Energy Management for Field Crop Production
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ENERGY FACTS

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Over 75% of all agricultural energy used is for field crop production. Nearly 1.6 quadrillion British thermal units (Btu) were used for field crops in 1974. This represents over 2% of the total U.S. energy consumption and is equivalent to the energy contained in nearly 12.5 billion gal of gasoline. Energy is required for tillage, planting, fertilizing, cultivating, irrigating, spraying, harvesting, and drying.

Improved fertilizer application, minimum and no-till methods, alternative crop drying techniques, improved pest control techniques, and better irrigation procedures can significantly reduce energy needs in field crop production. Table 1 gives typical amounts of energy required for various operations. These energy requirements may not coincide with amounts used on your farm, but they should be helpful for comparison and as a guideline for improving efficiency.

Tillage

1. *Consider reduced tillage.* Plowing, disking and/or harrowing a field before planting and crop cultivation are often unnecessary with reduced tillage practices. Potential benefits of reduced tillage include erosion reduction, less soil compaction, improved weed control, increased soil moisture storage, labor and cost savings and more double

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Table 1. Estimated fuel requirements for selected farming operation.

Operation	Gasoline* Avg Gal/Acre
Moldboard Plow	2.6
Chisel Plow	1.6
Spike-tooth Harrow	.4
Field Cultivator	1.0
Row-Crop Planter (with fertilizer, etc.)	
40-Inch Rows	.7
30-Inch Rows	.9
Grain Drill	.5
Row Crops, First Cultivation	.6
Mower-Conditioner (pto)	1.0
Mower-Conditioner (self-propelled)	1.4
Baler, Hay	1.4
Forage Harvester (Flail-type)	
Green Chop	3.4
Dry Hay or Straw	1.7
Combine Harvester	
Small Grain	1.5
Pea Beans and Soybeans	1.7
Corn, 40-Inch Rows	1.8
Corn, 30-Inch Rows	2.1
Corn Picker	
40-Inch Rows	1.3
30-Inch Rows	1.4
Sugar Beet Harvester	2.1
Row Crop Sprayer (each operation)	.2
Anhydrous Ammonia Applicator	1.6
Pea Bean Puller and Windrower	.6

**For Diesel Fuel requirements, multiply the values for gasoline by 0.7 and for L-P Gas multiply by 1.2. Figures do not include fuel requried for hauling seed, fertilizer, etc., to the field, nor for hauling the harvested crop from the field.*

SOURCE: (4)

cropping opportunities. In terms of direct fuel use (excludes chemicals), reduced tillage can save up to 4 gal/acre and cut farm costs by 40%.

Using herbicides for weed control instead of tillage and cultivation can cut tractor fuel use because the tractor passes over the field fewer times. Herbicide production, however, requires large amounts of fossil fuel. Table 2 gives the energy content/unit of active ingredient of the most commonly used herbicides.

Table 2. Energy per pound of active ingredient of various herbicides.

Herbicide	Btu/lb
Atrazine	133,200
Alachlor	170,500
2,4-D	87,300
Paraquat	178,300*
Lasso 15G	124,500

*Paraquat is equal to 44,580 Btu/pint

SOURCE: (2)

This chart, coupled with Fuel Requirements for Selected Farming Operations, Extension Bulletin E-780, will enable you to compare the energy for different farming practices. If you are already using herbicides for weed control, the switch to no-till may simply require the addition of paraquat. The energy equivalent would be less than one-third gallon of diesel fuel per acre.

Tables 3 and 4 indicate net energy profit and net dollar profit for four methods of weed control. Hand labor yields the largest net energy profit (Table 3), but herbicide use yields the largest net dollar profit (Table 4).

Unfortunately, the long-term effects of extensive pesticide use in agriculture are unknown. But no-till methods do reduce soil erosion which is the primary source of agricultural pollution.

Other opportunities exist for reducing fuel usage in tillage operations.

2. *Don't till too deeply.* The greater the depth of a tillage operation the greater the fuel requirement is per acre. Plowing or chiseling land that was in soybeans, dry beans, wheat or corn silage the previous year can be done at shallow depths (5 to 7 in) if no hard-pan layer must be loosened. Secondary tillage (i.e., discing, dragging, etc.) should not be done deeper than ½ the depth of plowing or other primary tillage unless needed for specific herbicide incorporation. Deep secondary tillage requires extra fuel and brings more weed seeds and wet soil to the surface.

3. *Use the most energy efficient implement for tillage.* A chisel plow uses only ½ as much fuel per acre as a moldboard plow. A spring or spike tooth harrow (drag) uses less fuel than a disc or field cultivator, and can often be used instead.

Table 3. Energy relationships in weed control in six experiments on corn in Minnesota*

Method of controlling weeds	Energy input for controlling weeds, kilocalories/acre	Yield of corn grain/acre		Net profit due to weed control, kilocalories/acre
		Bu	Kilocalories	
None	0	54	5,443,200	----
Cultivation	56,005	81	8,164,800	2,665,595
Herbicide	37,920	90	9,072,000	3,590,880
Hand labor	32,655	92	9,273,600	3,797,745

**The land was plowed, disked, and prepared for corn planting in the conventional manner.*

SOURCE: (3)

Table 4. Economic relationships in weed control in six experiments on corn in Minnesota

Method of controlling weeds	Costs/acre at 1976 prices			Yield of corn, bu/acre	Value of crop/acre at 1976 prices	Net profit/acre due to weed control
	Gasoline, machinery, chemicals	Labor	Total			
None	$ 0	$ 0	$ 0	54	$132.30	---
Cultivation	3.43	1.51		81	198.45	$61.23
Herbicide	9.58	0.31	9.71	90	220.50	78.49
Hand labor	0	159.00	159.00	92	225.40	-65.90

SOURCE: (3)

tension Bulletin E-550, Fertilizer Recommendations for Vegetable and Field Crops for Michigan.

8. *Develop a fertilizer program* to meet your specific needs. The MSU Cooperative Extension Service and Agricultural Experiment Station have much to offer. Your county Extension office has information about these programs and recommended fertilizer rates and procedures.

Efficient Irrigation

On many irrigated farms, water delivery to the field uses more energy than many other farm operations combined. Although irrigated crops require 2 to 3 times as much fuel, the energy needed per unit of product may be less than that used in dryland production.

1. *Operate irrigation pumping plants at maximum efficiency.* A good electric power pumping plant should approach 70% efficiency. Yet, tests on operating equipment showed efficiency actually varied from 10 to 75%. Performance will vary with the speed and condition of the pump. Compare the rated pumping rate with the actual pumping rate. Repairs or adjustments are usually justified for equipment working at less than 50% efficiency.

2. *Keep irrigation equipment in good repair.* Repair leaks in valves, pipes and risers. Check gaskets in the sprinkler lines for leaks which waste water and power. Inspect sprinkler nozzles; they enlarge after use and may apply water at a greater rate than needed. Enlarged nozzles also shorten the distance water is thrown. overload the pump and cause a pressure drop that increases droplet size. Clogged perforations or water screens at the water inlet may prevent water from flowing freely.

3. *Know the storage capacity of your soil* by checking the depth of a wetted zone after applying a known amount of water.

4. *Improve irrigation efficiency* by irrigating at night or during the day when wind velocities are low.

5. *Reduce the amount of water stored in the soil* by less frequent irrigation as the crop matures. With corn, cease irrigation when the kernels reach the dough stage. Reduced water content of the soil at this time will hasten maturity and permit earlier harvest.

6. *Check with your power company supplier* to see if reduced electrical rates are available for off peak hours or other conditions.

7. *Know the infiltration rate of water in your soil;* applying water too fast can result in water, soil and nutrient loss.

8. *Consult Extension Bulletin E-1143,* Energy Conservation Through Better Irrigation Practices—for Farmers, for practices to increase irrigation efficiency.

Grain Drying

High temperature drying of 100 bu of corn from 25 to 15% moisture requires nearly 1.7 million Btu. Compare this with the 1.3 million Btu of gasoline or diesel fuel needed for tillage, planting, cultivation, and harvesting 1 acre of corn. Corn harvest can usually begin when grain moisture is about 28%. However, corn to be sold at harvest must be dried to 15.5% moisture or sold at a discount. Corn stored on the farm is normally dried to 13 to 15.5% moisture depending on how long it will be stored.

1. *Feed high moisture corn when possible.* Corn containing 20 to 30% moisture is good, if not better than dryer corn for ruminant livestock.
   a. *Preserve through fermentation.* The storage container must be airtight.
   b. *Use propionic acid.* Propionic acid allows preservation of high moisture corn without fermentation. Animals will gain the same no matter which preserving method is used.
   c. EXAMPLE: 110 steer calves are finished to slaughter weight with 8,430 bu of No. 2 dry corn, equivalent to 9,660 bu of 26% moisture corn. About 1,750 gal of LP gas and 1350 kWh of electricity are needed to dry this corn from 26% to 15.5% moisture using a medium capacity high-temperature batch or continuous dryer. By not drying the 9,660 bu of corn, the savings at 40 cents per gal for LP and 5 cents per kWh for electricity, would be $768 ($700 for LP and $68 for electricity).

2. *Consider a delayed harvest.* The longer a crop stands in the field, the greater the loss to bad weather, but if you can delay harvest for a week or 10 days you may be able to harvest 25% instead of 30% moisture corn.

3. *Choose the hybrid that has the best yield,* quick field drying characteristics, lowest amount of stalk lodging and is as early maturing as possible. This allows you to wait longer to harvest yet have a good product which is drier.

4. *Consider low-temperature grain drying.* Even though this takes longer, you can cut your fuel needs in half by using partially heated air followed by natural air drying.

5. *Use the right combination of grain storage bins.* Using three small bins instead of one large bin and staggering grain drying requirements can save energy and dollars in the long run.

EXAMPLE: A farmer harvest 20,000 bu of 23.5% moisture corn. Using the one-bin system, he uses a high temperature batch or continuous flow *dryer to dry corn to 14.0% moisture for safe storage. The energy needed for each moisture point to dry 100 bu is 1.84 gal of LP gas and 1.40 kWh of electricity. He needs to remove 9.5 moisture percentage points (23.5% - 14% = 9.5%). This requires 3,496 gal of LP gas and 2,660 kWh.*

Using the three-bin storage system, he can stagger the harvest into three separate batches such that their moisture content is 25%, 23% and 20%. With proper drying and handling these three batches could supply feed for summer, spring and winter, respectively.

The summer fed corn could be dried from 25% moisture to 14% using around 1,370 gal of LP gas and 1.042 kWh. The spring fed corn could be dried from 23 to 18% moisture content using around 623 gal of LP gas and 474 kWh.

No drying would be needed for the winter fed corn.

The total energy needed to obtain safe moisture storage levels is 1,993 gal of LP gas and 1.516 kWh of electricity. The three-bin system saves 1,503 gal of LP and 1,144 kWh over the one-bin system. At 5 cents per kilowatt-hour the annual electric savings is $57; the savings in LP gas is $600 per year.

6. *Maintain dryer in efficient operation condition.* Keep dryer fan belts tight and replace those that are worn. Adjust the dryer burner regularly for the best air-fuel mixture and periodically clean out dryer air tunnels and perforated floors for maximum air flow.

7. *Keep accurate records of fuel consumption and maintenance.*

8. *Improve dryer management when needed.*

Forage Production

Forage production requires large energy inputs. An estimated 12 gal/acre of gasoline are needed to produce baled hay from three cuttings under average conditions. Large hay packaging systems (rolls and stacks) reduce labor needs, shorten harvesting time, and cut fuel costs/ton produced if the rolls are left in the field.

Follow manufacturer's directions on the best way to use and maintain machinery. Other energy tips include:

1. *Sharpen forage harvester knives regularly* and turn shear bar as needed to save 20 to 30% of fuel and do better work. Keep knife and shear bar setting as close as possible and check often.

2. *Run forage harvester and silo blower at rated pto speed only.* Overspeeding can increase power used/ton chopped by 25% or more.

3. *Keep blowers in good condition.* Blade tip clearance should be adjusted to about 0.06 in.

4. *Consider using an electric motor when replacing a tractor-powered blower.* Check with power supplier for proper size.

5. *Keep road speeds under 15 mph for safety and to save fuel.*

Additional Information

The following publications (free) offer helpful suggestions for energy conservation in field crop production.

- *Crop Residue and Tillage Considerations in Energy Conservation. Extension Bulletin, E-1123, Michigan State University, East Lansing. 1978.*
- *Energy Conservation Through Better Irrigation Practices—For Farmers.* Extension Bulletin E-1143, Michigan State University, East Lansing. 1977.
- *Fertilizer Management to Save Energy. Extension Bulletin E-1136, Michigan State University, East Lansing. 1977.*
- *Fuel Requirements for Selected Farming Operations.* Extension Bulletin E-780, Michigan State University, East Lansing. 1974.
- *Reducing Energy Requirements for Harvesting, Drying, and Storing Grain.* Extension Bulletin E-1168, Michigan State University, East Lansing. 1978.
- *No-Till Corn: 1, Guidelines.* Extension Bulletin E-904, Michigan State University, East Lansing. 1979.
- *No-Till Corn: 2, Fertilizer and Liming Practices.* Extension Bulletin E-905, Michigan State University, East Lansing. 1979.
- *No-Till Corn: 3, Soils.* Extension Bulletin E-906, Michigan State University, East Lansing. 1979.
- *No-Till Corn: 4, Weed Control.* Extension Bulletin E-907, Michigan State University, East Lansing. 1979.

References

1. Federal Energy Administration and United States Department of Agriculture (1977). A guide to Energy Savings—For the Field Crop Producer. Washington, D.C.
2. Myers, C.A., et al. (1979). Michigan Farm Energy Audit and Education program, Final Report to the Michigan Energy Administration, Michigan Department of Commerce Contract 78-18.
3. Nalewaja, J.D. (1974). Energy Requirements for Various Weed Control Practices. Proc. North Central Weed Control Conf. 29:19-23.
4. White, Robert (1974). Fuel Requirements for Selected Farming Operations. E-780. Michigan State University, East Lansing.

4. *Combine tillage or other operations* to reduce fuel consumption and time requirements. Pulling a spring tooth harrow behind a disc or applying herbicide with a planter are common examples.

5. *Don't till fields that are too wet* since this not only causes compaction but increases draft and fuel requirements.

6. *Don't create deep, dead furrows* not intended for surface drainages because they may require secondary tillage to level the field. In a 40-acre field, for example, two extra passes over the dead furrows with a disc requires about 5 gal of extra fuel.

7. *Operate and adjust the tractor and implements properly.* Under light loads, gearing up and throttling back reduces fuel consumption. Optimizing wheel slippage between 10 and 15% can save fuel. Properly adjusted and clean carburetors and filters enable the tractor to operate more efficiently. Adjusting a moldboard plow according to owner's manual specifications results in more uniform plowing and reduces horsepower requirements.

Fertilizers

Although considerable energy is expended in their production, transport, and application, fertilizers help conserve energy by improving the crop's ability to capture the sun's energy and store it as plant energy. Fertilizer production requires enormous energy, accounting for over 40% of the farm energy input. Production of anhydrous ammonia requires about 28,000 Btu (1/5 gal of diesel fuel equivalent) per lb of nitrogen. This represents nearly two-thirds of the total energy used for all fertilizers. Energy consumption values for phosphorus and potassium fertilizers are estimated at 5,000 Btu (1/25 gal of diesel fuel) per lb of phosphorous (P_2O_5) and 4,000 Btu (1/30 gal of diesel fuel) per lb of potassium (K_2O). Typical fertilizer applications for corn are equivalent to nearly 30 gal of diesel fuel/acre.

High analysis fertilizers generally require more energy for production, but less energy for transportation. Since transportation costs may represent 40 to 80% of the total farm cost of fertilizer, high-analysis fertilizers are usually a better buy.

There are two ways to reduce the energy needed for fertilizing: 1) obtain greater yields from the same amount of fertilizer or 2) maintain present yields with less fertilizer. To do this:

1. *Have your soil tested.* A soil test should be conducted every 3 years. Each soil sample should represent 10 to 15 acres. A soil test can determine residual fertilizer levels and may indicate the need for less fertilizer than might ordinarily be used. It can also determine lime, micronutrients or other fertilizer needs for optimum yields. Liming to a favorable pH can result in more efficient use of fertilizer nutrients.

2. *Calibrate distributor equipment properly.* Applying too much fertilizer is wasteful and may harm crops; too little fertilizer may result in yield reductions. Each time a distributor is used, check to make sure the proper application rate is set. Also, periodically check to see if the gauge settings actually deliver the desired application rate. The rate is influenced both by the granular characteristic of the fertilizer and by the humidity.

EXAMPLE: Suppose a bulk spreader is set to apply fertilizer at 300 lb/acre but upon calibration, you find it was actually delivering 350 lb/acre. With a fertilizer cost of $150/ton, the excess fertilizer would amount to $4.00/acre.

3. *Combine fertilizing with another compatible operation* when possible. Supplemental nitrogen can be applied through irrigation water in most overhead sprinkler systems. This practice may also be possible with furrow or trickle irrigation. Sidedress nitrogen can also be applied during cultivation. If fertilizer needs are small, the entire amount of fertilizer can be applied at planting time.

4. *Apply nitrogen, phosphorus and potassium together* when possible. Split fertilizer applications consume more fuel, but under some conditions they may be necessary for effective results. Split applications also lead to greater soil compaction.

5. *At planting, carefully place fertilizer in a band* away from the seed to avoid damaging the seedling with chemical burn. With some crops, all or most of the fertilizer can be applied at planting. Better yields may result from band rather than broadcast applicatons.

6. *Consider growing nitrogen-fixing plants.* A good stand of alfalfa, when plowed under, will supply 80 to 100 lb of nitrogen/acre. A poor stand of less than 30% alfalfa will supply no more than 40 lb of nitrogen/acre. A good stand of clover will supply 40 to 60 lb of nitrogen/acre. Soybeans return about 1 lb of nitrogen for every bu of soybeans produced. For example, a 40-bu/acre crop would produce 40 lb/acre of nitrogen.

7. *Consider using manure.* Manure, a low-analysis fertilizer, requires a lot of energy for uniform field distribution but should be effectively utilized whenever possible. Adjustments in fertilizer recommendations are presently being made at Michigan State University's Soil Testing Laboratory to credit 4 lb of nitrogen, 2 lb of phosphate and 8 lb of potash for each ton of cattle manure applied. Immediate incorporation of manure aids in nutrient retention. For additional information on nutrient composition of manures and their use, see MSU Ex-

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