PAPER NO. PNW 80-105

VEGETABLE OILS -- RENEWABLE FUELS FOR DIESEL ENGINES

by

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For presentation at the 1980 Annual Meeting
of the PACIFIC NORTHWEST REGION-ASAE

Great Falls, Montana
October 1-3, 1980

SUMMARY: Sunflower, safflower and winter rape have been evaluated for suitability as substitutes for diesel fuel. Performance data taken from a laboratory test stand is presented. Endurance testing is in progress.

American Society of Agricultural Engineers
St. Joseph, Michigan 49085

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VEGETABLE OILS--RENEWABLE FUELS FOR DIESEL ENGINES

Beginning in December of 1979 vegetable oils, specifically sunflower oil, safflower oil and winter rape oil, have been tested as diesel fuel substitutes for use in agricultural diesel engines. The tests have included: A. a 52-hp Ford 4600 3-cylinder diesel tractor, B. a 172 cubic inch displacement diesel engine connected to an electric dynamometer, C. two Yanmar single cylinder diesel engines connected to electric generators.

A. The 4600 Ford tractor is a demonstration unit which was first used with small amounts of a 50 percent sunflower oil - 50 percent diesel fuel mixture to demonstrate that the engine would continue to run with little or no loss in power. In June, 1980 the tractor main tank was filled with 100 percent safflower oil and has been operated only on 100 percent safflower oil since then. It has been used on the University of Idaho Plant Science Farm and has accumulated approximately 80 hours. No modifications have been made to the tractor or to the other engines mentioned here to use the vegetable oils for fuel.

B. The 4-cylinder diesel engine has been used on a laboratory dynamometer to measure engine performance of vegetable oils alone and in mixtures with diesel fuel. The data in the attached tables were obtained from the laboratory tests. Power output of the engine is essentially the same when operating on the vegetable oils; if anything, a slight increase in power has been measured. Fuel economy is also very nearly the same. Vegetable oils are heavier and have less energy per pound; therefore, the weight of fuel used per hour increases. Fuel use in gallons per hour remains the same. Fuel use versus horsepower output for 100 percent sunflower oil and diesel is shown on the attached tables. The data is typical of that measured for the other oils.

C. The two Yanmar single cylinder diesel engines are being run to test long-term effects of using the vegetable oils. One engine is being operated on diesel, the other on 100 percent safflower oil. The engines had been running for 700 hours when the engine fueled by safflower oil broke a fan belt causing premature shut down. It also suffered a rocker-arm failure. These problems may or may not be related to the vegetable oils. Additional testing will be required before use of vegetable oils alone or in combination with diesel fuel can be recommended for general use.

Oil Analysis

Analysis of the engine oil was conducted at four intervals during the operation of the Yanmar endurance engines. The analysis was performed by a commercial laboratory. The engine operated on safflower oil had high iron and copper readings at the first test (60 hours) which continued during the other tests. These high readings were evidently due to the wear on the rocker arms. Oil viscosity and oxidation remained the same except for the analysis at 600 hours when both oxidation and viscosity increased, probably due to overheating the engine which occurred when the fan belt broke. Oil analysis appears to be a good tool to use with the endurance engines. Triple samples from each engine were used with the results being very close.

Emissions

Emissions, specifically HC and NO_x were measured on the laboratory engine. A Beckman Model 109A portable hydrocarbon analyzer and a Beckman NO/NO_x Model 951 analyzer were used. This equipment is suitable for exhaust analysis on spark ignition engines but is not recommended for diesel engines. Hot gas analysis instrumentation is required. Consequently the results are only indications. The hydrocarbon analysis was quite variable with apparently higher HC levels at the higher percentages of vegetable oil. Nitric oxides were essentially the same throughout the tests. Additional work on emissions will be pursued.

Future Work

An oil expeller has been purchased for the University of Idaho by Brocke and Son's, seedsman at Kendrick, Idaho. This equipment will enable the project to pursue on-farm production of the oil-seed crop. Including crop production, oil extraction, oil utilization, meal utilization and economics. If vegetable oil is to economically replace diesel fuel, the meal must be utilized as a feed and the processing costs must be minimized.

Additional endurance tests are needed to evaluate the long term effects of the vegetable oils, especially on-farm processed oils, on diesel engines.

An interdisciplinary approach to studying the problems associated with vegetable oils as a diesel fuel substitute should hasten the day when they may be used with confidence and should help make many of our farmers and ranchers truly energy self-sufficient.

Preliminary Data Sheet
Research Project No. 706-H787

Department of Agricultural Engineering
University of Idaho

DIESEL ENGINE PERFORMANCE TESTS WITH VEGETABLE OIL AS A FUEL

Personnel: C.L. Peterson, K. Hawley, and R. Peterson

Location: Gauss Mechanical Engineering Laboratory
University of Idaho

Engine: 172 Cid Ford 4 cylinder; 2200 rated rpm

Date: Data is average of tests from July 18 and July 23, 1980 and is not corrected for ambient conditions

FUEL TYPE	HORSEPOWER	FUEL #/HR	FUEL GAL/HR	BSFC* # HP-HR	BSFC* HP-HR GAL	EXHAUST TEMP. °C	BTU's #	THERMAL EFFICIENCY %	FUEL WEIGHT #/GAL
100% Sunflower	39.6	22.32	2.90	0.564	13.65	660.4	16977.9	26.6	7.70
75% Sunflower	40.0	22.56	2.99	0.563	13.40	667.1	17564.2	25.7	7.55
50% Sunflower	40.5	22.36	3.02	0.552	13.41	670.6	18174.3	25.3	7.40
25% Sunflower	39.7	20.96	2.89	0.528	13.74	659.2	18809.7	25.6	7.25
DIESEL	39.5	20.84	2.94	0.527	13.47	662.7	19471.8	24.8	7.10
100% Safflower	39.4	21.57	2.87	0.560	13.73	659.3	17000.0	26.7	7.70
75% Safflower	40.0	22.24	2.95	0.557	13.57	665.7	17581.1	26.0	7.55
50% Safflower	40.0	21.64	2.92	0.541	13.65	658.7	18185.8	25.8	7.40
25% Safflower	39.8	21.20	2.92	0.532	13.62	663.8	18815.5	25.4	7.25
DIESEL	39.0	20.65	2.90	0.530	13.42	661.0	19471.8	24.6	7.10

*BSFC is Brake Specific Fuel Consumption and is a measure of work output per unit of fuel used.

NOTE: The water coolant temperature remained a constant 85° C ±1.0° C throughout the tests.

Preliminary Data Sheet
Research Project No. 706-H787

Department of Agricultural Engineering
University of Idaho

DIESEL ENGINE PERFORMANCE TESTS WITH VEGETABLE OIL AS A FUEL

Personnel: C.L. Peterson, G. Wagner and D. Hanson

Location: Gauss Mechanical Engineering Laboratory
University of Idaho

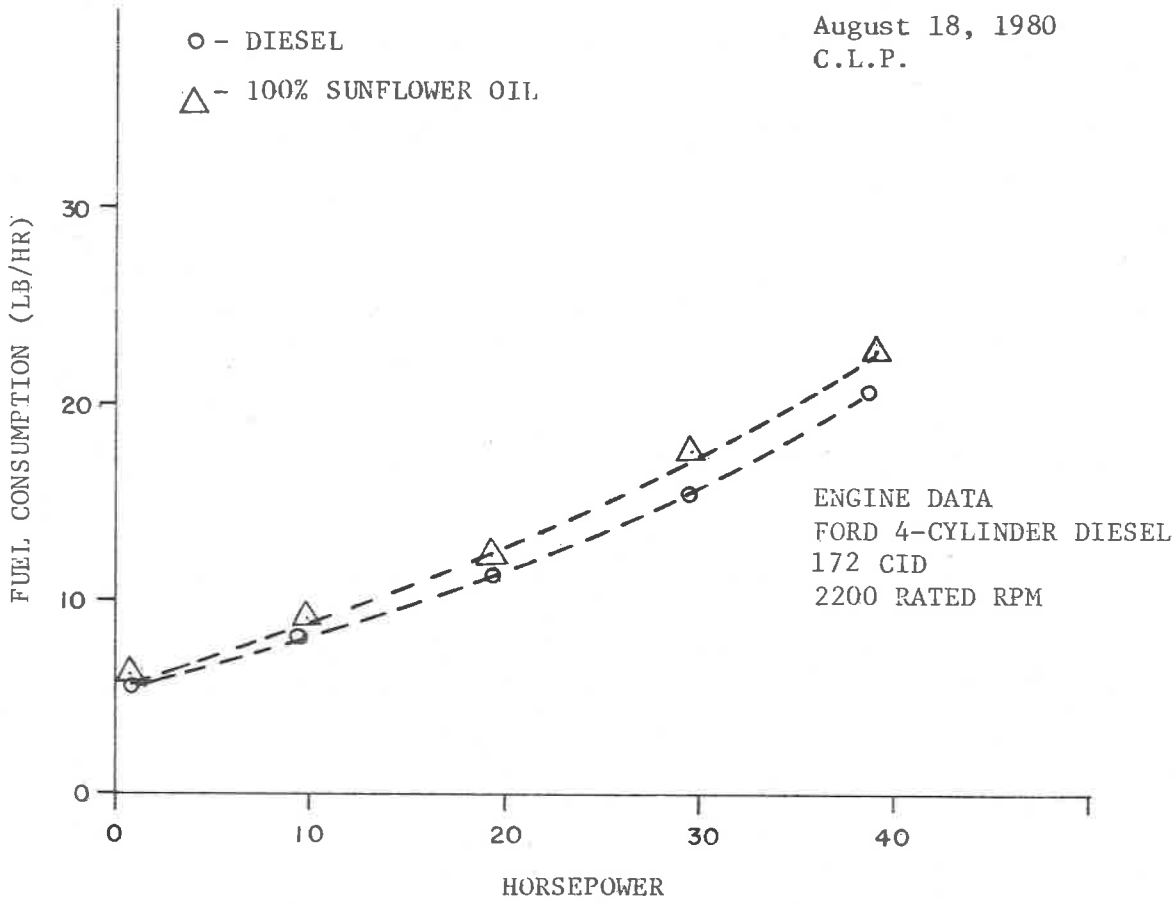
Engine: 172 Cid Ford 4 cylinder; 2200 rated rpm

Date: Data from tests September 10, 1980 and is not corrected for ambient conditions

FUEL TYPE	HORSEPOWER	FUEL		BSFC*		EXHAUST TEMP. °C	BTU's / #	THERMAL EFFICIENCY %	FUEL WEIGHT #/GAL
		#/HR	GAL/HR	# / HP-HR	HP-HR / GAL				
100% Winter Rape	38.75	21.36	2.81	0.551	13.80	692	17164	26.9	7.60
75% Winter Rape	39.45	22.80	3.05	0.578	12.93	704	17700	24.9	7.48
50% Winter Rape	39.69	22.56	3.06	0.568	12.97	715	18279	24.5	7.35
25% Winter Rape	39.19	21.84	3.02	0.557	12.98	710	18852	24.2	7.23
DIESEL	37.77	20.53	2.89	0.544	13.07	690	19472	24.0	7.10

* BSFC is Brake Specific Fuel Consumption and is a measure of work output per unit of fuel used.

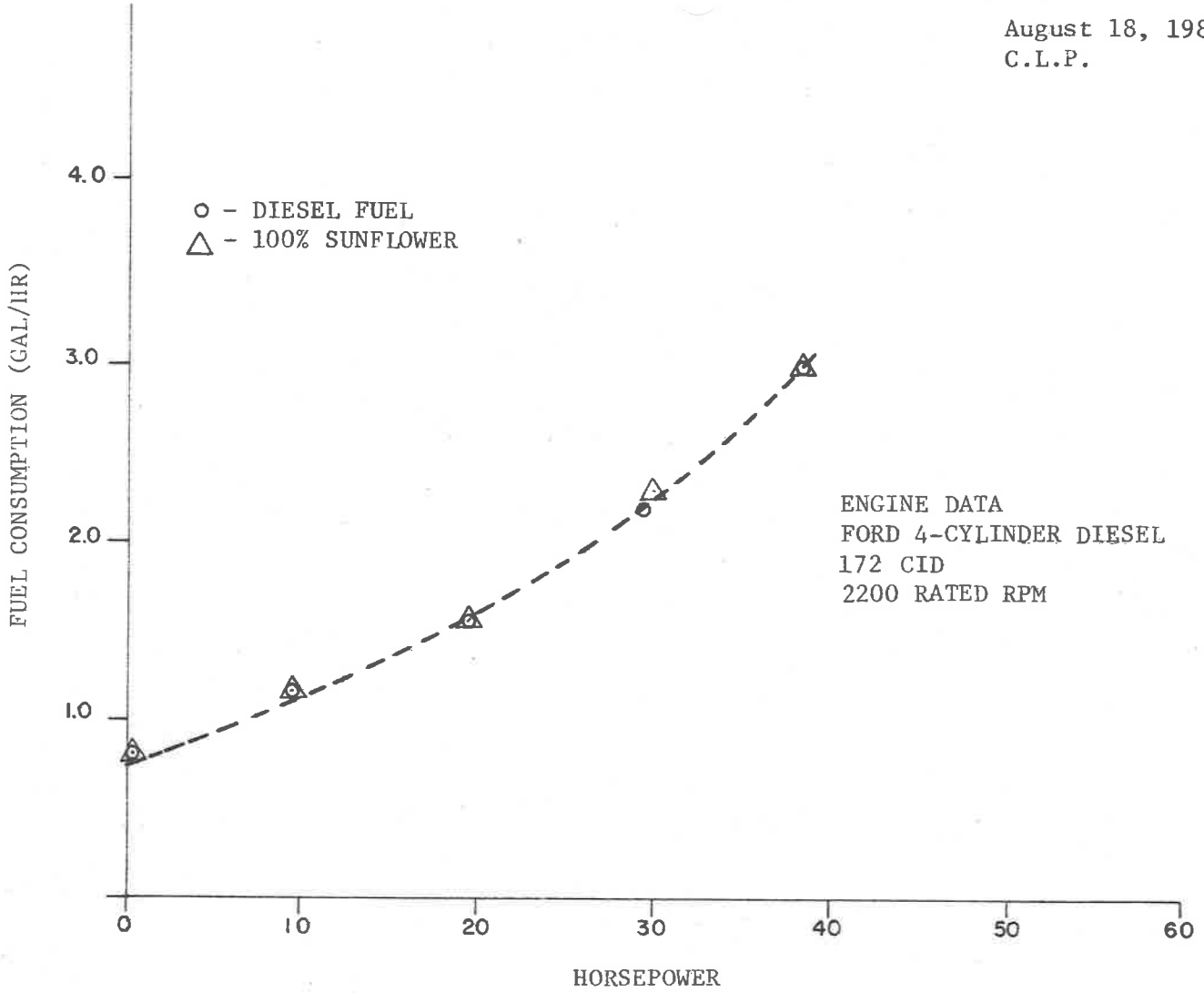
NOTE: The water coolant temperature remained a constant 84° C ±1.5° C throughout the tests.



DIESEL ENGINE PERFORMANCE TESTS WITH
VEGETABLE OILS AS A FUEL

NOTE: TESTS ON 100% SAFFLOWER OIL AND 75%, 50% AND 25% MIXTURES OF DIESEL FUEL AND THE VEGETABLE OILS WERE ALSO RUN. ALL OF THE DATA IS WITHIN THE INDICATED LINES AND CONSEQUENTLY WERE NOT PLOTTED SEPARATELY.

August 18, 1980
C.L.P.



DIESEL ENGINE PERFORMANCE TESTS WITH
VEGETABLE OILS AS A FUEL

NOTE: TESTS ON 100% SAFFLOWER OIL AND 75%, 50% AND 25% MIXTURES OF DIESEL FUEL AND THE VEGETABLE OILS WERE ALSO RUN. ALL OF THE DATA IS SO CLOSE TO THE INDICATED LINE THAT THE POINTS COVER EACH OTHER AND CONSEQUENTLY ARE NOT PLOTTED SEPARATELY.

The kinematic viscosity for five vegetable oil and diesel fuel mixtures.