National Program 307 Annual Report: FY 2002

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Introduction

Concerns about the security and reliability of our nation's energy supplies, about environmental degradation associated with fossil energy use, and about a struggling rural economy continue to spur interest in development of alternative, renewable sources of energy. Recent funding increases have been used to expand efforts to develop technology that will improve ethanol and biodiesel production and to initiate a program to develop plant species and management practices for sustainable production of energy crops.

Research coordination meetings were held for each component of the National Program 307 Action Plan. The purpose of these meetings was to enhance communication and coordination among ARS researchers to ensure that the research within each component is carried out as a coordinated, efficient, and productive national effort. These coordination meetings built upon the foundation established at the National Program Implementation Meeting held in 2001.

Development of biobased, renewable energy to the point where it provides a significant portion of the nation's needs is a major effort that requires the coordinated application of the skills and resources of many groups. During the past year, activities to increase partnering with others to leverage the research capabilities of ARS and to enhance the outcomes and impact of ARS research have continued. These activities have strengthened communication and partnering of ARS with other USDA agencies, with the Department of Energy and its national laboratories, with universities, and with industry.

Specific Accomplishments by Component

Component I: Ethanol

Corn with increased healthy fiber oil may improve ethanol economics. Oil contained in the aleurone cells that are part of the fiber of corn kernels (corn fiber) is rich in phytosterols. Though improved extraction processes have been developed, the cost of obtaining this healthy oil remains high. While most corn hybrids contain a single layer of aleurone cells, lines with multiple layers are available. ARS researchers in the Crop

Conversion Science and Engineering Unit at the Eastern Regional Research Center in Wyndmoor, Pennsylvania, extracted oil from several multiple aleurone lines and found that some had higher levels of phytosterols than common yellow dent corn. These findings could lead to development of corn genotypes suitable for economic extraction of corn fiber oil and that, as a result, would reduce the net cost of ethanol production.

Anhydrous ammonia reduces the cost to produce fuel ethanol. For ethanol to be more economically competitive cost of production must be reduced and valuable coproducts must be developed. ARS researchers in the Crop Conversion Science and Engineering Unit at the Eastern Regional Research Center in Wyndmoor, Pennsylvania, in cooperation with engineers at the University of Illinois, Urbana, developed new corn milling technology to lower the cost of fuel ethanol production. It was shown that brief exposure to anhydrous ammonia could reduce the steeping time required in the Quick-Germ process to recover coproducts before fermentation. The amount of ammonia used is only that needed anyway to supply the nitrogen required for yeast fermentation. A patent application has been filed. By lowering the cost to produce fuel ethanol, this technology may benefit corn growers, ethanol producers and transportation fuel consumers.

Engineered biocatalysts increase efficiency of ethanol production from biomass.

Expanding fuel ethanol production beyond that now produced primarily from corn starch will require conversion of lower cost cellulosic feedstocks. Though that conversion is now possible it is cost prohibitive. ARS scientists and engineers in the Fermentation Biotechnology Research Unit at the National Center for Agricultural Utilization Research, Peoria, Illinois used metabolic engineering to manipulate the biosynthetic pathways of microorganisms to develop a series of biocatalysts that improve conversion of biomass sugars to fuel ethanol, as well as to polylactate plastics. Strains of bacteria were developed that increase ethanol production by co-utilization during fermentation of the multiple sugars present in agricultural biomass. Other bacterial strains were engineered to efficiently produce optically pure L-lactic acid for polylactate plastics. The microorganisms developed bring the commercial production of fuel ethanol from agricultural biomass closer to reality.

Continued improvement of starch-degrading enzymes. The biggest cost of grain-to-ethanol production is the pretreatment of the feedstock to create simple fermentable sugars. ARS researchers in the Bioproduct Chemistry and engineering Research Unit at the Western Regional Research Center, Albany, California screened variants of a starch-degrading enzyme and isolated variants of the enzyme that are 200 times more reactive than the original enzyme. These enzymes are a factor of four more reactive than previously isolated enzymes. Successful development of these enzymes will enable the conversion of starch to glucose by use of lower temperatures or cold hydrolysis, thereby reducing the energy needed and associated capital and energy costs for producing ethanol.

Component II: Biodiesel

Development of a lower cost feedstock improves biodiesel economics. The successful widespread adoption of biodiesel as a motor fuel is jeopardized by its high cost relative to petroleum diesel. This is a reflection of the high cost of the refined oils traditionally used as feedstocks for biodiesel production. ARS scientists of the Fats, Oils and Animal Coproducts Research Unit at the Eastern Regional Research Center in Wyndmoor, Pennsylvania developed an efficient method to produce biodiesel from acid oil, a coproduct of edible oil refining that sells for approximately half the price of refined oils. The new technology adds value to a low value lipid while reducing the cost of producing biodiesel.

Component III: Energy Alternatives for Rural Practices

Solar pumping system provides water for remote regions. In many rural areas utility lines are not available to provide electricity to pump water from or streams and providing electrical service may be very expensive. Previous experience with solar-powered diaphragm pumping systems showed poor performance and short lifetimes. An ARS engineer with the Conservation and Production Research Laboratory, Bushland, Texas demonstrated that redesigned 100-Watt DC solar-powered one gallon per minute diaphragm-type water pumping systems operated for six years when pumping water from a depth of 90 ft. The system pumped water sufficient for 25 head of cattle. When comparing fixed panel solar systems with those having passive solar tracking, it was also found that the additional water flow obtained by use of passive solar tracking did not warrant purchase of the tracking equipment. This research shows that solar-powered diaphragm-type water pumping systems are reliable for supplying livestock needs as long as the pumping depth does not exceed 100 feet.

Component IV: Energy Crops

Genetic information to improve energy crop production. Without large amounts of quality biomass for use as feedstock for ethanol production, fuel ethanol will have limited impact on meeting the nation’s liquid fuel needs, on improving energy security and on enhancing the rural economy. Scientists at the Wheat, Sorghum and Forage Research Unit, Lincoln, Nebraska, in cooperation with the University of Wisconsin, released switchgrass germplasm that will be used to breed switchgrass cultivars for use in biomass energy production systems in the upper Midwest. It was also demonstrated that genetically modifying the lignin concentration of perennial grasses could affect plant fitness as measured by winter survival and showed the importance of monitoring cell wall changes that occur when perennials are modified by use of either conventional or molecular genetic technologies. The basic genetic information developed on switchgrass will enhance future efforts to breed high yielding energy crops.