ENERGY FACTS

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Energy Inputs and Returns from Various Cropping Systems

Donald R. Christenson
Crop and Soil Sciences Department

This publication outlines the energy costs and returns for several cropping systems common in Michigan, and deals mainly with those inputs which are used on the farm in one season. The information in this bulletin may be adapted to other systems by using other bulletins of this series and references at the end of this publication.

Energy consumption in agriculture production falls into several categories. Those considered here are land preparation (tillage, planting and cultivation), fertilizer and pesticide manufacture and application, manure and lime application, cultivation, harvesting, drying and transporting the product to market or feeding facility. Those not considered are transportation of fuel, fertilizer, chemicals and equipment to suppliers, manufacture of equipment, travel for repairs, field observation, shopping for equipment and supplies, and energy used in lubricants, tires, batteries and other maintenance items. Energy used in feeding of cattle, processing, packaging and distribution of food are not discussed in this article but they are by Fritsch et. al. (1).[1] Gross energy production values of the harvested product are given for the cropping systems.

All energy values in this bulletin are given in British Thermal Units (BTU). A BTU is the amount of energy required to raise the temperature of 1 pound (1 pint) of water 1 degree Fahrenheit. These values are then converted to an equivalent amount of diesel fuel per acre. *Diesel fuel is not used in most manufacturing processes*. Energy values used in this bulletin are given in Table 1.

CROPPING SYSTEMS

Four systems of cropping commonly used in Michigan are outlined below.

[1]For all numbers in parentheses, refer to list on p. 4.

System I Forage (Hay) System

Cropping Sequence: oats, alfalfa, alfalfa, alfalfa, alfalfa.

Method of Planting: alfalfa is seeded with a small grain.

Tillage: moldboard plow, disk, plant.

Herbicide: oats-seeding 3/8 lb and alfalfa ½ lb/acre for each of first 2 years.

Fertilizer: 45 lb P_2O_5 and 135 lb K_2O/acre broadcast prior to planting, 30 lb N, 30 lb P_2O_5 and 30 lb K_2O/acre at planting. 50 lb P_2O_5 and 150 lb K_2O/acre broadcast on alfalfa annually.

Insecticide: alfalfa weevil control, ¼ lb/acre each year.

Harvesting: cutting and windrowing in one operation, baling in a separate operation.

Hauling: pick up and hauling 1 mile in one operation (8).

Expected Yield: oats-80 bushels; alfalfa-4 tons in four cuttings.

System II Forage (Corn Silage) System

Cropping Sequence: continuous corn for silage.

Tillage: plow, disk once, plant.

Fertilizer: planting time–12 lb N, 50 lb P_2O_5, 50 lb K_2O/acre, 150 lb K_2O/acre broadcast prior to planting, 120 lb N/acre as anhydrous ammonia sidedressed.

Herbicide: 2 lb/acre.

Insecticide: 1 lb/acre.

Harvesting: corn is harvested for silage.

Hauling: distance 1 mile (8).

Expected Yield: 20 tons silage per acre.

Table 1. Energy values and references used for input and output of four cropping systems used in Michigan.

Variable	Value and/or source
	Input
Diesel fuel	134,000 BTU per gallon
Nitrogen	27,778 BTU per lb N (7)[1]
Phosphate	4,960 BTU per lb P_2O_5 (7)
Potash	3,968 BTU per lb K_2O (7)
Pesticides	43,651 BTU per lb active ingredient (5)
Tillage, planting, harvesting, pick-up in field	Calculated from values in Extension Bulletin E-780 (8)
Drying	25,040 BTU per bushel of corn from 28% to 14% moisture (3)
Hauling	Fertilizer in all cropping systems and grain in systems I & III: 5 tons/load, 5 gallons/mile.
	Navy beans and grain in Cropping System IV: 30 tons/load, 5 miles/gallon
	Sugar beets in Cropping System IV: 25 tons/load, 5 miles/gallon
	Other crops see reference 8.
	Output
Oats (grain)	2,698 BTU/lb (4)
Alfalfa	1,610 BTU/lb (4)
Corn Silage	704 BTU/lb (4)
Corn Grain	3,214 BTU/lb (4)
Soybeans	3,452 BTU/lb (4)
Navy Beans	2,938 BTU/lb (4)
Wheat	3,175 BTU/lb (4)
Sugar Beets	544 BTU/lb (4)

1. Numbers in parentheses refer to articles in the reference section.

System III Corn — Soybean System

Cropping Sequence: corn, soybeans.

Tillage: corn-fall chisel plow, spring field cultivate once, plant, cultivate once. Soybeans-spring moldboard plow, disk once, plant, cultivate once.

Fertilizer: corn-12 lb N, 50 lb P_2O_5, 50 lb K_2O/acre at planting, 100 lb K_2O/acre broadcast, 100 lb N/acre as anhydrous ammonia side-dressed. Soybeans-25 lb N, 50 lb P_2O_5, 50 lb K_2O/acre at planting.

Herbicide: corn-3 lb/acre, soybeans-2.6 lb/acre.

Harvesting: both crops combined. Corn dried from 28 to 14% moisture.

Hauling: both crops are hauled 10 miles to market, 5 tons per load, 5 miles/gallon.

Expected Yield: corn 120 bu/acre; soybeans 40 bu/acre.

System IV Navy Beans, Navy Beans, Wheat, Sugar Beets

Tillage: navy beans both years, fall chisel plow, spring disk twice, plant, cultivate twice; wheat-field cultivate once, plant, disk once after harvest; sugar beets-fall plow, field cultivate once in spring, plant, cultivate twice.

Fertilizer: navy beans-50 lb N, 50 lb P_2O_5, 50 lb K_2O/acre at planting each year; wheat-75 lb P_2O_5 and 75 lb K_2O/acre broadcast, 60 lb N/acre broadcast in spring; sugar beets-25 lb N, 100 lb P_2O_5 and 100 lb K_2O/acre at planting, 50 lb N/acre as anhydrous ammonia side-dressed.

Herbicide: navy beans — 10.6 lb/acre; wheat — 0.5 lb/acre; sugar beets — 3.0 lb/acre.

Harvest: navy beans — pulled, windrowed and combined; wheat — combined; sugar beets topped and harvested in separate operations.

Hauling: 10 miles to market, 25 tons of beets/load, 30 tons of navy beans or grain/load, 5 miles/gallon.

Expected Yield: Navy beans-20 cwt/acre, wheat-80 bu/acre, sugar beets — 25 tons/acre.

DISCUSSION

The consumable energy values for these four cropping systems are given in Tables 2 and 3. Several management practices can be varied by the producer in such a manner so as to reduce the consumable energy in these cropping systems. The main areas which can be varied are fertilizer, tillage, drying and harvesting.

Fertilizer

Fertilizers use 50 or 75% of the consumable energy in these cropping systems. The amount of fertilizer in these defined systems is modest but should produce high yields. Nitrogen requires the largest input of energy followed by phosphate and potash. Even though fertilizers are the greatest single energy input into these cropping systems, they also provide the

Table 2. Estimated consumable energy requirements for two cropping systems.

Input	System I		System II	
	gallons diesel/acre	BTU/acre (thousands)	gallons diesel/acre	BTU/acre (thousands)
Land Preparation	2.45	328.3	2.45	328.3
Planting	0.35	46.9	0.63	84.4
Fertilizer Materials	33.50	4,489	35.13	4,707
Fertilizer Application	0.70	93.8	1.26	168.8
Fertilizer Hauling	0.79	105.9	0.24	32.2
Herbicide Materials	0.45	60.3	0.65	87.1
Herbicide Application	0.32	42.9	0.11	14.7
Insecticide Materials	0.33	44.2	0.46	61.6
Insecticide Application	0.42	56.3	-----	-----
Windrowing	15.68	2,101	-----	-----
Baling	15.68	2,101	-----	-----
Chopping	-----	-----	2.52	337.7
Silo Filling	-----	-----	0.98	131.3
Combining	1.05	140.7	-----	-----
Hauling	4.28	573.5	1.40	187.6
Total for System	76.00	10,183.8	45.83	6,140.7
Average/year	15.20	2,036.3	45.83	6,140.7

Table 3. Estimated consumable energy requirements for two cropping systems.

Input	System III		System IV	
	gallons diesel/acre	BTU/acre (thousands)	gallons diesel/acre	BTU/acre (thousands)
Land Preparation	5.11	684.7	8.33	1,116
Planting	0.63	84.4	2.24	300.2
Cultivation	0.77	103.1	1.54	206.4
Fertilizer Materials	42.17	5,651	67.04	8,983
Fertilizer Application	1.26	168.8	1.40	187.6
Fertilizer Hauling	0.29	38.9	0.64	85.8
Herbicide Materials	1.82	243.9	4.59	615.1
Herbicide Application	0.21	28.1	0.42	56.3
Insecticide	-----	-----	0.33	44.2
Pulling-Windrow Navy Beans	-----	-----	0.84	112.6
Combining	2.94	394.0	3.36	450.2
Drying	22.42	3,004	-----	-----
Topping Sugar Beets	-----	-----	1.47	197.0
Harvesting Sugar Beets	-----	-----	1.47	197.0
Hauling Corn	1.60	214.4	-----	-----
Hauling Soybeans	0.53	71.0	-----	-----
Hauling Sugar Beets	-----	-----	5.40	723.6
Hauling Navy Beans	-----	-----	0.13	17.4
Hauling Wheat	-----	-----	0.32	42.9
Total for System	79.75	10,686.3	99.52	13,335.3
Average/year	39.88	5,343.2	24.88	3,333.8

greatest energy return per unit of input *provided* they are used efficiently. Vitosh (7) describes the efficient methods of using fertilizer. Among the tools available are soil testing, liming, proper placement, uniform applications, correct timing and use of manures and crop rotations.

Tillage

Tillage is another major input of energy comprising 3.7% in Cropping System I to 12.2% in Cropping System IV. The amount of tillage described here is far from a no-till concept, but is considerably less than many producers are using. In System IV, many producers are using twice the tillage described. This would amount to a 10% increase in energy consumption from this source. Robertson (6) describes energy savings as related to tillage systems.

Crop Drying

Where crop drying is required considerable energy can be consumed. In System III, drying accounts for 28% of the energy consumed. Drying from 26% moisture, rather than 28% reduces the energy for this component by 16%. Maddex and Bakker (3) describe methods for reducing these requirements. It is not the scope of this publication to go into this area, but one of the best ways is to grow corn hybrids which will mature in the area where the crop is grown.

Harvest and Transportation

In System I, harvesting operations (including hauling) account for 40% of the consumable energy while in System III, only 6%. Various harvesting systems undoubtedly are more energy efficient than others. The net energy cost can be reduced (energy produced minus energy consumed) by using other practices which produce maximum yields, since the major portion of the energy input is in the operation of the harvesting equipment regardless of the yield.

Energy Returned

Gross energy produced compared to consumable energy values are given in Table 4. At the field gate, forage systems produce more energy per unit of input than do cash cropping systems. However, animal systems take 7 BTU of plant energy to produce 1 BTU of food for humans. When food is processed, the energy consumed reduces the efficiency of energy use. In the total food production, processing and delivery system, fossil fuels are consumed at a rate about equal to the energy produced.

Table 4. Consumable energy, gross harvested energy and their ratio for four cropping systems.

Cropping System	Consumable Energy	Gross Harvested Energy	Ratio
	Total BTU (thousands)/acre		
I	10,020.5	58,426.9	5.83
II	6,140.8	28,160.0	4.59
III	10,686.3	29,330.6	2.74
IV	13,335.7	54,152.0	4.06

For further information, refer to the booklet by Fritsch et. al. (1) and one by Heichel (2).

SUMMARY

The major inputs into four agricultural production systems have been described. Fertilizer, tillage, crop drying and harvesting are major consumable energy inputs which the producer can control or reduce with good management.

SELECTED REFERENCES

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