in 100 million gallons of diesel fuel.

As important as fertilizers are to modern agriculture, it is essential to employ them in a frugal manner. There are two reasons demanding thrift when applying fertilizers. First, wise use of fertilizers is necessary to conserve the energy sources and the raw materials used to manufacture them. The ingredients used in manufacturing fertilizer are, for the most part, non-renewable resources. *Non-renewable* means there are no natural processes at work to replenish the reserves of these natural resources as they are consumed. When these resources are gone, they are gone forever. Second, improper use of soil nutrients results in waste our society can ill-afford. This "waste" often manifests itself dramatically in the form of tainted groundwater or algae blooms in our lakes. This fact sheet will provide energy data for various common forms of fertilizer and will address some of the aspects of fertility management affecting the efficiency of fertilizer usage.

ENERGY INPUTS FOR MANUFACTURING COMMON N, P, AND K FERTILIZERS

Manufacture of nitrogen-bearing fertilizers requires the most energy per unit weight of nutrient. The energy required to manufacture several nitrogen-bearing materials is given in Table 1. A brief study of Table 1 reveals that ammonia represents a smaller energy investment than other forms of nitrogen-bearing fertilizers. (Ammonia is the initial product in most nitrogen fertilizer manufacturing processes, hence it requires the least amount of energy.) Note, also, that urea-ammonium nitrate (UAN) solution requires less energy than the granular form of its constituents; the manufacture of liquid UAN bypasses the granulation processes, making it more energy efficient.

The energy required to manufacture phosphorus-bearing fertilizers is less per unit weight of nutrient than that required for nitrogen fertilizers. Table 2 shows the manufacturing energy required for several common forms of phosphorus fertilizers.

Potassium fertilizers require the least amount of energy to manufacture of any of the three primary nutrients. Table 3 shows estimated manufacturing energy for several potassium fertilizers.

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N-Source	%N	BTU/lb-N	MJ/kg-N
Ammonia	82	23.7 x 10(3)	55
Ammonium Sulfate	21		
Liquid UAN	32		
Ammonium Nitrate	34		
Urea	46		

LIMITING FACTORS

The concept of limiting factors is perhaps the most important fundamental concept to be considered when planning fertility management programs. This principle holds that plants will achieve genetically potential yields only if none of the necessary growth factors are limiting. These growth factors include water, nutrients, solar radiation, etc. Plants take up nutrients (and other inputs) according to their physiological state and respond only to the extent allowed by other inputs. It is nonproductive to apply more of one input than the aggregate of the other limiting factors will support. Another way of stating this concept is: a plant will not show response to the addition of one input such as nitrogen fertilizer, if another input, such as water, is limiting growth.

NUTRIENT LOSS/REMOVAL MECHANISMS

From the concept of limiting factors, it can be appreciated that there is some optimum amount of available nutrients in the soil required by the growing crop. It is convenient to view the soil profile as a box holding these nutrients for plant use. A fertility management program tries to maintain an environmentally sound, profit maximizing nutrient level in the box representing the soil. Planning this program over the long term is facilitated by understanding the mechanisms that remove nutrients from the root zone.

Harvest constitutes a major removal mechanism. An annual harvest of 5 tons per acre of coastal bermudagrass removes 250 lb of N, 30 lb of P₂O₅, and 200 lb of K₂O per acre. A tomato harvest of 30 tons per acre removes 150 lb of N, 70 lb of P₂O₅, and 220 lb of K₂O per acre. It should be noted that crops may not require the total amount of nitrogen from external materials (manure or chemical fertilizer). Legumes can supply much of their needed N through N-fixing bacteria which can be removed with the legume crop or plowed in for use by the next crop.

Leaching can be a serious loss mechanism of nitrogen and potassium for shallow-rooted crops in sandy

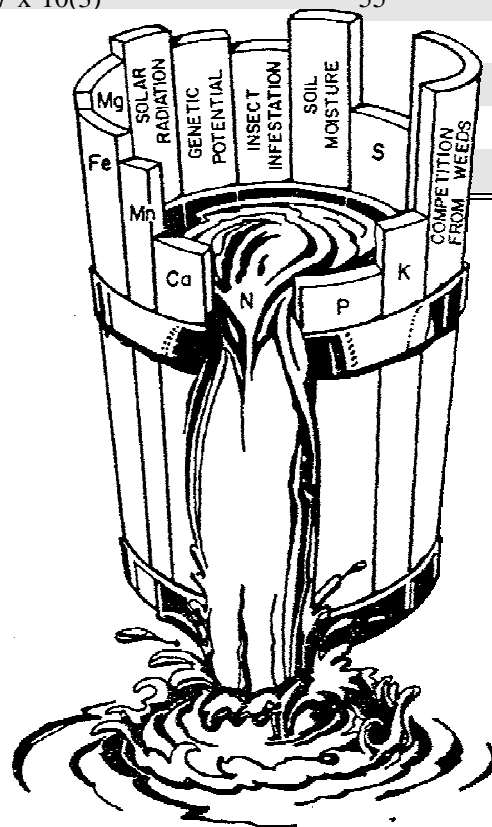


Figure 1. Barrel-Stave Analogy Showing Nitrogen-Limited Growth

soils subjected to high rainfall and/or irrigation such as found in Florida. Sandy soils have few clay particles to bind these nutrients in the soil profile. Sandy soils also do not hold water well, so any excess

Table 2. Energy inputs for manufacturing phosphorous-bearing fertilizers.

P-Source	%P ₂ O ₅	BTU/lb-P ₂ O ₅	MJ/kg-P ₂ O ₅
Monoammonium phosphate (MAP)*	48	7.2 x 10(3)	16.6
Concentrated superphosphate	46	7.2 x 10(3)	16.6
Superphosphate (DAP)**	20	7.2 x 10(3)	16.6
Diammonium phosphate	46	6.5 x 10(3)	15.1
Notes			
* Also contains 11% N. The manufacturing energy is given per pound (or kg) of N plus P2O5.			
** Also contains 20% N. The manufacturing energy is given per pound (or kg) of N plus P2O5.			

Table 3. Energy inputs for manufacturing potassium-bearing fertilizers.

K-Source	%K ₂ O	BTU/lb-K ₂ O	MJ/kg-K ₂ O
Muriate of Potash	50-60	2.15 x 10(3)	5
Potassium Magnesium Sulphate	22	2.15 x 10(3)	5
Potassium Sulphate	50	2.15 x 10(3)	5

water will move rapidly through the soil carrying with it soluble nutrients. These nutrients are soon out of the reach of shallow-rooted crops. Trees such as slash pine, with their deep roots, draw nutrients from a larger volume of soil and experience much lower leaching losses than other crops. Timely application of fertilizers and irrigation can minimize leaching losses when growing shallow-rooted crops in sandy soils.

Nitrate nitrogen can be lost from flooded soils by a process called denitrification. Under these conditions, certain soil bacteria begin to use the oxygen from the NO₃⁻ as the oxygen in the soil is depleted. As O is taken from the NO₃⁻ ions, N₂ gas is released which is then lost to the atmosphere.

In cases of serious soil erosion, phosphorus can be lost by the transport of phosphate-bearing compounds from the field. Although the phosphate may be in an insoluble form, it is lost via physical removal from the field and can pose significant water quality problems.

Many crops absorb potassium at rates greater than needed for normal growth. Such a tendency, referred to as "luxury consumption", does not increase the yield or quality of the crop. In fact, excess potassium fertilization has been implicated in the onset of grass tetany, a fatal disease occasionally contrasted by cattle when grazing.

RECOMMENDATIONS

Maximize Profit Not Yield. Maximum profit usually does not occur at the point of maximum yield. As yields approach maximum, the return on each increment of added fertilizer decreases.

Use Irrigation Planning. When irrigating, use scheduling or soil moisture probes to avoid over-application of water. Water seeping through the soil profile is carrying the soluble N and K forms along with it out of reach of the plants. If a heavy rainfall is expected in the near future, avoid bringing the field up to field capacity via irrigation; the rainfall will result in leaching losses.

Don't Fertilize If You Don't Need It. A regular soil-testing program should be instituted to monitor soil fertility. Follow the soil test recommendations; test results showing High or Very High levels of a nutrient indicate yields will not benefit from additions of that nutrient.

Substitute Crops or Varieties. Consider crops requiring less fertilizer. There are cases where crop or variety substitution can be made without requiring major changes in farm operation. For example, IFAS agronomists have selected two varieties of perennial peanut that can, in many cases, replace coastal bermudagrass and remove the requirement for supplemental nitrogen (the peanut is a legume).

Split Fertilizer Applications. Apply fertilizers in small amounts during the growing season or use timed-release fertilizers to help avoid leaching losses.

ADDITIONAL READING

Rhue, R.D. and Street, J.J. *Nitrogen--A Primary Plant Nutrient*. Fl. Coop. Ext. Svc. Soil Science Fact Sheet SL-31, 1984.

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