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Michigan State University
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Fertilizer Management to Save Energy

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An estimated 0.8 percent of the total U.S. annual energy consumption is presently being used for fertilizer production.[1] This represents an annual use of about 584 trillion Btu's (British Thermal units) or 146 trillion Kcals (kilogram calories).[2] The production of anhydrous ammonia, which requires approximately 7,000 Kcals per pound of nitrogen, represents nearly two-thirds of the total energy used for all fertilizers. Energy consumption values for phosphate and potash fertilizer are estimated at 1,250 Kcals per pound of phosphate (P_2O_5) and 1,000 Kcals per pound of potash (K_2O).

Energy use for the production of fertilizer, however, is not the entire story. Energy required for transporting fertilizers to the dealer and then to the farm is also a part of the total energy budget. High-analysis fertilizers generally require more energy for production, but less energy for transportation. Since transportation costs may represent 40 to 80 percent of the total farm cost of fertilizer,[1] high-analysis fertilizers are usually a better buy.

Energy use for transportation varies greatly, depending upon the fertilizer source being shipped, the methods of transportation, and the distance of travel. Approximately 403 Kcals are required to move one ton of fertilizer one mile by rail or barge and 1,033 Kcals per ton mile by truck.[3] Pipelines are another means of transporting ammonia fertilizer and should be included in any energy-cost analysis.

Although fertilizers are expensive and consume large quanitities of energy, they also help plants utilize the sun's energy more efficiently. Green plants capture energy from the sun by the process of photosynthesis and store energy as carbohydrates, oil and protein, which eventually are available for human and animal consumption. Quite often the maximum absorption of energy by plants is not attained without the use of fertilizers.

A bushel of corn contains approximately 95,000 Kcals of energy; therefore, each pound of nitrogen must increase yields 0.074 bushels to return the amount of energy required to produce one pound of nitrogen (7,000 Kcals). Putting it another way, 7.4 bushels of corn contain as much energy as 100 pounds of nitrogen. Quite often a farmer can expect a 40 to 50 bushel increase in yield with 100 pounds of nitrogen. Thus, it is easy to see that fertilizers often result in a greater return of energy. The fact remains, however, that with our present technology, plant energy (other than coal or wood) is not utilized for the production of fertilizer, heating of homes, or transportation. In the future, technology may permit the sun's energy or plant energy to be utilized for the production of fertilizer, fuel or transportation.

Hopefully new inventions and discoveries will permit man to harvest the sun's energy efficiently. Meanwhile, conservation of energy is our greatest hope of stretching out the finite supplies of natural petroleum resources.

EFFICIENT USE OF FERTILIZERS

One of the most important ways the farmer or grower can conserve fertilizer energy is in making efficient use of fertilizer. Efficient use can be defined as maximum yield with a minimum amount of fertilizer. The greatest efficiency usually results from the first increment of added fertilizer. Additional increments of fertilizer usually result in a lower efficiency but may still be profitable. A

[1]White, Bill. 1977. Fertilizer Cost Trends — Energy, Environmental and Transportation. *In* Fertilizer Progress 8(1) 13-14. The Fertilizer Institute, 1015 18th St., N.W., Washington, D.C.
[2]See conversion factors on page 4.
[3]Hoeft, R.G. and J.C. Siemens. 1975. Do Fertilizers Waste Energy? *In* Crops and Soils, American Society of Agronomy, Inc., Madison, WI.

grower will want to maximize profits and will usually sacrifice some fertilizer efficiency. Presently there are few incentives for the grower to maximize efficiency, yet there are many growers who could very profitably use fertilizers more efficiently.

Soil Testing

Fertilizer is an important source of plant nutrients required for optimum plant growth. The soil, however, also supplies a large portion of the essential nutrients. Soil testing is a means of evaluating the soil's ability to supply these nutrients. Some soils are naturally fertile or have been made more fertile by the use of fertilizers. An assessment of what the soil can supply can be related to crop yields and is used extensively for making fertilizer and lime recommendations. Soils that test low in phosphorus (P) or potassium (K) will need larger amounts of fertilizer P and K than soils testing high in these two nutrients. Much fertilizer energy can be saved by soil testing if fertilizers are applied to soils which have the greatest need and by using reduced rates where soil reserves are high.

Liming

Limestone is an important source of the essential nutrients calcium and magnesium. It is commonly used to raise the soil pH, which is a measure of soil acidity or alkalinity. Nutrient availability to plants is often affected by soil pH, with the greatest availability generally occurring between pH 6.5 and 7.0. For example — on acid soils, soluble aluminum is toxic to many plants and reduces the availability of P fertilizers. On alkaline soils, P availability is also reduced, resulting in reduced fertilizer efficiency and crop yield. Liming acid soils will also improve nodulation of legumes and increase fixation of atmospheric nitrogen, thereby reducing added fertilizer requirements.

Fertilizer Placement

It has long been known that banding (placing fertilizer near the seed at planting) is more efficient at supplying nutrients to the crop than broadcast applications, yet many crop producers are moving away from band applications. One of the reasons for this shift is that many soils no longer respond to P and K fertilizers as they once did. In Michigan, however, a response to band-placed P for many crops can still be seen, particularly under cool, wet conditions, even though many soils test high in P.

Another reason for the shift from band to broadcast fertilizer is low fertilizer cost in comparison to high labor cost and the importance of time. Many farming operations have expanded to the point where time and labor are the major factors affecting the productive capacity of the farm. Corn yields are greatly affected by time of planting. Any operation which delays planting, such as filling fertilizer hoppers, can cause a reduction in yield, resulting in a significant economic loss.

Before one switches from banding to broadcasting, a thorough analysis of band application should be made. Banding usually means less fertilizer per acre, fewer trips across the field, and may mean higher yield per acre. Estimates of additional time involved in banding fertilizer are as low as 30 seconds per acre. As farmers become better equipped to handle bulk blended fertilizers for use in planters, and as fertilizer prices continue to escalate, a decline or reversal of this trend away from banding is likely.

Uniform Fertilizer Applications

Uniform application of broadcast fertilizer is important in maximizing yields. Nonuniform application of dry bulk blended fertilizers due to segregation or separation of nutrients in loading, hauling and spreading or due to poor spreading pattern can result in overfertilization or underfertilization of certain areas in the field. The result is reduced yield, lower fertilizer efficiency and wasted energy.

Liquid fertilizer, which generally has a higher cost of production due to larger inputs of energy, would appear to have some advantages when considering uniform application and efficient use. Thus, the larger cost for energy for producing liquid fertilizer may be offset by greater efficiency due to more uniform application.

Time of Application

Sidedress applications of nitrogen (N) applied after plant emergence — particularly on shallow-rooted crops such as potatoes grown on sandy soils which are subject to leaching, or on crops grown on fine-textured soils where denitrification is a problem — may be used advantageously to increase effectiveness of fertilizers. Agronomic research has shown that delaying the time of N application will result in better usage of N. Corn and potatoes are good examples of crops having a high requirement of N late in the growing season. Sidedressed N will help to assure that N will be plentiful during the later stages of growth.

Applying N through the irrigation system is another means of improving nitrogen efficiency. Such a procedure requires little additional energy for application and assures that adequate nitrogen is available during the plant's greatest period of use. This practice is well adapted to sandy soils where leaching of N is a problem.

MANURE

Manure is an organic fertilizer available on poultry and livestock farms. It is a low-analysis fertilizer and thus requires a great deal of energy for uniform distribution to the field but should be effectively utilized whenever possible. The nutrient composition of manure varies greatly, depending on the type of livestock, method of handling and spreading. Adjustments in fertilizer recommendations are presently being made at Michigan State University's Soil Testing Laboratory to credit 4 pounds of N, 2 pounds of phosphate (P_2O_5) and 8 pounds of potash (K_2O) for each ton of cattle manure applied.

Incorporation of manure immediately after application will reduce volatilization losses of ammonia nitrogen from manure and result in better nutrient recovery. Because it is not always possible to incorporate manure and because a great deal of energy must be expended in the incorporation process, such practices are not extensively used. For additional information on nutrient composition of manures and their use, see MSU Extension Bulletin E-550.[4]

LEGUMES

Plowing under a legume crop such as alfalfa is an excellent way of improving the N status of the soil. Legumes fix atmospheric N by a process called symbiotic N fixation. Therefore, roots and nodules rich in N when plowed under release readily available N for other crops. Fertilizer N recommendations should be adjusted for the amount of N returned by the legume residue. A good stand of alfalfa, when plowed under, will supply 80 to 100 pounds of N per acre. A poor stand of less than 30 percent alfalfa will supply no more than 40 pounds of N per acre. A good stand of clover will supply 40 to 60 pounds of N. Soybeans in southern Michigan may supply up to 40 pounds of N to next year's crop with less supplied by soybeans grown further north.

OTHER CROP MANAGEMENT PRACTICES

Fertilizers often carry over from one year to another. More carry-over can be expected with high application rates and following droughty years. Yield reduction due to drouth, poor stand, insect or disease problems often results in less nutrient uptake and removal, which can significantly influence the carry-over of fertilizer. Nutrient carry-over from manured soils also contributes to the fertility of the soil. Not all of the nutrients in manure are released in the first year of application. Only half the N and P are considered available in the first year of application. All of the K should be available in the first year.

Crop rotation is also important in using fertilizer efficiently. A low nutrient-requiring crop such as soybeans following a heavily fertilized corn crop may require little or no fertilizer. Such practices are common and helpful in utilizing fertilizer efficiently.

SUMMARY

Although the amount of energy used for the production of fertilizer is small compared to the total U.S. energy consumption, conservation wherever possible is important. Considerable energy is also expended in transporting and applying fertilizers. Fertilizers, however, help conserve energy by improving the crop's ability to capture the sun's energy and store it as plant energy. Present technology, however, does not permit large-scale use of plant energy other than coal or wood for production of fertilizers, fuel or transportation.

Agricultural producers have many opportunities to make efficient use of fertilizers. Management practices such as liming, soil testing, band placement of fertilizer, uniform application, timing of nitrogen application to coincide with the crop's period of greatest use, use of manure, legumes, carry-over fertilizer, and advantages of certain crop rotations can all help to conserve energy.

Conversion Factors

1 Btu	=	heat to rise temperature of one pound water 1°F
1 Kcal	=	heat to raise temperature of one kilogram of water 1°C
1 Btu	=	0.252 Kcal
1 bushel corn	=	95,000 Kcal
1 pound N	=	7,000 Kcal
1 pound P_2O_5	=	1,250 Kcal
1 pound K_2O	=	1,000 Kcal

[4]Warncke, D.D., D.R. Christenson, and R.E. Lucas. 1976. Fertilizer Recommendations for Vegetable and Field Crops for Michigan. Extension Bulletin E-550, Michigan State Univ., East Lansing.

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