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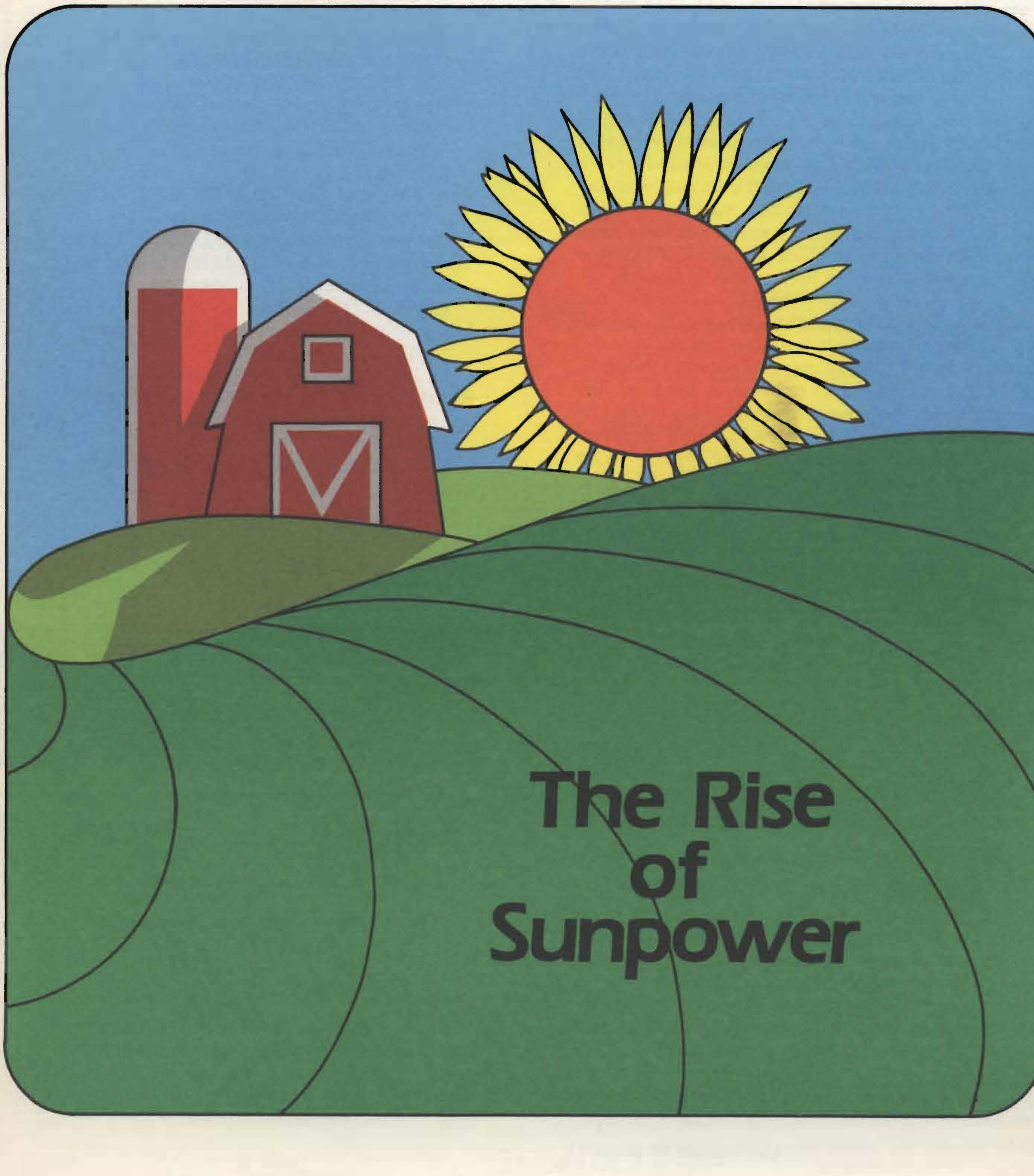

Guest Column

KENTON R. KAUFMAN

Since 1951, oil booms have come and gone in the small towns and open country of western North Dakota. When newly discovered domestic oil was decontrolled in 1979 and prices rocketed to almost $40 a barrel, the oil boom was revived in places like Williston and Dickinson. The exact amount of oil in North Dakota is unknown, but the current estimates put the total recoverable reserve at somewhere in excess of one billion barrels. North Dakota now occupies a strategic place in the nations' energy future. Besides oil and gas, the state will soon have the country's first coal gasification plant, a massive multibillion dollar project being built in Beulah.

It is instructive to look at the energy path that led North Dakota to where it is today. On August 27, 1859, Col. Edwin L. Drake discovered oil in Pennsylvania. Liquid fuels became popular as lamp oil. Dr. Rudolph Diesel, a German engineer, conceived the idea of utilizing the heat produced by high compression for igniting the fuel charge in the cylinder of an internal combustion engine. In 1892 he secured a patent on an engine designed to operate in this manner. As Diesel worked on perfecting his engine, he investigated the possibility of using vegetable oils as fuel. His success was demonstrated at the Paris exposition of 1900 where his engine ran wholly on the oil of an African earth nut. Diesel later commented, "The use of vegetable oils for engine fuels may seem insignificant today, but such oils may become in the course of time as important as petroleum and the coal tar products of the present time."

Research continued through the fuel shortages of World War I and II. Although researchers obtained and reported encouraging results, there is little evidence to show that their investigations were actively pursued.

In 1947, the U.S. produced almost all the oil it used. However, by 1957, the U.S. was importing about 18 percent of its total oil supply. By 1970, more oil was produced domestically than many experts had predicted would ever be found, but our nation was also importing about 23 percent of its demand. Not even the price increase of 1973-74 could diminish the U.S. hunger for imported oil. In 1977, the U.S. imported nearly 48 percent of its oil demand from other countries. Since the second large price increase in 1979, U.S. imports have dropped

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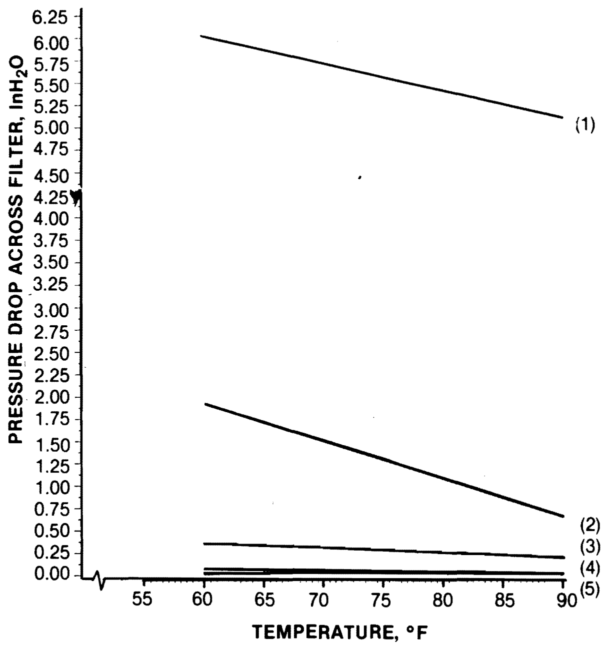

(1) = 100% SUNFLOWER OIL
(2) = 75% SUNFLOWER OIL & 25% #2 DIESEL FUEL
(3) = 50% SUNFLOWER OIL & 50% #2 DIESEL FUEL
(4) = 75% SUNFLOWER OIL & 25% #2 DIESEL FUEL
(5) = 100% SUNFLOWER OIL

Fig. 7. Pressure Drop Across Filter, InH_2O, vs. Temperature, °F (All Sunflower Oil Fuels.)

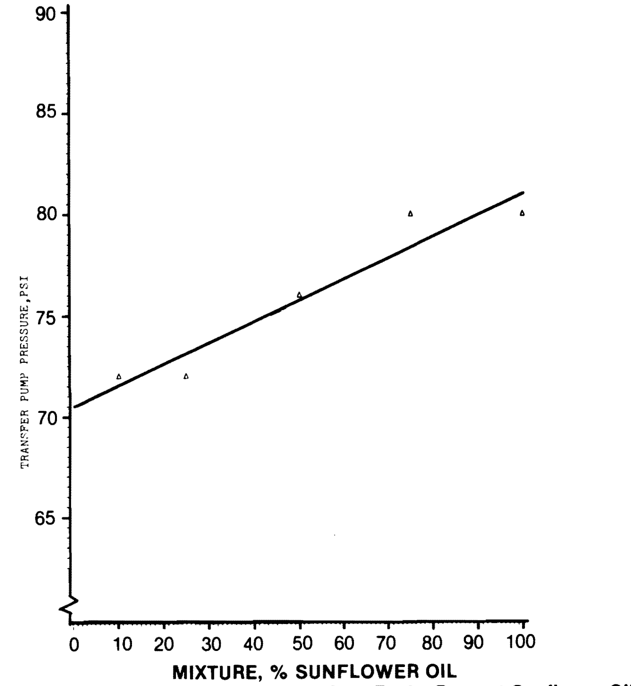

Fig. 8. Transfer Pump Pressure, psi vs. Fuels, Percent Sunflower Oil Fuel.

Transfer Pump Pressure:

Transfer pump pressure was recorded once for each mixture since it did not vary with any of the other parameters being evaluated. Transfer pump pressure was initially set to factory specifications and was not adjusted throughout the tests. Transfer pump pressure vs. fuels is shown in Fig. 8.

Transfer pump pressures were higher when using high percentage sunflower oil fuels, especially at low temperatures. This pressure change may require modifications of factory specifications when using sunflower oil as a fuel.

Fuel Injection Timing:

No changes were noted with the various fuels, so no changes in the diesel injection system timing would be necessary if sunflower oil fuels are used unless engine performance tests show a greater efficiency at other settings.

Summary:

Results from a test stand evaluation of a typical diesel fuel system show changes in performance of the system as the sunflower oil content of the fuel increases and the temperature decreases. It appears low percentages of sunflower oil may be used successfully in the system under "summer" conditions. Design changes to the system may be necessary for higher percentages of sunflower oil and cold conditions.

Guest Column continued from page 2

off, but not enough to give the U.S. the energy security it needs. Concerns over petroleum arise from the fact that fossil fuels are the largest source of energy used in this country. Presently the three fossil fuels (oil, natural gas, and coal) account for about 92 percent of the energy used in the U.S.

The dependence on fossil fuels has dictated that innovative Americans start looking for alternative fuels. Gasohol started showing up at service station pumps in the 1970's. This fuel, a blend of nine parts gasoline and one part alcohol, was supposed to help reduce America's dependence on foreign oil. It's symbol was the corncob since the alcohol for use in gasohol was primarily distilled from corn. However, attention has shifted toward the development of vegetable oils for use as an alternative fuel source, especially for agricultural production. One major reason is that while alcohol is readily adaptable for use in gasoline engines it should not be used in diesel engines which power most of the farm machinery. Methanol has been used exclusively in many racing automobiles for years, but alcohol has not been proven practical in diesel engines. In recent years, there has been a solid shift toward diesel farm tractors and other engines used on self-propelled farm equipment. A recent estimate is that 95 percent of farm motive power is supplied by diesel engines. Diesel engine manufacturers know conceptually how to use alcohol fuels, but their use results in decreased engine life or even catastrophic failure. The major manufacturers of diesel engines for farm and industrial equipment do not recommend alcohol fuel use in diesel engines at the present time.

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Water Content

Water content is determined by heating the fuel under reflux with a water immiscible solvent such as xylene. The condensed solvent and the water are separated in a trap with most of the solvent returning to the still. Water, even in small quantities, is damaging to diesel systems. It causes wear of the precisely machined parts of the injection system, promotes corrosion and may cause filter plugging. No water was present in the samples of sunflower oil, blends and diesel that were tested.

Summary

The test results for the diesel, sunflower oil and a 75 percent diesel:25 percent sunflower oil blend are summarized along with the limiting requirements for No. 2 diesel in Table 1.

If any comparison is made among the fuels, it must be considered that No. 2 diesel is recommended for high speed engines in farm tractors under intermediate to heavy loads at ambient air temperatures above 41°F. When the three fuels are compared, there is a marked difference in the pour point from diesel to sunflower oil. However, when comparing the use of thee two fuels above 41°F, the pour and cloud points can be overlooked, because they occur at temperatues well below this reference temperature.

Table 2. Cloud and pour points of sunflower oil and blends with diesel, °F.

	No. 2 D	75% D 25% sfo	50% D 50% sfo	25% D 75% sfo	100% sfo
Cloud Points, °F	1.4	3.90	8.00	12.51	20.30
Pour Points, °F	-58	2.19	5.85	5.85	16.30

D = No. 2 diesel sfo = sunflower oil (alkali-refined)
*from Barsic & Humke, 1981 **from U.S. DOE, 1980

The fuel properties that determine a good compression ignition fuel are primarily cetane rating and volatility. They determine the knock characteristics and ease of starting the diesel. Sunflower oil has a relatively low cetane rating compared to the minimum for No. 2 diesel. The importance of this parameter, however, needs to be investigated further as it may not have the same significance for sunflower oil as it would for diesel fuels.

The difference in heat of combustion of the sunflower oil is 4.7 percent lower than No. 2 diesel fuel. Theoretically an engine should consume 4.7 percent more sunflower oil to produce the same amount of work as when using No. 2 diesel fuel.

The higher viscosity of the sunflower oil does not favor its use in unmodified diesel engines. Potential problems with such high viscosity oils are filter and fuel line obstructions, higher injection line pressures and poor atomization.

The fuel properties of diesel fuel-sunflower oil blends were intermediate between the No. 2 diesel, and the vegetable oil. The blends that had proportionally more No. 2 diesel fuel had properties closer to No. 2 diesel fuel. The initial boiling point of the 75:25 blend is just 5.4°F higher than that of No. 2 diesel fuel, so it should vaporize nearly as easily as No. 2 diesel fuel. The cetane rating of this blend is just above 40, the minimum recomended for No. 2 diesel fuel. Its kinematic viscosity is higher than No. 2 diesel fuel at all temperatures. At 100°F, however, it approaches that specified for No. 2 diesel fuel. The gross heat of combustion of this blend is 99 percent of the value for No. 2 diesel fuel. On the basis of this comparison, a 75 percent diesel fuel:25 percent sunflower oil blend should perform very close to No. 2 diesel fuel when burned in the engine under similar conditions.

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Vegetable oil is the favored substitute for diesel fuel. Diesel engines require fuels which self-ignite readily at compression ignition temperatures. This requirement is characterized by a measure of fuel ignition quality called cetane number. The fuel properties of vegetable oils make them a reasonable emergency fuel for farmers. The major technical problem with vegetable oils is their high viscosity and tendency to form residues on combustion. A technology called trans-esterification may solve this problem. The esters have low viscosities and the residue problem may be virtually eliminated.

The problems and potentials of using vegetable oils as an alternative fuel for diesel engines are presented by the various articles in this issue of North Dakota Farm Research. I refer you directly to those articles for information on economics, use in diesel engines, and feeding trials with the meal remaining after the oil has been extracted from the seed.

One of the great benefits of growing plants for oil is the wide variety of species available. One can choose the plant that is best suited for the growing conditions in a particular area. Sunflower is adapted to many parts of the world including the midwest U.S., South Africa, and the Soviet Union. Other vegetable oils may be more suitable for other countries. Besides sunflower, soybean, and peanut, there are more exotic species such as jojoba, guayule, milkweed, eucalyptus, squash, copaiba, malmeleira, babassu nut, and chinese tallow tree.

Vegetable oils have an advantage in that it is easy to extract the oil from them compared to the production of alcohol. All that is required is to squeeze the oil out of the seeds by a simple mechanical operation. However, if vegetable oils are ever to be used as commercial fuels, it will be necessary for them to meet quality standards. These standards will be developed as research continues.

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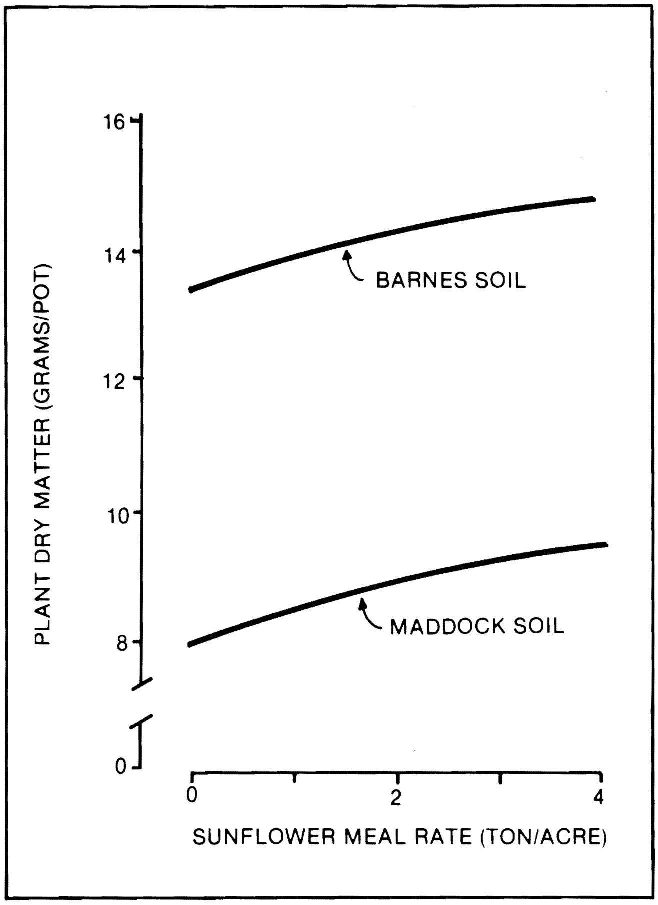

FIGURE 2. Dry Matter Yield of Kitt Wheat as Influenced by Residual Soil Applications of Sunflower Meal (Averaged Over the Four Previous NPK Fertilizer Treatments).

SUMMARY

The use of sunflower meal as a fertilizer source appears to be an alternative method for utilization of this by product material as evidenced by the response on the two soils tested. The response obtained was greatest on the soil with lower N, P, K and organic matter soil test levels suggesting that maximum benefit would be obtained by applying the sunflower meal to soils of this fertility status. The current dollar value of the sunflower meal as feed far exceeds the value of the nutrients. A three fold increase in current fertilizer prices would make the use of sunflower meal as a soil additive more competitive. Additional field research would need to be conducted to establish application rates over a wider range of soils if the use of sunflower meal as a soil additive becomes a management practice.

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Before we turn to vegetable oils as fuels, we need to know how much they cost and how much energy it takes to grow and process these plants. Energy ratios have always been controversial when considering biomass energy. Benefits are questioned when crops are grown and fermented to make alcohol. Both positive and negative energy ratios have been reported. On the other hand, vegetable oils are an excellent energy source. The energy output of the crop produced in comparison with the cultural energy input (growing and processing the oil crop) varies between 2.2 and 6.1 to 1.0 depending upon the reference. So, compared to other processes for fuel production from renewable agricultural resources, plant oil production gives a good input/output relationship with considerable net fuel energy output.

The practicality of an alternate farm fuel is dependent on the amount of land required to produce the crop. The average sunflower yield in the United States for the past three years was 1243 pounds per acre. The oil content of the sunflower seed ranges from 40 to 45 percent. Almost all oil in the sunflower seed can be extracted in a commercial operation. Therefore, it is possible to produce approximately 65 gallons of sunflower oil per acre of land. The direct on-farm fuel required to produce an acre of sunflower or small grain in North Dakota ranges from 6 to 9 gallons per acre. Under these conditions, an acre of sunflower could produce enough fuel to grow 7 to 11 acres of small grain or sunflower. About 10 percent of a farmer's land devoted to the production of sunflower could provide his direct on-farm fuel requirements. In 1919, the agricultural acreage devoted to the production of feed for horses and mules in the U.S. was 22 percent of the harvested cropland. We should not be surprised if once again a sizeable percentage of our farm land was devoted to the production of raw materials for the manufacture of fuel, even though it is not to feed horses and mules.

So far the positive aspects of growing plants for their oil have been emphasized, but we have to recognize the problems. No biomass fuel system is perfect, including vegetable oils.

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the best for North Dakota sunflower oil at present. Breeding would accomplish the same, but requires several years of time.

The oil from sunflower grown in the south or in other warm climates such as Australia and South Africa has a lower linoleic acid content. If the iodine value of this oil is 125 or less, the problem would be minimized.

Other vegetable oils that are low in linoleic acid such as rapeseed, high oleic safflower and peanut oil are also good choices.

To eliminate oxidation, literally thousands of antioxidants have been identified. However, massive amounts of expensive antioxidants would probably be required. An antioxidant would not eliminate the problem of thermal polymerization.

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Plants need land and compete with other resources that are required for food production. It can be expected that there will be increasing public debate about the use of an edible oil product for fuel use. David Bartholomew, manager of the oilseeds division for Merrill, Lynch, Pierce, Fenner, & Smith of the Chicago Board of Trade, points out that from the beginning of time, man has used the productivity of agriculture as a source of fuel for the provision of motive power for on-farm and off-farm use. It has been only since the 1930s that the U.S. shifted from horses and mules to the use of petroleum-powered implements and vehicles that did not use food for fuel. Seen in this light, it should be said that petroleum is the "alternative" fuel, instead of vegetable oil and alcohol as being alternatives. The U.S. made the shift just about 50 years ago when the government adopted a cheap petroleum policy as a stimulant to mechanization and industrialization. Presently, some form of renewable energy sources must begin to take the place of the nonrenewable sources.

Unfortunately, alternative fuels are not yet economically competitive with petroleum-based fuels. In April, 1982, No. 2 diesel fuel cost $1.11 per gallon compared to $1.65 per gallon for 200 proof ethanol and $2.07 per gallon for sunflower oil. Clearly, diesel fuel is the least expensive. However, comparing costs for the alternate fuels, it is important to remember that ethanol contains only 84,000 BTU per gallon as compared to 138,000 BTU per gallon for No. 2 diesel fuel and 131,000 BTU per gallon for sunflower oil. So sunflower oil will provide 100,000 BTU's of energy for $1.58 whereas it will cost $1.96 for ethanol to provide the same amount of energy.

Even though vegetable oils are not yet economically competitive with diesel fuel, they may be competitive in the future. The price ratio of soybean oil to diesel fuel was 4.6:1 in 1971 and increased to 10.7:1 in 1973. Since then the price ratio has decreased. In February, 1982, the crude soybean oil price hit 17.8 cents per pound or $1.37 per gallon. In the future vegetable oils may cost about the same as No. 2 diesel fuel. In some parts of the world, vegetable oils cost less than diesel fuel today.

So even though it is hard to get excited about the use of alternative fuels, we need to continue our research on renewable energy sources. The U.S. is in the midst of a temporary oil glut. Crude-oil imports have declined by 25 percent in the past two years. Successful energy conservation and the recession have dampened the market for petroleum. Refineries are now running at only about 65 percent of capacity. Many people are now saying the oil crisis is over. Yet the most dangerous thing is to draw long-term conclusions from short-term events. James Cook points out in the March 15, 1982, issue of FORBES magazine that the so-called glut is only a correction and not a change in the fundamental conditions of supply. It is not the coming of spring, but that rare sunny day in January. The U.S. needs a synfuels program — oil shale, coal gasification and liquefication — every bit as much as it ever did. Not only does such a program serve to warn OPEC that there really are limits to how high its prices can go, it also offers hope of providing the U.S. with the energy security it needs in the event of a disruption in worldwide supplies. Clearly, the U.S. has to conduct research before vegetable oil can become an accepted fuel. But vegetable oil fuels look like a sleeper in the research and development program for synthetic fuels.

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