RAPESEED OIL AS DIESEL FUEL AN OVERVIEW

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Abstract

For more than a decade, Idaho researchers have been evaluating the potential of vegetable oil based fuels as a diesel substitute. The investigations began by using unmodified vegetable oils in diesel engines, then progressed to the use of modified vegetable oil through the transesterification process. The fuel production process was identified, developed, optimized, evaluated and improved. The oilseeds used for the process are from several cultivars of rapeseed developed by Idaho workers and grown locally.

At first, the main focus of fuel evaluation was on rapeseed methyl ester (RME), for which off-road engine tests have been done, including: a) short term tests on a stationary tractor engine; b) fuel performance tests on small stationary engines; c) endurance engine tests (1000 hours duration); d) durability testing of engines; e) combustion modeling of the fuel (KIVA) using the Cray supercomputer at Los Alamos National Laboratory; and f) fuel utilization in tractors used in normal farm operations. The engine tests indicate that RME is a suitable substitute for diesel fuel.

In recent months, the process of transforming rapeseed oil into a suitable fuel has been upgraded and modified. A simpler and shorter transesterification process has been developed and identified. The process uses ethanol as the other main ingredient. The washing phase has also been redesigned. Ethanol is a "better" alcohol compared to methanol because the former is derived from agricultural products, is a renewable fuel, and is relatively harmless to the environment.

Introduction

Scientists at the University of Idaho have been involved with the use of vegetable oil as diesel fuel since 1979. The current project entitled "Rapeseed as an Agricultural Fuel" involves:

Agricultural Engineering:	Process Scale-up and Engine Evaluation of Rapeseed Oil Based Fuels
Agricultural Economics:	Economic Considerations of Vegetable Oil as a Fuel
Biochemistry:	Genetic Modification of Fatty Acid Composition for Vegetable Oil Based Biodiesel Fuel
Chemical Engineering:	Production of Alcohol Esters of Vegetable Oils
Plant Science:	Increasing the Genetic Potential of New and Improved Cultivars

Objectives

1. Develop higher yielding rapeseed cultivars with fatty acid composition suitable for diesel fuel and co-products.

2. Develop more efficient and environmentally acceptable processes for converting rapeseed oil to diesel fuel and associated co-products.

3. Develop more efficient methods and technology for storing, handling and utilizing diesel fuel from rapeseed.

4. Assess economic costs and potential benefits associated with producing and using rapeseed oil as a fuel extender.

Recent Progress

Plant Science

The following cultivars have been developed at the University of Idaho resulting from past rapeseed breeding efforts: Cascade,Tri-Cascade, Bridger, Tri-Bridger, Humus, Aspen, Rebel (Auld et al., 1987a; Auld et al., 1987b; Auld et al., 1991b; Auld et al., 1991c).

Two winter B.napus selections have been identified which have high seed yield, high percentage of oil content and very high levels of erucic acid. These selections are

being increased in isolation for large scale commercial adaptation trials this coming season.

In addition, there are further 32 F_6 Canola quality selections and 28 F_6 industrial rapeseed selections which are presently under evaluation in replicated yield trials. Each of these populations have been selected for yield, oil content and fatty acid composition.

A collection (125 genotypes) of germplasm for different world growing areas was sown at three locations on summer fallow and recrop land to determine the feasibility of recrop. The most advanced lines (F_6) bulk populations were planted in Northern Idaho and seed was also sent for evaluation in Kansas and Missouri. F_1 hybrid seed from two 4 x 4 half diallels (involving both spring and winter genotypes) were produced by hand pollination as an initial test of heterosis in rapeseed. F_1 seed from 120 spring x spring Brassica napus crosses were planted in the greenhouse to provide F_2 seed for early generation cross prediction methods.

Biochemistry

A Staphylococcus aureus protein A:acyl carrier protein I gene driven by the CaMV35S promoter was transferred and expressed in transgenic tobacco. An elevated level of oleic acid and elevated total fatty acid content(in some plants) was found compared to plants transformed with the vector alone. The high oleic acid phenotype (5-20 fold in excess of the control) may now be conferred to oilseed rape.

In related research, an antisense construct against the neomycin phosphotransferase gene (nptII) was evaluated and found to be useful as a negative selectable marker for gene targeting in plants. Gene targeting will allow us to specifically modify the composition of rapeseed oil without diminishing agronomic performance. The use of the protein A:acyl carrier protein I gene with the anti-sense RNA technology developed at Idaho should provide a means to greatly enhance biodiesel production in rapeseed.

Chemical Engineering

Previous work (Caringal, 1989) has shown that rapeseed oil plus excess methanol in the presence of alkali metal catalysts react to form methyl esters plus glycerin (and unreacted methanol + catalyst). The products of this reaction separate into an ester phase and a glycerin phase with catalyst and unreacted methanol distributed between the two phases. The methyl ester has been washed with water to remove unreacted methanol and catalyst; the wash water has been disposed of as waste. It had been shown with small scale experiments that the glycerin can be purified by vacuum distillation.

The results of this work has shown that the ester/glycerin phase separation, alcoho' catalyst phase distribution, and manufacturing cost are significantly affected by:

a) Type of alcohol, moisture content, and denaturing impurities.
b) The excess alcohol ratio and type of catalyst.
c) Eighty percent of the cost of producing methyl ester is presently determined by the cost of the vegetable oil.

Agricultural Engineering

Two diesel powered pickups were started on an on-road test. One is a 5.9 Liter, turbo-charged, direct injected engine operated on 20% RME-80% D2 and the second is a 7.3 liter N.A. engine, precombustion engine operated on 20% raw rapeseed oil-80% D2. The fuel systems were modified to provide on-board fuel mixing. Heaters were installed in the vegetable oil tanks for cold weather operation. A new small-scale expression plant has also been constructed.

Agricultural Economics

While to the present vegetable oil fuels have tended to be more expensive than traditional petroleum based fuels, there may be situations or conditions in which this relationship does not hold. Two of these conditions may be when petroleum based fuels become unavailable or in short supply and when petroleum fuels cause excessive air pollution or are in some other way more harmful to the environment than the biologically based fuels. The quality and use of the meal will also have an important bearing on oil prices.

Recent Publications

Listed below are selected publications by University of Idaho researchers that relate to the use of rapeseed oil in agricultural applications:

Auld, D.L., K.A. Mahler, D.A. Erickson and P.L. Raymer. 1991. Registration of Humus rapeseed. Crop Sci. 31:

Auld, D.L., K.A. Mahler, D.A. Erickson and P.L. Raymer. 1991. Registration of Aspen rapeseed. Crop Sci. 31:

Auld, D.L., K.A. Mahler, D.A. Erickson, P.L. Raymer and J.L. Butler. 1991. Registration of "Rebel" rapeseed. Crop Sci. 31:493-494.

Bam, N.B. 1991. Process Development of Rapeseed Oil Ethyl Ester as a Diesel Fuel Substitute. An Unpublished M.S. Thesis, University of Idaho, Moscow, Idaho 83843.

Feldman, M. 1991. Optimization of a Direct Injection Diesel Engine for Operation on Winter Rape Methyl Ester. an unpublished M.S. Thesis, University of Idaho, Moscow, Idaho.

Feldman, M.E. and C. L. Peterson. 1992. Fuel Injector Timing and Pressure Optimization on a DI Diesel Engine for Operation on Biodiesel. in Liquid Fuels from Renewable Resources, Proceedings of an Alternative Energy Conference, ASAE, St. Joseph, MI 49085-9659.

Guerra, D.J., J.B. Ohlrogge and M. Frentzen. 1987. In "Structure and Function of Plant Lipids" (Stumpf, P.K. and W.C. Nes, eds.), Plenum Publ. Corp.

Guerra, D.J., K. Dziewanowska, J.B. Ohlrogge and P.D. Beremand. 1988. J. Biol. Chem., 263, 4386-4391.

Hinman, Herbert, Thomas Hoffman and Andrew Thostenson. 1991 Enterprise Budgets for Canola Production Under Dryland Conditions in the Lincoln/Adams Area of Washington State. EB1596, Washington State Extension System, Washington State University, January 1991.

Korus, R. A., D. S. Hoffman, N. Bam and D. C. Drown. 1992. Biodiesel, Alcohol Esters of Vegetable Oil: Ethyl Ester of Rape Oil. in Renewable Energy:...Technology for Today proceedings of the 18th annual conference of the Solar Energy Society of Canada, Edmonton, Alberta.

Melfi, J. A. 1992. Economic Analysis of Rapeseed as a Crop in Idaho, MS Thesis, Department of Agricultural Economics, University of Idaho, February.

Perkins, L. A., C. L. Peterson and D. L. Auld. 1991. Durability Testing of Transesterified Winter Rape Oil (Brassica Napus L.) as Fuel in Small Bore, Multi-cylinder,DI,CI Engines. SAE paper 911764, selected for reprinting in SAE 1991 Transactions -- Journal of Fuels and Lubricants, printed fall 1992.

Peterson, C.L., M. Feldman, R.A. Korus, and D.L. Auld. 1989. A Batch Type Transesterification Process for Winter Rape Oil. ASAE Paper No. 89-6569.

Peterson, C. L., M. Feldman, R. Korus and D. L. Auld. 1991. Batch Type Transesterification Process for Winter Rape Oil. Transactions of the ASAE 7(6):711-716.

Peterson, C. L., D. L. Reece, R. Cruz and J. Thompson, 1992. A Comparison of Ethyl and Methyl Esters of Vegetable Oil as Diesel Fuel Substitutes. in Liquid Fuels from Renewable Resources, Proceedings of an Alternative Energy Conference, ASAE, St. Joseph, MI 49085-9659.

Peterson, C. L. 1992.Biodiesel, An Alternative Fuel to Reduce U. S. Dependence on Imported Oil and for Helping the Environment. University of Idaho, Agricultural Communications Center, Moscow, Idaho 83843

Vander Griend, L., M. Feldman, and C.L. Peterson. 1990. Modeling Combustion of Alternate Fuels in a DI Diesel Engine Using KIVA. Transactions of the ASAE 33(2):342-350 (ASAE Paper Award).

Withers, R. V. and J.A. Melfi. 1992. Is Rapeseed an Economic Alternative on Idaho Farms. Idaho Economics, Department of Agricultural Economics and Rural Sociology, Cooperative Extension Service, University of Idaho, Moscow, Idaho 83843.

Xiang, C. and D. J. Guerra. 1993. The Anti-npt II gene, A Potential Negative Selectable Marker for Plants. Plant Physiol. 102:287-293.

Xiang, C. 1992 The protein A:ACPI expression in tobacco and strategies for gene targeting. an unpublished Ph'D dissertation, University of Idaho, Moscow, Idaho 83843.

Zhang, Q., M. Feldman, and C.L. Peterson. 1988. Diesel Engine Durability when Fueled with Methyl Ester of Winter Rapeseed Oil. ASAE Paper No. 88-1562

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