GERMPLASM IMPROVEMENT AND AGRONOMIC DEVELOPMENT OF NEW ALTERNATIVE CROPS

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PROJECT SUMMARY

Agricultural diversification is important for achieving economic stability and future growth of agriculture. One way to achieve diversification is the development of new crops. New/alternative crops must complement instead of compete with existing traditional crops. In addition, the new crops must be able to conserve water and nutrients and help in improving the environment. The objectives of this project are to (1) acquire and characterize germplasm of promising new/alternative crops; (2) evaluate and enhance new crop germplasm for industrial materials; (3) develop basic knowledge of floral biology, seed production, and plant responses to environmental stresses; (4) develop economical production systems for new crops under various environmental and management conditions; and (5) develop methods for efficient guayule latex extraction and seed oil analyses for characterizing latex, resin, and oil properties. This research will result in scientific and popular publications on the basic biology, characteristics, production systems, and methodology for evaluating, enhancing, and growing new crops. The long-term goal is to provide high yielding germplasm of new crops that is adaptable to a variety of environments and has materials needed for industrial uses. This CRIS is the lead USDA-ARS project for breeding, genetics, germplasm collection, germplasm evaluation, and germplasm enhancement of new crops, and is the major source of the raw materials needed for pursuing related work on product development and utilization. The development of guayule as a new crop would provide relief to the 6 % of the US population with allergies to Hevea latex products. This includes 40 % of the medical workers and 60 % of multiple surgery cases. It would also develop a domestic source of latex, reducing our dependence on imported rubber. Development of additional products from the bagasse could result in additional products such as insulation, termite and wood rot resistant wood products, and a new natural gum base to use in chewing gums. Development of lesquerella as a new crop would result in a domestic source of hydroxy fatty acid, replacing castor oil imports that cost over $100 million annually. The oil would serve as base for renewable based lubricating oils.

OBJECTIVES

1. Acquire and characterize germplasm of guayule, lesquerella, vernonia, and other promising new/alternative crops.

2. Evaluate and enhance germplasm of new crops for industrial materials.

3. Develop basic knowledge of floral biology, seed production and plant responses to environmental stresses.

4. Develop economical production systems for new crops under various environmental and management conditions.

5. Develop methods for efficient guayule latex extraction and seed oil analyses for characterizing latex, resin, and oil properties.

NEED FOR RESEARCH

Description of the Problem to be Solved

The need exists for improving the economic status of the U.S. farmer and reducing the costs associated with surplus crops. In addition, improving this country's balance of payment and decreasing its vulnerability to imports of strategic industrial raw materials cannot be readily dismissed. Successful commercialization of the new crops may even lead to the export of the raw and finished products. Agricultural diversification is important for achieving economic stability and future growth of agriculture. New/alternative crops must complement instead of compete with existing traditional crops. In addition, the new crops must be able to conserve water and nutrients and help in improving the environment.

The U.S. spends over one billion dollars annually importing Hevea rubber - the only source of natural rubber for use in industry and commerce. More recently, it was discovered that a large portion of the world population has become allergic to the Hevea rubber hygienic products. These allergies can sometimes be life-threatening. Guayule (*Parthenium argentatum*) synthesizes latex rubber, which has been found to be hypoallergenic and offers an alternative to Hevea latex. Since the plant is native to the southwestern United States, cultivation of this crop could mean additional economic sources for the farmers in this region. Successful commercialization of guayule, however, depends on the identification and development of acceptable production practices and processing methods. While much is presently known about maximizing solid rubber production, little is known about maximizing latex production.

The U.S. imports over 40 million dollars of castor oil, a strategic raw material, annually for use in lubricants, cosmetics, plasticizers, protective coatings, surfactants, and pharmaceuticals. Production of castor in the U.S. is restricted because of its high level of allergic reactions and seed toxicity. Lesquerella (*Lesquerella fendleri*), a plant native to the U.S., produces a hydroxy fatty acid, which is an acceptable alternative to castor oil. Successful commercialization of lesquerella depends on the identification and development of enhanced germplasm with high seed yields, high oil content, high lesquerolic acid content, autofertility, and acceptable production practices. A large germplasm collection is being developed and evaluated for desirable characteristics at the U.S. Water Conservation Laboratory. Much work remains to be done to finish the evaluation of the collection and to transfer the desired traits into commercially acceptable lines. Information is also needed on optimizing production practices.

The oil-based paint and pesticide industries are looking for ways to reduce emissions of volatile organic compounds (VOC), which contribute to the pollution of the atmosphere. One alternative to correct this problem is to use vegetable oils high in epoxy fatty acids. Vernonia (*Vernonia galamansis*) is one of the few plants that naturally synthesizes an epoxy fatty acid, which has low volatility and good solvent properties needed in paints. Other industrial uses for the oil are in epoxy-alkyd paints, toughened epoxy resins, dibasic acids, lubricants, pesticides, and adhesives. Successful commercialization of vernonia depends on the development of germplasm with high yield and oil content, high vernolic acid content, good seed retention, uniform maturity, day neutral flower induction as well as acceptable crop production features.

Information available on the cultural management of these new crops is incomplete. Thus, additional work must be done to obtain answers before wide-scale commercial production is possible. Some examples of areas needing work are dates of planting for maximum stand establishment and yield,
seeding rates that are economical, seed treatments to ensure stands and break dormancy, planting methods that result in acceptable stands and result in maximum yields, dates of harvest for maximum yield and quality, harvesting methods that result in minimum losses, water use data for scheduling irrigations, nutrient requirements that minimize pollution and result in high yields, pest control measures for insect, disease, and weed problems, post-harvest and preprocessing studies to maximize yields and quality.

Relevance to ARS National Program Action Plan

This research involves collecting, evaluating, and enhancing germplasm of new crops, while developing planting, growing, and harvesting systems for producing a profitable crop, which contributes to the Plant Germplasm Conservation and Development National Program. Cooperative research with other scientists leads to commercial and industrial applications for new crops and new analytical methods necessary for making progress in a breeding program. Besides the primary uses of these crops, additional products such as gums, bagasse, resins, and seed meals for animal feed contribute to the New Uses National Program 306.

Potential Benefits

The development of guayule as a new crop would provide relief to the 6 % of the US population with allergies to Hevea latex products. This includes 40 % of the medical workers and 60 % of multiple surgery cases. It would also develop a domestic source of latex, reducing our dependence on imported rubber. Development of additional products from the bagasse could result in additional products such as insulation, termite and wood rot resistant wood products, and a new natural gum base to use in chewing gums. Development of lesquerella as a new crop would result in a domestic source of hydroxy fatty acid, replacing castor oil imports that cost over $100 million annually. The oil would serve as base for renewable based lubricating oils.

Anticipated Products

This research will result in scientific and popular publications on the basic biology, characteristics, production systems, and methodology for evaluating, enhancing, and growing new crops. The long-term goal is to provide high yielding germplasm of new crops that is adaptable to a variety of environments and has materials needed for industrial uses.

Customers

Customers of this research include other scientists, cooperative state extension personnel, regulatory

agencies, growers, users of the GRIN system, other federal agencies, and industry.

SCIENTIFIC BACKGROUND: Refer to 2001 Annual Report

APPROACH AND RESEARCH PROCEDURES: Refer to 2001 Annual Report

PHYSICAL AND HUMAN RESOURCES: Refer to 2001 Annual Report

Milestones and Expected Outcomes
This project is scheduled for formal review in 2002, thus only three year milestones and expected outcomes are listed.

Date	Objective 1	Objective 2	Objective 3	Objective 4	Objective 5
January 2002	New lesquerella germplasm from Mexico will be obtained and seed increased	Guayule germplasm lines will be evaluated for latex and growth	Environmental effects on guayule will be determined	New studies on water use for guayule will be started	Effects of different surfactants on latex extraction will be established
January 2003	New lesquerella germplasm from the US and Mexico will be obtained, evaluated, and seed increased for GRIN system	New lesquerella germplasm lines will be released with higher oil yields	Production system guidelines for lesquerella will be released to growers	Harvesting guidelines for lesquerella will be developed and made available to growers	New products for lesquerella oil will be developed and tested in cooperation with a commercial partner
January 2004	New vernonia germplasm will be released	New higher yielding and faster growing guayule germplasm lines will be released	Production system guidelines for guayule will be released to growers	Production system guidelines for guayule will be developed and made available to growers	New products from guayule bagasse will be developed in cooperation with industry

PROGRESS:

Great potential exists in using waste guayule material for controlling extensive and expensive wood damage caused by insects and microbes. ARS Researchers at the U.S. Water Conservation Laboratory in Phoenix, Arizona, working cooperatively with the U.S. Forest Products Laboratory and the University of Illinois, found that wood made from the waste guayule bagasse and also wood impregnated with guayule resin were shown to be resistant against termite and wood-rot fungal attacks. U.S. and International patent applications have been filed for the fabrication of guayule composite boards with biocontrol properties, and one industry group is interested in licensing the patent when granted. Use of guayule composite boards and/or resin impregnated wood products would reduce the multi-billion dollar damage caused by termites and wood rots each year, as well as reduce the use of pesticides and wood preservatives that are not environmentally friendly.

Knowing when to harvest guayule is critical for maximizing latex yields and quality. A biomonthly harvest test was conducted by ARS researchers at the U.S. Water Conservation Laboratory in Phoenix, Arizona, over a three-year period using an improved approach to the statistical analysis of harvest data. Results indicated that to optimize latex yield harvest should be done between November and April. These results will form the basis of recommendations for industry to use in determining harvesting schedules, thus maximizing yields and crop value.

Industrial users of lesquerella oil need lower costs to improve chances of commercialization of the crop and to successfully grow it in cultivation. Plant breeding by ARS researchers at the U.S. Water Conservation Laboratory in Phoenix, Arizona, has focused on improving yi9elds by mass selecting for higher oil content and seed yield and producing hybrids with higher amounts of hydroxy fatty acids. These advanced generations are significantly improved over the best lines that are now available and a new germplasm line will be release3d as a result. The new lines provide high genetic diversity for future improvements to public and private researchers and an alternative domestic source of hydroxy fatty acids presently filled by imported castor.

Improvements in seed yields of lesquerella are needed on farmers' fields for progress in commercialization. ARS researchers at the U.S. Water Conservation Laboratory in Phoenix, Arizona, in cooperation with researchers from Texas A&M University planted newly released germplasm selections on two farms in Texas and two in Arizona in Fall 2001 to compare the yields from previous grow-outs at these sites. The site with the best yields used a flat field planting methods and obtrained seed yields more than twice that of previous results using older germplasm. The results indicate that lesquerella yields have improved due to better breeding lines and agronomic practices.

Genetic diversity is needed to continue plant improvements of lesquerella. New collections were made from Arizona and Oklahoma by a cooperator from the University of Buenos Aires, and seed wasa increased and evaluated by ARS researchers at the U.S. Water Conservation Laboratory in Phoenix, Arizona, using plant descriptors. Traits related to seed and oil yield were measured. Traits from these new accessions can be used to improve L. Fendleri and its profitabiliyt as an alternative crop.

Lesquerella Breeding and Agronomy: To determine progress in greeding and agronomy of lesquerella, newly released lines were planted on two farms in Texas and two in Arizona in 2001. Farm #1 in Arizona was planted on raised beds with furrow irrigation, and Farm #2 on flat borders with flood irrigation. Germinations at Farm #1 was limited to sides and furrows of beds. A uniform stand was obtained at Farm @2. Seed yields were 1,507 kg/ha at Farm #2., compared to 950 kb/ha at Farm #1. This compares to yields of 714 to 1071 kg/ha in previous tests. Poor stands and lower yields at Farm #1 compared to Farm #2 were presumabely due to salinity on top of the beds. Results indicate that lesquerella yields have improved due to better breeding lines and agronomic practices.

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