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Program Abstracts

PLENARY SESSION

DEVELOPING POLICY SUPPORT FOR NEW CROPS AND NEW USES

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Efforts to direct the attention of funding sources toward new crops and new uses have been going on at the national level for over 20 years. To date successes have been modest and infrequent. Much of the advance in these issues has been the work of a few well-placed people, inside and outside of Washington. The history of this issue is illustrative of the political problems inherent in making changes in agriculture policy generally.

In the late l970's Congressman George E. Brown, Jr. became interested in the guayule plant as a possible commercial crop in the southwest. This interest resulted in the passage of the Native Latex Commercialization Act, mostly as a measure to please Brown, who served on the House Agriculture Committee.

Following the passage of the Native Latex Commercialization Act, Rep. Jamie Whitten became interested in this work and put modest funding into the Agricultural Appropriations bills. In the l98l and subsequent Farm Bills, work was undertaken to widen the scope of the new crop work beyond the southwestern crops that got Rep. Brown started on his work. At the same time, the Corn Belt members were interested in opening up more non-food/feed markets for corn and Rep. Madigan was provided support from the ARS lab in Peoria, IL that was involved in alternative uses of ag commodities. In the Senate, Sen. Harkin was interested and the result of this was the AARC. This involved a broader political base, but also involved some tension between the new crop and new use communities. Most recently, work was undertaken to put in place a comprehensive program on new crops through the Thomas Jefferson Initiative for Crop Diversification.

Most Members of Congress are not interested in new crops - the existing commodity organizations are not carrying the message and the "new crops community" has its hands full finding research funding with little time left for political organization. But it does not take much work - just a few key placed champions. The modest success to date illustrates that.

The problem has been to find a political lever to move flat funding for ag research into new programs. Ways must be found to overcome the fact that existing research constituencies feel threatened by new programs and there is internal resistance. At the same time, connections to existing political constituencies must be exploited - namely connections to the commodity organizations. The geographic distribution of programs and efforts has to be exploited in political terms. Finally, some connections must be drawn to higher-profile public issues, such as biodiversity. The challenges faced in this area are high, but the existence of the organizations and individuals at the October meeting is testimony to the successes to date.

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FEDERAL PROGRAMS IN BIOBASED PRODUCTS

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Periodically there is renewed emphasis in the US on what in the past has been called "new uses." This usually occurs when supplies of basic commodities are high and prices are low. For at least the last ten years we have been experiencing one of these cycles. Whether or not this is "just another cycle" remains to be seen. However, several things are happening which would indicate the "movement" is picking up momentum and will be sustained this time.

The 1990 Farm Bill contained a provision to create a venture capital entity inside USDA to commercialize industrial uses for biobased products. Although Congress refused to continue to fund the Alternative Agricultural Research and Commercialization Corporation for 2000 many parts of the portfolio are still performing and an effort is underway to set up a private corporation utilizing the assets of the AARCC.

Executive Order 13101, *Greening the Government Through Recycling and Waste Prevention*, is the document which is the controlling authority for a whole series of environmental orders from the White House. This September 1998 document is significant because for the first time the phrase biobased industrial products is used in the same breath as recycled products. USDA is still in the process of preparing a list of biobased products for suggested purchased by federal procurement officials as called for in the E.O.

August 12, 1999, President Clinton signed Executive Order 13134, *Developing and Promoting Biobased Products and Bioenergy.* Again, there was recognition at the highest levels that this industry is indeed alive. For the past year I have served as the USDA Director of the Bioproducts and Bioenergy Office, the staff office set up to support the E.O. A report to the President on the state of the industry should be sent forward by the end of the fiscal year as well as a Strategic Plan.

On June 20th, the Biomass Research and Development Act of 2000 was signed into law. The act authorizes $49 million in additional funding for USDA, establishes a Biomass R & D Technical Advisory Committee and a Biomass R & D Interagency Board to coordinate and oversee activities related to the legislation. These replace similar bodies put in place by E.O. 13134.

In 1999, for the FY2001 budget cycle, USDA's many agencies dealing with biobased products put together a unified USDA budget which was $46 million "above the line." That is, new money was requested. At this time it does not appear that Congress will honor that request. In any event, a similar unified budget is being prepared for the FY2002 budget.

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COMPOSITE MATERIALS FROM AG RESOURCES

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The demand for building materials and the dwindling supply of whole lumber has resulted in significant growth in the wood composites arena for many decades. No longer are roofs made with tongue-and-grove boards, but rather from plywood and the more recently developed oriented strand board. While structural building materials must possess inherently high strength, many indoor products do not require such high performance properties.

Each year, large excesses of crop residuals are produced across the United States and many are suitable building blocks from which to produce composite systems. When blended with appropriate adhesives and cured appropriately, strong, water-resistant composites are created. In addition, these materials offer an advantage over traditional lumber sources by providing fibers that can improve the physical properties of a composite through entanglement.

While the inherent strength of wood is higher than ag residues, their blends create hybrid systems with an array of physical properties. Through the incorporation of ag resources, new composites are created with properties tailored for specific end uses. For instance,

blending a lower density ag material with wood produces a composite with an overall density lower than that achievable by the wood alone.

Through better utilization of ag resources, many alternative materials can be employed in unique ways that improve our society. In particular, the search for composite materials made principally from ag materials is at an all time high, and will be the subject of this discussion.

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ADVANCED NETWORKS IN THE DEVELOPMENT OF AGRICULTURAL FIBER BASED INDUSTRIES IN NORTH AMERICA

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AgroTech Communications, Inc. is utilizing an advanced, database driven internet site called AgFiberTechnology.com, combined with several field activities including agricultural demonstrations and an annual conference, to generate and disseminate pertinent, action oriented market data concerning the use of agricultural fibers in a variety of industrial applications. This information and the network created through AgFiberTechnology.com is being utilized to create commercialization ventures among agricultural entrepreneurs throughout North America.

Fibers from agricultural crop residues can be used to make a variety of products including feedstocks for chemicals and fuels, biomass for energy production, fiber for construction materials and specialty pulps, to name a few. According to Monsanto Company,[1] the following crop residues are currently available.

	U.S. Tons	World Tons
Corn Stover	44 M	218 M
Rice Straw	3 M	360 M
Wheat Straw	76 M	600 M
Sugar Cane	4 M	102 M

Bast fiber crops including industrial hemp *Cannabis sativa L*, kenaf *Hibiscus cannabinus*, roselle *Hibiscus sabdariffa*, and sunn hemp *Crotalaria juncea*, are currently being utilized in a variety of products such as replacements for glass fiber in automobile composites, high quality animal bedding products, specialty pulps, industrial textiles, and assorted nonwovens. Energy crops such as switchgrass *Panicum virgatum* and miscanthus *Miscanthus* X *giganteus* are being researched by the United States Department of Energy as potential sources of domestic fuel.

[1]Hunt, Ken, Cellulose Conversion & Fiber, Proceedings of the 1999 Ag Fiber Technology Showcase

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OILSEEDS 1

PROSPECTS FOR INDUSTRIAL UTILITY OF GENETICALLY ENHANCED OILS

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Interest is growing in using plant oils as renewable sources for various industrial products. The utility of such oils for use in industrial materials is enhanced when the chemical composition of the oil better meets the end use needs. Progress has been made in breeding plants for oils with superior chemical compositions for various purposes. This process of tailoring the chemical composition of vegetable oils for particular end uses is being greatly enhanced and accelerated by modern techniques of genetics and biotechnology. The ability to enhance the chemical composition is aided by advances on both of these fronts. First it is becoming ever more practical to clone genes that encode enzymes catalyzing unique chemical reactions from anywhere in nature. Second great progress has been made in the genetic engineering of oilseeds regenerated to whole fertile plants for carrying out this unique chemistry. For example genes have now been cloned that encode enzymes catalyzing hydroxylations, epoxidations, conjugations and acetylenations from various plant sources. These genes can be placed in productive oilseeds and expressed only at the time of oil accumulation in developing seeds. They can effect the seed-specific accumulation of these unusual fatty acids but accumulation in triacylglyceride has generally been limited to 10% or less. This is apparently due to the lack of specificity of triglyceride biosynthetic enzymes for the unusual fatty acids. Progress is being made in engineering oilseeds for accumulation of unusual fatty acids such as epoxy fatty acids specifically in the triacylglyceride.

Altering the mix of fatty acids normally present in vegetable oils is even more advanced. For example a single genetic change can produce soybeans with > 70% oleic acid. This greatly increases the utility of soybean oil for lubricant applications. This can be further enhanced by accumulation of shorter chain monounsaturated fatty acids.

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DEVELOPMENT OF A VEGETABLE BASED FUNCTIONAL FLUID USING ESTOLIDE TECHNOLOGY

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USDA-ARS-NCAUR

Biodegradable functional fluids are finding acceptance within the market place, particularly in specialty applications and Europe where stricter environmental standards are in place. Vegetable based fluids fill a part of these markets but often fail to meet all of the rigors that the application requires. In particular, vegetable based fluids have suffered from poor oxidative stability, high pour points and are expensive when compared to their mineral oil based counterparts. Additive packages have made small improvements in the vegetable based materials properties but with increased cost of manufacture.

Estolides that are derived from vegetable sources have shown a strong promise of greatly enhancing the physical properties of a vegetable based material without costly additive packages yet maintaining the biodegradability of the material. Vegetable oils typically have pour points near -10°C and with additives can be stretched to -20°C. Costly derivatives of vegetable oils such as TMP trioleates have improved pour points from -20 to -450°C. Estolides which cost approximately $0.11 - $0.15 to manufacture from fatty acids give pour points from -30 to -41°C without additives.

Estolides were compared directly to 11 current mineral oil based crank case lubricants on the store shelf. Only two commercial motor oils outperformed the estolide in pour point (pour point of -42 and 45°C). Both of the commercial oils were derived from synthetic esters with retail prices near $4.00 per quart compared to the estolides estimated cost of $1.59 per quart. The pour point range of the non-synthetic commercial oils was -21 to -36°C with a price range of $0.94 - $1.37 per quart.

The estolides were found to have good wear properties with four ball wear scars of 0.365- 0.391 mm compared to high oleic sun flower of 0.652 mm. Viscosity index of the estolides is high with VI of 182-200 compared to the commercial mineral oils of 132 to 170.

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SYNTHESIS OF FATTY COMPOUNDS CONTAINING AN ISOXAZOLINE HETEROCYCLE

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USDA-ARS-NCAUR

The 1,3-dipolar cycloaddition reaction between a nitrile oxide and an alkene has been known for many years, and provides convenient access to the five-membered heterocyclic ring system known as D^2-isoxazolines. Because nitrile oxides are highly reactive and dimerize to furoxans readily, they are usually generated *in situ* in the presence of an olefinic substrate. One method commonly employed to generate nitrile oxides is by converting an aldoxime into its corresponding hydroxamic acid halide with the use of a halogenating agent. Subsequent base catalyzed dehydrohalogenation of the hydroxamic acid halide generates the desired nitrile oxide which is trapped by an olefin. This two-step process is typically performed in one-pot, may be easily scaled-up, and can be performed cheaply utilizing household bleach as the halogenating reagent, readily available water insoluble aldoximes, and unsaturated alkyl esters.

Recently, interest in isoxazoline heterocycles has increased markedly because of reports describing their pharmacological properties, and because they represent synthetically versatile intermediates that can readily undergo further transformations, e.g. alkylation, dehydrogenation, or reductive cleavage to expose functionality such as b-hydroxy ketones, or g-amino alcohols. If vegetable oil derived isoxazolines could be readily synthesized, this moiety could be utilized to simply functionalize these oils into potentially useful intermediates.

The aldoxime method was examined as a practical method into fatty acid ester isoxazolines from unsaturated fatty acid ester derivatives. The one pot biphasic reaction of aldoximes with aqueous sodium hypochlorite gave their corresponding hydroxamic acid chlorides, which subsequently reacted in the presence of triethylamine to generate nitrile oxides *in situ*. The derived nitrile oxides underwent 1,3-dipolar cycloaddition reactions with the olefinic substrates such as methyl 10-undecenoate to give fatty ester D^2-isoxazoline heterocycles. Good yields and excellent regioselectivity were obtained when methyl 10-undecenoate, was used as the olefin. The isoxazolines obtained from these reactions have been reductively cleaved to obtain b-hydroxy ketones in excellent yields. Currently, vegetable oil derived disubstituted olefins, such as methyl oleate and methyl linoleate, are being examined for their ability to undergo these 1,3-dipolar cycloadditions. The straightforward synthesis of D^2-isoxazolines, their potentially interesting properties coupled with their synthetic versatility make them an interesting class of compounds, and further research should make this methodology an attractive way to functionalize vegetable oils.

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IRRIGATION, PLANTING DATE, AND WEED CONTROL METHODS FOR *Euphorbia lagascae* SEED AND OIL PRODUCTION

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Euphorbia lagascae seed contains large amounts of vernolic acid, a C:18 epoxidized fatty acid with potential application in the paint and coatings industry. We are studying euphorbia because it is drought-tolerant and seems well adapted to the warm, dry, Mediterranean climate of SW Oregon. For this study we examined the effects of agronomic practices such as planting date, irrigation, and post-emergence herbicides on plant growth and maturity (including herbicide tolerance), seed yield, oil content, and post-harvest crop regrowth.

The irrigation X planting date study used three irrigation rates (zero, low, and high) and three spring planting dates (March 19, April 9, and April 27). Irrigation in all plots ended on or before June 25. Seed was direct-harvested with a Hege 125C plot combine on August 27. Seed yield for the high irrigation rate was significantly greater than the yields for low and zero irrigation. However, harvesting the seed from the high irrigation treatment was very difficult due to stem greenness, large amounts of stem latex, and increased weeds. Seeds were more uniformly mature in the low and zero irrigation treatments, and were much easier to harvest. Seed yield of the March 19 planting date was significantly greater than the April 9 planting, which itself was significantly greater than the April 27 planting date. Irrigation increased seed yield more for the early planting date than the last date, indicating that for an April 27 planting the season was too short at this location to allow for full maturity, and that added irrigation in the early summer is only of small benefit if seed is not planted until late April.

After harvest (cutting to within 5 cm of the soil surface followed by no management of any kind), there was a striking difference in the survival and regrowth of the *Euphorbia* (measured on November 8). There was no regrowth from the March 19 planting date for any of the irrigation treatments. There was a little regrowth from the high irrigation treatment for the April 9 and 27 planting dates, as well as the medium irrigation treatment for the April 9 planting date. There was profuse and vigorous regrowth for the zero irrigation treatment for the April 9 and 27 planting dates, as well as the low irrigation treatment for the April 27 planting date. It appeared that plants grown under the greatest moisture stress (less irrigation, later planting) set seed and finished their life cycle during that stress and were somehow triggered to begin vegetative growth again once cooler temperatures and available moisture returned in the fall. Plants grown under the least moisture stress (irrigated and/or planted earlier) set seed and finished their life cycle under less stress, and were somehow not triggered into vegetative growth again in the fall. These observations (though their cause is not understood) may have implications for managing euphorbia as a perennial crop in areas where re-planting may be difficult or rotation options are minimal.

The herbicide tolerance study used 16 post-emergence materials (some at more than one rate). Vegetative tolerance was evaluated 14 and 29 days after spraying, and seed yield was measured at harvest. Vegetative damage after 14 days was unacceptably high for 2,4-D, bromoxynil, oxyfluorfen, and picloram. Damage was negligible or very low for imazethapyr, DCPA, ethofumesate, alachlor (low rate only), bentazon, acifluorfen, chloridazon, and clopyralid. Damage from other materials was visible, but tolerable. After 29 days the relative damage from the herbicides was similar to that at 14 days, except for: bentazon and ethofumesate, whose damage increased somewhat into the visible, but tolerable group, and for: metsulfuron, imazapyr, alachlor (both rates), and imazamox, whose visible damage decreased to either very low or zero. Dicamba remained in the visible, but tolerable damage rating group on both dates. By 29 days after spraying the plants treated with bromoxynil and 2,4-D appeared dead or nearly so, and plants treated with picloram and oxyfluorfen were heavily damaged.

In general, the plants showing the least vegetative herbicide damage produced the highest yields, and vice-versa. Exceptions where moderate to high damage occurred along with surprisingly high yield included: oxyfluorfen and bromoxynil. Exceptions where low damage occurred along with moderately low to very low seed yields included: DCPA, imazethapyr, imazamox, and imazapyr.

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DEVELOPING MANAGEMENT CRITERIA FOR THE PRODUCTION OF CUPHEA IN THE NORTHERN CORN BELT

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The manufacturing of many industrial chemical products relies on medium-chain fatty acids derived from petroleum and coconut (*Cocos nucifera* L.) and palm kernel *(Elaeis guineensis* Jacq.) oils. Currently, there are no temperate-climate/short-season crops available to meet the industry's demands. However, several species in the genus *Cuphea* (plant family Lythraceae) have been found to produce large quantities of medium-chain fatty acids in their seeds, and some of these show potential for domestication. Seed of a fertile interspecific hybrid of *C. viscosissima* (native to the US) X *C. lanceolata* (native to Mexico) was obtained from Dr. Steven Knapp at Oregon State University. We are conducting a series of field and growth chamber experiments to examine basic management practices for optimizing production in the upper Midwest and exploring environmental effects on plant growth and development. A field study was initiated in the summer of 1999 to determine optimum planting date and row spacing for seed yield. Five dates ranging from April 15 to June 15 and four row spacings from 0.125 to 0.5 m wide, with a fifth spacing of 0.75 m added in 2000, are being used for this study. Due to a very limited seed supply in 1999, plots were only 1 m^2. The plots were established in a randomized complete block design in triplicate with rows running north-south for the planting date and east-west for the row spacing experiments. A row of soybean grown adjacent to each outside row of *Cuphea* was used as a border. Additional experiments were added in the summer of 2000 to examine mechanical harvest methods, harvest date and crop water use on larger plots. In the field, the time from emergence to when flowers were first visible ranged from approximately 47 to 54 days. Planting in May and harvesting in August resulted in maximum seed yield, which was as high as 1 Mg ha^{-1}. Seed yield declined as much as 27 and 56 % with earlier and later planting dates, respectively. Also, yield increased with row spacing up to 0.5 m. Wider rows resulted in greater branching and subsequent filled-pod numbers per plant. Controlled environment experiments showed that the temperature requirement for *Cuphea* seed germination was similar to that of soybean cultivars grown in this region, but only when sown at a soil depth no greater than 1 cm. A daily mean growth temperature of 15°C slowed development and reduced above-ground vegetative biomass by about 11 % at final harvest as compared to plants grown at a mean daily temperature of 21°C. However, pod fill was greater under the lower temperature regime. The development of *Cuphea* for commercial production is still at an early stage. However, our results indicate that it can be successfully cultured in cool temperate environments with short growing seasons.

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NATURAL RUBBER & RESINS 1

QUALITY CHARACTERISTICS OF GUAYULE SEED

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Recent studies have shown that guayule can be successfully direct seeded with conditioned seed and precision planting. Direct seeding can significantly lower establishment costs as compared to transplanting. High quality seed is essential for direct seeding, and an efficient seed cleaning system must be developed. A study was initiated in 1999 at the Texas A&M Agricultural Research Station near Pecos, Texas to: (1) harvest seed from three, two-year-old guayule lines in Spring (June) and Fall (November), (2) evaluate existing seed cleaning techniques, and (3) document seed quality parameters (1,000 seed weight, seeds/g, and seed germination). Seed were hand-harvested from lines N6-5, P3-1, and CAL-6 in June and November 1999. Preliminary cleaning involved passing the unthreshed seed through a 6 mm by 6 mm square hole screen and a No. 16 round hole hand testing screen to remove leaves, inflorescence stalks, and other trash. The achenes were then separated from their enclosing structures by threshing in a Forsberg Burr Clover Huller. Final cleaning was accomplished with the Clipper Office Tester using a combination of vibrating screens and air flow. Cleaned seed was separated into three quality classes depending on size, weight, and amount of trash. The trash was then removed from each sample by hand. Laboratory germination was determined by placing 50 seeds of each quality class in separate petri dishes (with four replications) maintained at room temperature and under constant fluorescent light of 6500 lm/m2 intensity for 11 days.

CAL-6 yielded the greatest amount of unthreshed, field-harvested seed/plant as compared to N6-5 and P3-1. The yields for CAL-6 averaged 6.1 and 3.2 g/plant at the November and June harvests, respectively. Generally, the greatest amount of seed produced by all lines occurred at the November harvest. The highest percentage clean seed obtained was 6.5% with CAL-6 (2.3 % 1st quality, 0.6% 2nd quality, 3.6% 3rd quality). Seed weights were greatest with 1st quality seeds at the November harvest. In most instances, seed germination was higher in seeds collected in June versus November.

Seed cleaning equipment has been established at the New Mexico State University Leyendecker Plant Science Research Center. The seed cleaning technique is being scaled-up to accommodate commercial-size seed lots. The procedure must be refined to effectively clean the 2nd and 3rd quality seed which is probably lost in available commercial cleaning operations.

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HERITABILITY ESTIMATES OF GROWTH AND YIELD PARAMETERS IN GUAYULE

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Plant breeding in apomictic guayule, a latex producing plant, has not been as effective as predicted or desired. This is surprising since large amounts of variability have been reported in the extant germplasm for traits such as plant height, width, resin, rubber and latex contents, which have been shown previously to be major components of yield in guayule. Gain through selection is a function of heritability, which is the proportion of the total measured variance due to genetic differences among individuals in the population. This study was designed to calculate the proportion of the total measured variance due to environmental influences and the proportion due to genetic factors within and between three released germplasm lines.

Plant heights were measured at one-, two- and three-years-of-age; and resin and rubber content at two- and three-years-of-age. Broad sense heritabilities were estimated for each trait and year by dividing the variance due to different genotypes in the population by the total variance. The total measured variance is due to a combination of environmental effects upon the population and the genetic differences among members of the population. To estimate the environmental variance we used clonally propagated plants from each germplasm line. The assumption being that these plants as clones are all the same genetically. Any variance observed among the clonally propagated plants is assumed to be due only to environmental effects. To estimate the genetic component of the measured variance, we subtracted the estimated environmental variance from the total variance measured for open-pollinated progeny populations from each line, assuming that the variance among open-pollinated progeny is due to a combination of environmental and genetic effects.

In general, the variances of the means for the measured traits were lower in the clonally propagated plants compared to the open-pollinated plants. The heritability estimates calculated for each trait differed from year to year. For instance, heritability for plant height was estimated in line AZ-2 to be 0.84 at one-year-of-age; 0.47 at two-years-of-age; and 0.00 at three-years-of-age. These values imply that a large portion of the observed variation in this line is attributed to genetic differences among individuals in the first two years of growth. As the plant grows over several seasons, the environmental effects compound, masking the genetic effects, making effective selection difficult. Heritability for latex content for the same line was estimated to be 0.97 for the second year and 0.55 for the third year.

Selections for the traits measured in this study should be most effective during the first and second years of growth, with effectiveness diminishing during the third year. Most selections previous to this study were performed on plant material three- and five-years-of-age, thus suggesting one reason for the lack of significant progress through plant breeding.

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SEASONAL CHANGE IN RESIN COMPOSITION IN MEXICAN WILD GUAYULE SHRUBS

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The rubber content in guayule shrubs has been extensively studied by several authors who report content changes for different varieties, climatic conditions and seasons. On the contrary, the study of the non rubber fraction, named resin, is scarce although this fraction may play an important role on rubber biosynthesis as, apparently, part of the chemical components are used for the rubber chain building. The present paper reports on the resin variation occurring in a period of 14 months and its relationship with rubber synthesis.

Different Guayule samples were collected from four sites at two localities; three sites in the state of Coahuila (Rocamontes locality one site, and Gomez Farias locality with two sampling sites; at the valley and the hill) and one in Zacatecas (Norias de Guadalupe). Fifteen plants per site and date were randomly selected and its spread diameter measured at the field, afterwards the plants were uprooted and transported to the laboratory for morphologic measurements (dry weight, main stem diameter and plant height) rubber and resin content were determined by Soxhlet extraction; resin analysis was performed by gel permeation chromatography.

The rubber and resin mean content were similar to those previously found in wild guayule plants, 5-12% rubber and 8-12% for resin. The dry weigh of the plants ranged from 280-574 g/plant at Rocamontes, 197-359 g/plant at Gomez Farias hill, 116-342 g/plant Gomez Farias valley and 223-879 g/plant at Norias de Guadalupe. The resin analysis results and its relationship with rubber content changes will be presented and discussed in the full paper.

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OILSEEDS 2

FOUR CYCLE ENGINE TESTS OF A BIO-BASED MOTOR OIL

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Four cycle motor oils used in most automotive, home and industrial applications require a lubricant which is separated from the combustion chamber and the fuel. The oil and engine are designed to work together to reduce friction and provide power to move objects, be it motion in an automobile or water from a pump. Oilseed-based engine oils invented in 1994 have been refined, developed and are currently functionally equal to or superior to conventional petroleum motor oils. They are superior to synthetic oils in bench tests for boundary friction and produce half the volatile organic compounds (VOC's) of either conventional or synthetic oils. The oils are equivalent to SAE 10W30 petroleum but the unique properties of vegetable oils allow the motor oil to be a single weight, thereby conferring the beneficial physical properties of both.

A year-long test of these oils, derived primarily from canola, sunflower, safflower and soybeans, have shown their application in the U.S. Postal Service fleets in Grand Rapids, Waterford and Royal Oak, Michigan for the past year. In addition, private vehicles from the Michigan State Legislature, the USDA and Michigan Department of Agriculture were evaluated, giving a broad range of test conditions. All totaled, thirty-eight vehicles were included in the test. The high detergency of the oils quickly remove metals from sludge in the engines. Evaluations of metals from bearings (copper, tin and lead) show significantly reduced wear. Metals common to sludge (lead and zinc) were removed quickly. Metals indicative of engine wear (iron) were reduced by half when compared to iron content of the petroleum drain oil. Given a clean engine, wear is expected to be reduced by half, resulting in an engine which is capable of service for twice its expected life.

Tailpipe and manifold emissions results show significant reductions in hydrocarbons (averaging 38%) and carbon monoxide (averaging 54%) per vehicle. Reductions in VOC's further reduce air pollution from volatilization through the manifold. With the reduced boundary friction, vehicle mileage is expected to increase by 3-5% and observational data supports this.

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BIOLUBRICANT AND BIOFUEL FROM SUNFLOWER OIL: RECENT RESULTS

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The use of vegetable oils as fuels for diesel engines is a great tradition in France. Rudolph Diesel might had inspirited this interest. His first engine exposed 1900 in Paris could be supplied with vegetable as well as animal oils. At the beginning of the eighties a considerable amount of studies and experiments has been done on the use of vegetable oils as fuels. Two main ways of investigations were settled: the esterification of vegetable oils for non modified diesel engines, or the modification of engines fueled by non esterified vegetable oils.

Generally the combustion of non esterified vegetable oils in direct injection engines leads to some difficulties, whereas it can be even better than the one of diesel fuel in swirl precombustion chamber diesel engines.

Short and long term durability tests with sunflower oil as a fuel for cars, agricultural tractors and electrical plants were achieved. Specific consumption, power output, efficiency and exhaust gas emissions levels were compared with those of 7 vegetable oils and diesel fuel.

Sunflower oil can be a suitable biofuel, its efficiency not far from diesel fuel, indicates a good combustion process confirmed by exhausts emission levels. The quality of sunflower oil as fuel is also dependent on the process used to extract the oil.

The valorization of sunflower oil as biolubricant was tested in cars and compared to classical lubricants. This biolubricant include 70% of oleic sunflower oil. Results on engines wear are comparable to classical lubricants after 20,000 miles.

Industrial vegetable or animal oils are mixtures of straight chains fatty acids. In addition, downstream industrial processing deals mainly with the carboxylic group and the fatty chain structure remains unchanged after most of the oleochemical reactions whereas it is well known that "functionalized" chains give useful properties for lubricant applications. Heterogeneous catalysis is a good way to achieve a high selectivity under practical conditions suitable for industrial applications, especially easy separation and re-use of the catalyst.

Several reactions have been investigated for this purpose. The condensation of two fatty acids over bauxite gives fatty ketones with a high selectivity. According to the starting mixture various secondary alcohols and branched-chain wax esters are among the many possible derivatives from these ketones. Alkyl aromatic ketones are also obtained by acylation over a zeolite. Also a promising way to diversify the chain structures is the addition of small molecules to the double bond to get new branched compounds.

These examples from our results show the diversity of new oleochemicals that could be achieved by exploring the heterogeneous catalysis field.

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STUDY OF THE BIOMASS PRODUCTION AND OIL CONTENT IN MEXICAN SUNFLOWER VARIETIES

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Sunflower (*Helianthus annuus* L.) is a crop with high adaptability to different conditions of soil and climate due to its root system, which uptakes moisture from deep soil levels allowing the plant to resist extended drought periods. Considering this, sunflower is a good cropping option for agricultural producers in the semiarid lands in Mexico. At the university there is a study line for development of varieties that may be adapted to the region and this paper reports on the production of biomass, grain yield, oil and protein content of two sunflower varieties, bred at the university, and monitored through a five year period.

Seeding was performed during May-June 1993, 1994, 1995, 1996 and 1998 at the university experimental field using a random block design with two treatments and four replications. Varieties were SAN-3C and SANE-23578. Watering was applied during the vegetative and blooming stages. Rainfall and temperature was monitored during the experiment period. Plant sampling was performed at five development stages according to CETIOM scale. Six plants were sampled at each stage and transported to laboratory to evaluate each plant part and the total dry weight, plant height, head diameter and grain yield. Oil content was determined by Soxhlet extraction and the protein content by Kjeldahl.

Results show for SAN-3C that biomass production varied from 5-10 tons/ha, grain yield lye between 2-3.4 ton/ha. The maximum oil and protein content were 48% and 26% respectively. The variety SANE show values ranging 4.8-6.2 ton/hectare for biomass and 1.22-3.2 ton/hectare for grain yield. The maximum oil content was 42% and 29% for protein.

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EFFECT OF HYDROGENATION ON STRUCTURE OF HYDROGENATED SOYBEAN OIL TRIGLYCERIDES

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High pressure liquid chromatography (HPLC) was used to characterize the structures of triglycerides resulting from the hydrogenation of soybean oil under laboratory and commercial conditions. Soybean oil consists of 3 triglycerides and their isomers which account for about 50% of the total. These include trilinolein (LLL), oleyl dilinolein (OLL) and palmito dilinolein (PLL). Other prominent triglycerides present in soybean oil include linoleyl diolein (LOO) and linoleyl oleyl palmitin (LOP). Other common vegetable oils, including corn, cottonseed, sunflower and canola have similar triglyceride distribution patterns. HPLC analysis of samples taken during hydrogenation showed that the reaction takes place through definite pathways rather than by random saturation of fatty acids within triglyceride molecules. For example, at 500 psi H pressure and 120^{o}C the kinetic pattern for the 5 major soybean oil triglycerides follows the kinetic pattern:

LLL ® OOO ® OOS ® OSS ® SSS

LLO ® OOO ® OOS ® OSS ® SSS

LLP ® OOP ® OSP ® SSP

LOO ® OOO ® OOS ® OSS ® SSS

LOP ® OOP ® OSP ® SSP

At 50 psi the kinetic pattern can be represented as follows:

LLL ® OOO ® OOS ® OSS

LLO ® LOS ® LSS

LLP ® OOP ® OSP

Pressure and temperature have marked effects on the reaction products. Although HPLC will not resolve positional triglyceride isomers and the presence of *trans* isomers formed during hydrogenation affects resolution, information useful for quality control can be obtained. Application of the HPLC method to commercial margarine/spread oils, hydrogenated winterized soybean oil and margarine and shortening basestocks will be presented and the results discussed.

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INTERSPECIFIC HYBRIDIZATION OF LESQUERELLA SPECIES TO ALTER HYDROXY FATTY ACID CONTENT

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Progress in breeding to improve the hydroxy fatty acid (HFA) content in *Lesquerella fendleri* seed oil has been slow. There has been only one public germplasm release with increased HFA of a few percent above the best available lines. The problem appears to be the lack of genetic variation for the trait. Populations of L. fendleri examined from representative collections have HFA contents ranging between 49 and 56%. This is an important problem since lack of improvement prevents the cost of the oil from reaching a competitive price compared to castor, the only similar vegetable oil.

L. fendleri is the candidate species for domestication because of its many superior agronomic characteristics. This species has abundant seed yield, extensive variation for oil content, good seed retention, and is adaptable to farm production. However, other species of *Lesquerella* have much higher levels of HFA seed oil content. Species found in the wild with this type of HFA do not hybridize.

The goal of this study was to improve HFA content in *L. fendleri* through hybridization with other species. An additional benefit is to expand the region where the plant could be grown to areas where the hybrid parent is native. Three other species used in this study included *L. gracilis*, *L. lindheimeri*, and *L. pallida*. All three are from the Southwestern U.S. but extend beyond the regions of *L. fendleri* into Oklahoma and Texas. All three have HFA contents above 80%. Controlled greenhouse crosses were started in Spring of 1999.

Seed set of crosses between species were very low, ranging from 0 to 0.025%. We found that when *L. fendleri* was the maternal parent in the cross, the HFA oil content of seed from the hybrid and the material plant were very similar. When the maternal plant was another species and *L. fendleri* was the pollen parent, the HFA oil content of the hybrid was above 80%, similar to the maternal plant. We attributed this to maternal inheritance of HFA oil content.

In many cases, embryo rescue was necessary to produce plants since developing seeds otherwise aborted. Another obstacle we encountered was sterility of the hybrids, possibly due to lack of chromosome pairing during meiosis. To restore pollen production in these plants so more seed can be produced, explants were treated with a chemical called colchicine to induce polyploidy.

Once fertile plants were produced, plants were then backcrossed with *L. fendleri* so the high HFA seed oil content would remain due to maternal inheritance and more desirable traits from L. fendleri are incorporated. These plants will undergo a number of backcross generations until new generation of hybrids are produced with most of the characteristics of *L. fendleri* and the HFA seed oil of the other species. These new hybrids have the potential to reduce the price of the oil from $3 to $1 per pound.

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CHIA, A NEW SOURCE OF OMEGA-3 FATTY ACIDS: FROM RESEARCH TO COMMERCIALIZATION

Ricardo Ayerza

Bioresources Research Facility, The University of Arizona

Chia (*Salvia hispanica L.*) production and commercialization are the result of the Northwestern Argentina Regional project. The goal of the project was to identify and bring into commercial production new industrial crops which can help diversify agricultural production and increase profits for farmers in northwestern Argentina. Both private and government organizations in the USA and Argentina have been working cooperatively on this project since its inception. This technical cooperation was made possible through the Farmer to Farmer program, financed by the Congress of the USA as part of the 1990-95 Farm Bill (Public Law 480), and the USAID

Chia is a summer annual belonging to the *Labiatae* family. This species originated in mountainous areas extending from west-central Mexico to northern Guatemala. Pre-Columbian civilizations, mainly Aztecs, used chia as a raw material in making several medicines and nutritional compounds, and even paints. It was one of the main crops of the pre-Columbian societies of the region, and was surpassed only by corn and beans in terms of significance.

Chia seeds contain oil amounts varying between 32-39%, with the oil offering the highest natural percentage of g-linolenic fatty acid known (60-63%). Chia seeds have demonstrated a strong anti oxidizing activity. The most important antioxidants obtained are chlorogenic acid, caffeic acid and flavanol glycosides. Since oxidation is delayed, chia shows a great potential within the food industry compared to other g-linolenic acid sources. This essential fatty acid has been shown to exhibit significant importance in a great number of industrial compounds such as varnish, paints, cosmetology, etc., and in a number of functional foods, like egg, bread, and milk.

Although chia was an important grain during the pre-Columbian age, its cultivation decreased following America's discovery. Nowadays, in its native location, this species is limited to a few hectares, and the seeds are using only to prepare a local drink called "chia fresca."

The R&D project included determination of new production areas, and modern products and practices aimed at bringing chia to the market as a new product. Today, as a result of the project, a number of farmers grow chia in Argentina and Bolivia on a regular basis. The possibility of producing this crop in two different and distant areas (not usual for new crops) decreases climatic and political risks, and avoids concentrating the delivery season.

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NATURAL RUBBER & RESINS 2

EVALUATION OF GUAYULE GERMPLASM FOR AGRONOMIC AND LATEX CHARACTERISTICS

T. A. Coffelt[1], D. A. Dierig[1], D. T. Ray[2], and F. S. Nakayama[1]

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Latex allergies in the United States have become a serious health problem in certain population groups, such as health care workers and patients who undergo multiple surgeries. Guayule (*Parthenium argentatum* Gray) is a source of hypoallergenic latex. Higher yielding, faster growing, and easier to establish germplasm lines are needed for guayule to be successful as a new crop. The objective of this study was to evaluate the genetic variation among 20 guayule lines for agronomic and latex characteristics. The lines were transplanted at the Maricopa Agricultural Center, Maricopa, Arizona, on 6 April 1995 in one meter rows with 36 cm between plants. Survival rate and plant height were determined at one and two years after transplanting. Plant width was measured two years after transplanting. Changes in survival rate and plant height from year 1 to year 2 were calculated as well as the plant height to width ratio in year 2. Latex content, plant weight (wet and dry), chipping losses, latex yield/plant, and latex and plant biomass per square meter were determined in year 3. The check lines were 11591 and N565.

Significant variation was found among the 20 lines and two checks for all characteristics studied. While none of the lines was significantly better than the checks for all characteristics, six lines were identified that merit further study. G7-14 was the fastest growing line (40 cm tall) the first year and had the best survival rate (99%). N9-4 was the fastest growing line the second year (51 cm tall and 47 cm wide), but not significantly different from the 11591 check (55 cm tall and 46 cm wide). Two lines P3-11 (4.1%) and P10-4 (4.2%) had a significantly higher latex content per plant than either 11591 (2.4%) or N565 (3.1%). G1-16 had the highest wet plant weight (2.7 kg), and was one of the highest for dry plant weight (1.6 kg) and total plant biomass yield (2214 g/m2) of all the lines. The most promising line was N9-3, which had the highest dry plant weight (1.6 kg), weight of plant material after chipping (2.27 kg), weight of latex per plant (60.3 g), latex yield per m2 (83 g), and total plant biomass yield (2259 g/m2), as well as the lowest percentage of loss during chipping (14.8%). These results indicate that there is significant variation available in this germplasm for significant improvements in all the characteristics studied through a breeding and selection program.

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GUAYULE AS A WOOD PRESERVATIVE

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Conventional preservatives used to protect wood from insect and microbial damages are presently of major concern to human health and the environment. Finding alternative and economical preservatives has not been successful. Previous studies have shown that the resinous material extracted from the guayule plant (*Parthenium argentatum*, Gray) has both insect and microbial resistant properties.

Unfortunately, the application of guayule byproducts has not been accepted commercially because of the lack of an adequate supply of the raw material. However, the potential domestication of the guayule plant to produce hypoallergenic rubber latex will result in the production of large amounts of waste wood material. This should provide opportunity to use this natural source of the biologically resistant resinous chemicals.

The objective of this preliminary study was to determine the effects of the rubber latex-removed wood residues or bagasse and the resinous extracts on termite- and decay-resistant properties. Two types of test materials were used in the study. One was wood impregnated with organic- solvent extracted resinous material from the plant. The other was composite wood fabricated using the residue or whole plant and plastic binder, which was used to improve the physical properties of the composite. Accelerated laboratory tests were conducted to determine the resistance of the wood products against the Eastern subterranean termite and wood fungi (brown- rot). The wood and stem of the guayule plant, wood treated with the resinous extract, and particle and composite wood made from ground guayule exhibited termite and wood fungal resistance. Because the guayule plant is drought tolerant and its biocontrol products can reduce the need to harvest trees for replacing wood damage, its cultivation as an alternative crop will help conserve water and forest resources worldwide.

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IDENTIFICATION OF A CONTACT ALLERGEN IN GUAYULE LATEX AND FORMULATED GUAYULE LATEX PRODUCTS

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Guayule latex does not contain proteins that elicit an allergenic response in subjects sensitized to *Hevea* latex. However, guayule whole shrub tissue does contain varying amounts of guayulins A-D, a family of sesquiterpene esters. Guayulin A is a potent contact allergen in sensitized test subjects.

Our recent investigations using HPLC, and confirmed with GC/MS and authentic guayulin standards, have confirmed the presence of guayulins A and B in guayule latex. Furthermore, both compounds were isolated from cured, dipped films prepared from guayule latex. Guayulin A was present in the films at levels equivalent to those found in whole shrub tissue.

We conclude from these preliminary results that it is important to establish the potential for guayule latex and latex products to provoke Type IV reactions in individuals sensitized to guayulin A. For cultivars of commercial interest, the guayulin A content of latex should be profiled over time. In addition, the effects of post-harvest processing and compounding on guayulin levels should be determined.

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GENERAL CROPS 1

BARRIERS FACING ECONOMIC DEVELOPMENT OF NEW CROPS

Mark Downing

Oak Ridge National Laboratory

Many technical, as well as non-technical and institutional barriers to viable economic development of new crops have been identified. Examples of technical barriers are manufacture and development of strong and durable harvesting equipment, refinement of agricultural or forestry production management strategies to optimize yield, and reliability and availability of technically viable biomass conversion systems. These technical barriers will not be addressed here.

Non-technical and institutional barriers in this paper are segregated into two categories - markets and policy. For markets to be identified as a barrier, it may be interpreted that some type of market failure exists. This type of market failure arises from energy, agriculture, or environmental market failure. More specifically, the reasons for market failure in these three sectors of the economy may be due to presence of monopolies, distorted taxes, presence of public goods, distortion in capital markets, incomplete knowledge, and/or presence of externalities. Government intervention may be appropriate in these cases.

When policy barriers are identified, these typically are energy, agriculture, or environmental sector barriers as well. These policy barriers may lead directly to market failure. Energy policy, for example, may not provide adequate returns to private capital investment because the window of benefits does not always coincide with optimal conditions in financial and lending markets. Agriculture policy may not provide incentive to private landowners because of inadequate returns to scale on smaller farms. Environmental policy may restrict development of new crops on land currently producing crops supported by farm commodity programs. Land use restrictions or discouragement may exist with regard to cropping near easements, wetlands, or other conservation program land. Final end-use of crops may not accrue sufficient benefits, for example, in renewable energy markets due to lack of robust economic incentives regardless of the known environmental amenity improvements over the *status quo*.

The Biomass Power for Rural Development initiative by the U.S. Departments of Energy and Agriculture along with numerous financial partners has resulted RD&D projects in New York, Alabama, Minnesota, Iowa, and Hawaii. Regardless of the state, bioenergy crop being grown, or residue or waste being developed, similar issues arise peculiar to the feedstock development part of the project matrix. This paper will present non-technical and institutional barriers common and peculiar to large-scale commercial RD&D projects such as these, and provide some detail of these projects as case studies.

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NEW DEVELOPMENTS IN BAMBOO

John E. Woods

West Wind Technology, Inc.

Current research and experience with bamboo at West Wind Technology now makes available plantlets, nursery consultation and plantation management. In this hemisphere bamboo was not widely considered as a viable non-wood species for industrial uses. For the first time, the major barrier to industrial use of bamboo has now been overcome by using never before available propagation methods. Bamboo biomass feedstock can now be available by the time the processing facility construction is completed (2-4 years).

Bamboo has the following industrial uses:

1) Bamboo Shoots for food.

2) Bamboo Biomass for pulp, ethanol, and electrical energy.

3) Bamboo Fiber for construction, panels, flooring, beams, crossties, rebar.

Bamboo has the following characteristics:

1) High biomass production.

2) Harvest biannually.

3) Replanting every 25 to 120+ years

4) Mechanical harvest available.

5) Long, thin, high quality fiber for pulp and paper.

Industrial technologies from World Ecolink, Ltd. make possible efficient ethanol production from bamboo up to 160 gallons of ethanol from one dry ton of bamboo. Technology from new pulping systems allows environmentally friendly pulp production from small mills at competitive prices. New developments in composites allow bamboo to be made into many exciting products, even some without glue.

Today, markets and special arrangements with financial services allow industrial bamboo biomass projects to be developed in most any country with appropriate plantation sites. Our newest projects are being developed in Mexico, Haiti, Honduras, and Vietnam. Why not the USA?

Contact Dr. Woods at West Wind Technology, Inc., 520 Old Riceville Road, Athens, TN 37303. Phone 423-745-5087, 423-744-8689 fax E-mail: jewwwt@usit.net ; Web site http://esi.athenstn.com/wwt/wwt.html

RECENT PROGRESS WITH MIMOSA AS A MULTI-PURPOSE CROP

Bransby, David I., Teresa Morrison, Steve Duke and Gopal Krishnagopalan

Auburn University

Leguminous trees have a wide range of potential uses, including production of bioenergy, pulp and paper, and forage for animals, as well as for alley cropping. Research on short rotation woody crops for production of bioenergy in the United States has been focused primarily on hybrid poplar and willow, and relatively little of this work has been conducted in the Southeast. Furthermore, both of these species are established vegetatively from cuttings, and not from seed. Clearly, this makes establishment more expensive, and reduces genetic diversity, thus making plantations more vulnerable to diseases and pests.

In order to produce quality fine paper for use in copiers and computer printers, the short fibers from hardwood tree species are needed. In the southeastern United States these fibers are currently obtained from species like oaks, maples, sycamore and sweet gum, and the longer fibers used for newsprint are obtained from pines. While the forestry industry is replanting pine trees following harvesting, hardwoods are not being reestablished in plantations, and take 30 to 60 years to regenerate naturally. This has resulted in a situation where hardwoods are almost definitely being depleted. Additional disadvantages with the pulp and paper and forestry industries at present are the major pollution caused by pulp mills, and the long delay before economic returns are experienced, even after planting of pine trees (10 to 15 years).

One of the most important requirements for tree crops that are to be used for bioenergy or pulp and paper is the ability to produce high yields of biomass per acre. Pine, hybrid poplar and willow typically produce 3 to 7 tons of dry matter per acre annually. The potential of mimosa for energy and pulp and paper has been studied in Alabama for only 4 years. When grown in small plots with 36 inches between rows and 18 inches between plants in the row, annual harvests provided an average yield of total dry biomass of 16.6 tons per acre over a 4-year period (1996-1999), with approximately 85% of this as wood. In 2-acre fields, mimosa planted in rows 6 ft apart and 18 inches apart within rows provided yields of 5.6 and 7.9 tons of dry wood per year when harvested after 1 or 2 years of regrowth, respectively. Furthermore, these yields were achieved with no fertilization.

Fiber quality and properties of paper made from mimosa were similar to those from sweet gum, which is one of the most widely used hardwoods in the southeast. However, mimosa required less chemicals, less cooking time and less bleach to produce paper of similar quality, suggesting that its use will result in lower production costs if used alone for pulp and paper production.

We conclude that mimosa offers considerable potential as both a energy crop and a fiber crop for pulp and paper. It has several distinct advantages over species that are currently being used or investigated for these uses and, therefore, deserves further research attention.

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NEW ENVIRONMENTALLY FRIENDLY PULPING PROCESSES

Richard J. Williams

WILCOM L.L.C., Tulsa, Oklahoma

To comprehend the significance of "new environmentally friendly pulping processes", one must consider the history of making pulp for paper, the transition of raw materials from nonwood to wood and (possibly) back to nonwood, and the evolution of pulping and bleaching processes.

Pulping of non-wood fibers has been performed since the invention of paper, supposedly in China almost 2000 years ago. The widespread use of making pulp from wood began only about 150 years ago.

The pulping and bleaching processes presently in use were, by and large, not designed with consideration for the environment. Most processes must be retrofitted for compliance with current environmental awareness. The total costs of making pulp with traditional processes do not consider the social/environmental costs of the effluents of the processes.

Most current nonwood pulping facilities are outside the U. S. Most of those facilities do not properly treat their effluents, and with new environmental awareness many are being shut down.

New processes for nonwood fibers must compete economically with traditional processes even though the economic calculations are not on the same basis. That is, new processes must ALSO be environmentally friendly, in most cases at an additional cost, and most new processes are not economic successes by this measure.

On a global basis, "carbon credits" may soon force traditional processes to be converted to environmentally friendly processes. And new processes that are both environmentally friendly and economically sound will be the winners.

One such process is the WILCOM Environmentally Friendly Pulping Process, that can be build in smaller units to match the local supply of nonwood fibers, create socially acceptable coproducts of molasses and high nitrogen fertilizer, and will produce world class, Elemental Chlorine Free (ECF) bleached pulp as economically as large traditional wood pulp mills.

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MEADOWFOAM

WHERE HAVE ALL THE FLOWERS GONE? – THE STATUS OF MEADOWFOAM GERMPLASM

Daryl T. Ehrensing

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Meadowfoam (*Limnanthes spp.*) seed is the source of long-chain fatty acids with novel physical and chemical properties. After many years of cooperative effort among USDA, university researchers and growers, meadowfoam is now in commercial production in Western Oregon. Production trials are in progress in other states and countries.

The availability of a wide diversity of meadowfoam germplasm is essential to continue development of improved meadowfoam cultivars. Erratic yield and relatively narrow climatic adaptation currently limit commercial meadowfoam production. Increased biomass and seed yield, greater resistance to lodging and insects, elimination of seed dormancy, and improved winter hardiness would expand the agricultural adaptation of meadowfoam.

Natural populations of meadowfoam are widely distributed in Southern Oregon and Northern California. Current *Limnanthes* germplasm accessions represent only a small fraction of the diversity available in the genus. The USDA National Plant Germplasm System currently holds 23 accessions of *L. alba* and 31 accessions of the remaining 15 *Limnanthes* species and subspecies. Most *Limnanthes* accessions in the USDA collection have not been regenerated since entering the collection, and seed viability of accessions in the working collection appears to have degraded. The Oregon State University Center for Oilseed Research maintains 30 or more *L. alba* accessions as well as families and lines from various segregating populations. The status of UC-Davis and UC-Berkeley collections made in the 1970's is uncertain, and samples from these collections never entered the NPGS collection.

Rapid urbanization and land development are imminent threats to meadowfoam's continued existence in the wild. Many known wild populations have disappeared in recent years. Particularly disturbing is the apparent destruction of *L. alba* populations in the vicinity of Sacramento, CA which provided the original germplasm for development of the current commercial meadowfoam cultivars. In addition, the wild population that was the source of self-pollinated lines now in the OSU breeding program was destroyed by human development soon after the initial seed collection. Adequate germplasm collection across the genus is essential to preserve genetic diversity of these species in the face of rapid habitat degradation throughout meadowfoam's native range.

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PLANTING TIME AND CULTIVAR EFFECTS ON MEADOWFOAM IN VIRGINIA

Harbans L. Bhardwaj[1] and James M. Crane[2]

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Seven experiments were conducted in Virginia during 1998-99 season to evaluate effects of cultivars and planting time on meadowfoam. The performance of three meadowfoam varieties (Floral, Knowles, and OMF-78) was evaluated at Orange, Petersburg, and Suffolk by planting at different dates. Each planting time experiment was conducted separately with three replications. All plots received 25 kg/ha of nitrogen. All rows were 3 m long with 17 cm spacing between rows. At Orange, the three varieties were planted on December 18, 1998 and January 29, 1999. At Petersburg, the three varieties were planted three times (November 16 and December 21 during 1998 and January 29 during 1999). At Suffolk, the three varieties were planted on January 7 and February 1 during 1999. All plots in these experiments matured and were harvested during June, 1999. The seed yields of three cultivars varied from 59 to 281, 112 to 739, and 87 to 613 kg/ha, respectively for Orange, Petersburg, and Suffolk locations, depending upon planting time. The earlier planting times of December 18 at Orange and Nov 16 at Petersburg resulted in highest seed yields and higher oil contents. However, late planting at Suffolk (February 1 vs. January 7) resulted in higher seed yield and higher oil content. Knowles and Floral cultivars were, generally, superior than OMF78 for seed yield. The oil content in the seeds of meadowfoam produced in Virginia, during 1998-99 season, was approximately 22 percent. However, the seeds of all three cultivars when planted at Suffolk on February 1, 1999 had approximately 26 percent oil. These results indicate that meadowfoam planting times would need to be established specifically for different locations in Virginia. Details of these experiments and additional experiments conducted in Virginia during 1999-2000 season will be presented and discussed.

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MEADOWFOAM PROGRESS AND DIVERSITY

Jerry Hatteberg and Michael Martinez

OMG Meadowfoam Oil Seed Growers Cooperative and Natural Plant Products

The development of Meadowfoam as a new crop has taken tremendous time and effort by many researchers, growers, marketers, and customers, but all this work is beginning to show positive returns. The OMG growers may finally be on the launching platform to increased production and improved economic returns. The growers marketing company, Natural Plant Products, is optimistic about the rapidly growing demand for Meadowfoam Seed Oil in the cosmetics market. A 40% increase in oil sales over the last l2 months, discovery of new applications in the pharmaceutical and lubricant industries, and recent approvals to market products incorporating the seed meal left after oil extraction, all demonstrate the growing economic potential of this crop.

Research has indicated the potential for using Meadowfoam seedmeal in a variety of agricultural applications and products. These include fertilizers, growth enhancement products, as well as selective herbicides, pesticides, and fungicides. Products based on Meadowfoam seedmeal could replace synthetic products currently used in the agricultural industry. The key to unlocking this new market is gaining access to additional research and development funding. These funds would be used to carry on current projects and in the completion of all necessary approval processes.

The challenge of developing Meadowfoam as a sustainable crop with multiple benefits, is being aggressively pursued by OMG growers, Oregon State University researchers, and industry partners in a national effort to revitalize U.S. agriculture for the farming industry.

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ANTIOXIDANT FROM MEADOWFOAM STABILIZES OTHER OILS

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Natural lipids and oils are used in pharmaceutical preparations, food products, cosmetics, and various industrial products such as lubricants, coatings, inks, paints, plastics and the like. These lipids are subject to oxidative degradation which can affect color, odor, viscosity, and lubricity characteristics of the oils, adversely affecting the quality of the commercial products containing the lipids. In the food, cosmetics and pharmaceutical industries, maintaining high quality color and odor of oils and other lipids is important to avoiding oxidation-induced rancidity which is affected by factors such as the oxygen concentration, light and heat, as well as the degree of unsaturation of the lipid or oil, and the amount of natural or synthetic antioxidants present. Biodegradable lipids, oils and their derivatives that are used as cutting lubricants are recognized to be adversely affected by heat induced oxidation.

Meadowfoam (*Limnanthes alba*) seed oil has been demonstrated to be highly stable to oxidation. Mixing meadowfoam oil with other oils imparts enhanced oxidative stability to the mixture. (Isbell, T.A., Abbott, T.A. and Carlson, K.D. 1999. *Ind. Crops Prod*. 9(2):115-123). Refined meadowfoam oil (and other refined seed oils and vegetable oils) exhibit reduced oxidative stability as a result of the refining process. Meadowfoam is known to contain 3-methoxyphenylactetonitrile, 3-methoxybenzylisothiocyanate and 3-methoxybenzaldehyde. When added to refined meadowfoam oil at levels from about 0.1% to 1.0%, these compounds exhibit only small to moderate antioxidative effects, at best (Abbott, T.P. and Isbell, T.A. 1998. *Abstracts of the 89th American Oil Chemist’s Society Annual Meeting & Expo*, Chicago, IL, May 10-13, 1998. p 66).

Putting together the puzzle pieces - isolated products of oxidation, a substituted urea and $S0_2$; breakdown products found in GC-MS, 3-methoxybenzylisothiocyanate and 3-methoxybenzylamine, we realized that the precursor must be 1,3-di(3-methoxybenzyl)thiourea (3MBTU). This was synthesized and it breaks down on GC-MS to the isothiocyanate and amine, making it difficult to initially identify. Addition of 0.1% to 1.0% of 3MBTU increased the OSI time of jojoba oil from 30 to 240% and refined meadowfoam oil from 15 to 218% at 110°C. At 130°C, refined meadowfoam oil stability was increased by 234%, to 1,054%. An addition of 1% of 3MBTU to high oleic sunflower oil increases its OSI time at 130°C from 9 hr to 157 hr. Soybean oil and milkweed are increased in OSI time 8-fold and 6-fold at 130°C with this antioxidant.

Computer models of 3MBTU compared to commercially available 1,3-bis(2-methoxyphenyl)-2-thiourea show that the conformations of of 3MBTU allow easier access to the sulfur which explains why 3MBTU out performs the phenyl derivatives.

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GENERAL CROPS 2

IMPROVED WATER RESISTANCE AND FLOW OF A NOVEL, SOYBEAN PROTEIN-BASED PARTICLEBOARD COMPOSITE ADHESIVE

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Soybean protein is an ancient, versatile agricultural raw material that is available worldwide. It has a history of being used to produce non-food items such as plastics and adhesives, yet, its inherently poor water resistance has prevented soybean protein from becoming a major adhesive for wood composites, such as particleboard. The polar characteristic that contributes to many of the unique features of proteins is also responsible for their high water solubility.

Our research has focused on improving the water resistance of protein based adhesives while maintaining adhesion and strength. Through the inclusion of vegetable oil derivatives we were able to alter the polarity of the adhesive when cured, and produce composites with physical strengths comparable to commercial particleboard. While the water resistance and thickness of swell results approached commercial values, they did not however, show a consistent behavior. This response was noticeable in the composite core and was attributed to poor adhesive flow at the curing temperatures and pressures found within the core. Through the combination of adjusting the pre-cure processing conditions and adhesive formulation, improved water resistance and thickness of swell have been achieved on a repeatable basis.

To monitor changes in the adhesive flow, dynamic mechanical analysis (DMA) was used to approximate the composite curing conditions. Without this analysis, the flow characteristics of the adhesive are difficult to obtain. Using the DMA, the adhesive is subjected to varying temperature and pressure profiles while monitoring the percent flow. While it is important to improve flow and increase substrate wetting, excessive adhesive flow produces a starved glueline and composites with inferior strength characteristics.

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COMPARISON BETWEEN THE PRODUCTION OF LEAVES, GEL, AND JUICE IN ALOE VERA GROWN WITH PLASTIC MULCH OR NATURAL CONDITIONS.

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In Mexico, *Aloe vera* is a recent introduced crop presently covering 2000 hectares. Most of the production is exported to USA for pharmaceutical and cosmetic products. This crop may be a new economic opportunity for the arid and semi-arid lands agricultural producers in Northern Mexico due to the proximity to the market. There is lack of information regarding this crop management hence the objective for this work is to evaluate the yield of leaves, gel and juice in plants grown under natural conditions and compare the values with those obtained from plant grown using plastic mulch.

The plants were transplanted to the university experimental field in March 1998, under a random block design with two treatments and four replications. The mulching treatment consisted of three beds separated 1.8 m with 6.0 m length, plants were placed in double file to obtain a density of 25,000 plants/ha. The treatment without mulching consisted of parcels with five rows, separated 1m, with 6 m length, the distance between plants was 0.4 m to achieve the same 25,000 plants/ha density. Irrigation was carried out using drip irrigation tape for both types of treatment. The plants were sampled twice during 1999, in August and December, when the external leaves (4-5) reached its maximum development. The leaves were weighted in the field and transported to the laboratory for measurements of length and thickness, afterwards they were passed trough an aloe leaves processor for juice and gel extraction.

In the mulching treatment the leaves yield was 30.5 and 24.2 ton/ha for the first and second sampling respectively. The leaves yield for the other treatment was 23.8 and 17.9 ton/hectare. The yielding from the mulched plants, for the December sampling, was 22.36% gel, 38.84% juice and 38.8% bagasse, the plants without mulch yielded 23.84% gel, 37.52% juice and 38.64% bagasse.

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GROWTH CHARACTERISTICS, SAPONIN AND PROTEIN CONTENT OF QUINOA CULTIVATED IN NORTHERN MEXICO

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Quinoa (*Chenopodium quinoa* Willd) is a plant native from the Andes with high nutritional value and resistant to low temperatures. The quinoa seeds have been commercialized traditionally but the plant use as forage has not been evaluated. This use may be interesting to increase the possibility for livestock feeding in semi-arid lands. The present paper reports on the determination of dry weight, as well as saponins and protein accumulation of two quinoa varieties grown under three irrigation conditions and the determination of the efficiency of the water use on the biomass and protein production.

The plants were seeded on March 14, 2000 at the locality of Jaguey de Ferniza, 20 km from the city of Saltillo, using a divided parcel design. The large parcel are watering treatments and the small parcel are varieties with four replications. The watering treatments were: high, medium and low. Two quinoa varieties (Sajama and Chucara) were studied; sampling was performed at five development stages. The genetic material was from the Patacamaya experimental station, located at La Paz, Bolivia. The evaluated parameters were: fresh and dry weight, saponins and protein content. Also the soil moisture content was measured.

At the third sampling date (80 days after seeding) no significant differences in dry weight were observed between varieties but significant differences were observed among treatments. Sajama variety dry weight at high humidity was 5821 kg/ha, medium humidity 3459 kg/ha and 2710 kg/ha for low humidity. When the plants were at the blooming stage (fourth sampling date, 99 days after seeding) dry weight was 10808, 7461 and 5945 kg/ha respectively. The mean values for the efficiency of the water use on the biomass production were 2.09, 1.4 and 1.42 kg/m^3 for high, medium and low humidity levels respectively. The protein content diminished with the increment on dry weight, going from over 20% down to 15% at blooming stage.

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