

1999 Annual Conference Diversity in Agricultural Markets: New Crops and New Markets

October 17-21, 1999
Eugene, Oregon

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PLENARY SESSION

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Edgar B. Cahoon

DuPont Agricultural Products

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Steven J. Knapp

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NEW USES COUNCIL: NEW USES FOR THE NEW MILLENNIUM

BIOBASED PRODUCTS - THE NEW MILLENNIUM

Jeffrey W. Gain, Chair AARC/USDA

BIO-ENERGY INITIATIVE

Robert Harris, Coordinator, Bio Energy, US DOE

AGRICULTURE FIBER FUTURES

Jeffrey W. Gain, Chair AARC/USDA

NUTRACEUTICALS AND MEDICINAL EXTRACTIVES

Robert Armstrong, Exec. Dir., AARC/USDA

Shelby Thames, Distinguished Prof., University of Southern Mississippi

Erwin Lloyd, Dir., BioComposite Solutions

William Miller, Pres., Miller Consulting Group

Michael Bishop, V. P., Research, Infigen, Inc.

Gary Miller, Sr. V. P., Nutraceuticals, Archer Daniels Midland

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MEADOWFOAM

THIRTY YEARS OF MEADOWFOAM RESEARCH AT OREGON STATE UNIVERSITY

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Meadowfoam research at Oregon State University has been gone on since the USDA discovered that the oil contained unique fatty acids. Three major events have kept this work going for over thirty years.

The decision to domesticate meadowfoam (*Limnanthes alba* Benth.) was made at OSU in 1971. One of the main reasons for making this decision was the ban on whale oil imports. Meadowfoam oil was considered to be a possible replacement for whale oil in many products. By the end of the first decade of research, cultivars had been developed that would allow commercial production, but markets for the oil had not developed.

In the early eighties, burning of grass seed fields in the Willamette Valley became an issue, and interest in growing meadowfoam as an alternative crop for grass increased. A meadowfoam grower's organization was formed to produce and market the oil. However, by the end of the second decade of research, oil sales still had not developed.

The third major event happened in the early nineties when the growers association contracted with Fanning Corp. to market meadowfoam oil. Fanning's efforts to sell meadowfoam oil combined with research for new uses at the USDA Lab in Peoria IL led to the development of new markets. Resulting in a significant increase of production acreage in the Willamette Valley.

DNA FINGERPRINTING SHOWS THAT MEADOWFOAM IS GENETICALLY DIVERSE: A SURVEY OF EXOTIC AND ELITE GERMPLASM ACCESSIONS

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Germplasm resources for meadowfoam (*Limnanthes alba* Benth.) are critical for sustaining the development of the meadowfoam industry and protecting *Limnanthes* as a species. The genetic diversity of *Limnanthes* is eroding in nature as a consequence of urban development and human activity. The aim of this study was to survey and catalog the genetic diversity of the present day germplasm collection using DNA fingerprinting. One hundred and ten progeny from 43 accessions (34 *L. alba*, 2 *L. gracilis*, 5 *L. floccosa*, 1 *L. montana*, and 2 interspecific accessions) were screened for amplified fragment length polymorphisms (AFLPs) using six primer pairs. Cultivars, enhanced germplasm lines, wild populations, and inbred lines were sampled, as were cross- and self-pollinated *L. alba* lines. The primer pairs tested amplified more than 60 bands each. There were 40 to 50 polymorphic bands per primer pair (assay) among *L. alba* accessions. This analysis uncovered patterns of diversity concordant with geographic, subspecies, and breeding origin. Although *L. alba* seems to be a genetically diverse species, the germplasm base for this crop needs to be broadened. Several wild populations have never been collected and none can be safely preserved in situ.

WEED MANAGEMENT CHALLENGES IN MEADOWFOAM.

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Meadowfoam (*Limnanthes alba* Benth.) is a low-growing winter annual that is well adapted to the Willamette Valley of Oregon. Because meadowfoam has a short stature, it is easily over-topped by many of the winter annual broadleaf and grass weed species in the region.

The small acreage and limited growing area have made it difficult to obtain registrations for herbicides to use in meadowfoam. The herbicide registrations that have been obtained are 24(c) Special Local Need state labels. The three herbicides that have labels for use in Oregon are Dual (metolachlor), Stinger (clopyralid), and Prism (clethodim). Dual is effective on a range of broadleaf and grass weeds but does not control all weeds and is applied pre-emergence. Dual will not provide season-long weed control. Stinger controls many broadleaf weeds and is especially effective on weeds that belong to the composite family. Prism controls only grasses.

Studies were conducted to evaluate meadowfoam tolerance to the labeled herbicides and to other herbicides that might be beneficial for use in meadowfoam. Expanding the herbicides available should allow meadowfoam growers to select an effective herbicide for the weed species present. Non-labeled herbicides tested were Nortron (ethofumesate), Ramrod (propachlor), and Spartan (sulfentrazone). None of the herbicides tested caused unacceptable crop injury.

Studies also were conducted to evaluate the application timing of Prism for weed control and crop tolerance. Prism was applied at monthly intervals to meadowfoam starting in November and continuing through April. The treatments applied near or during bloom reduced yield.

THE DEVELOPMENT OF FOOD GRADE MEADOWFOAM OILS

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Meadowfoam (*Limnanthes alba* Benth.) oil is a source of three novel unsaturated long-chain fatty acids (20:1 D 5, 22:1 D 5, and 22:2 D 5, D 13) and erucic acid (22:1 D13), a fatty acid produced by rapeseed (*Brassica napus* L.) and other Cruciferae. Because erucic acid has been shown to pose health risks, our goal was to develop low erucic acid meadowfoam to open pharmaceutical and food markets for meadowfoam oil. We developed low erucic acid (22:1 D13) lines by exposing M_0 seeds of Mermaid to methanesulfonic acid ethyl ester (EMS) and selecting for reduced erucic acid concentration among manually self-pollinated M_1 , M_2 , and M_3 progeny. One M_1 (LE78) produced less erucic acid than the wildtype. The erucic acid concentration was 3.1% for the selected M_2 line (LE78-1) and 2.4% for the selected M_3 line (LE78-1-3) versus 9.4% for the untreated control (Mermaid). LE78-1-3 produced less 20:1 D5 (51.4 versus 65.5%) and more 22:2 D5, D13 (37.8 versus 17.3%) than the wildtype. M_3 seeds produced 1.3 to 3.7% erucic acid. The narrow phenotypic ranges for erucic acid and other fatty acids among M_3 progeny showed that the induced mutation(s) are probably fixed. We have begun introgressing the low erucic phenotype from LE78-1-3 to elite open-pollinated populations (OMF78 and OMF86) with different genetic backgrounds and investigating the genetic basis for the low erucic phenotype. The erucic acid distribution among LE78-1-3 x OMF86 F_2 progeny was continuous and normal. The low erucic mutation(s), in the OMF86 background, produced more 20:1 D5 (70.7 versus 65.5%) than the wildtype, but had no effect on 22:2 D5, D13 concentration; thus, the phenotypic effect of the low erucic mutation(s) seems to vary across genetic backgrounds. Progeny from other crosses have not yet been assayed. LE78-1-3 and other low erucic acid lines open the way to the development of pharmaceutical, nutraceutical, medical, and food markets for meadowfoam oil.

COMMERCIAL APPLICATION OF MEADOWFOAM DERIVATIVES

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The unique fatty acid profile of Meadowfoam seed oil has facilitated the synthesis of a wide variety of commercially useful derivatives.

Meadowfoam alkanolamides, when used in personal care products, perform a variety of functions including viscosity enhancement, foam stabilization, emulsification and detergency. The alkanolamide can progress to the preparation of the Meadowfoam betaine which is a very mild, stable and effective surfactant and conditioning agent. Both of these Meadowfoam derivatives benefit from the long chain fatty acid structure and non-conjugated double bonds by providing superior liquidity, lubricity and outstanding oxidative stability.

A variety of Meadowfoam esters have been prepared and evaluated for personal care and industrial applications.

These include esters of guerbet alcohols, dimethicone copolyols, and transesters with other triglycerides. In addition, alkoxyated derivatives have been made to provide varying degrees of water solubility and consequently function as surface active emulsifiers. Meadowfoam estolide, a dimeric ester resulting from self- condensation, has demonstrated excellent conditioning properties in hair care formulations.

Cosmetic "substantivity", or the ability to adhere to the negatively-charged surface of skin and hair, results from the use of cationic quaternized Meadowfoam derivatives that provide conditioning properties in a variety of personal care products.

RECENT DEVELOPMENTS IN CHEMICAL DERIVATIVES OF MEADOWFOAM OIL

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Meadowfoam (*Limnanthes*) is a developing oilseed crop that posses an unusual D 5 20:1 fatty acid as a major component (ca 63%) of its triglyceride. The crude hexane extracted oil was recently reported to be the most oxidatively stable vegetable oil currently known and the D5 unsaturation of the individual fatty acids was also shown to possess unusually high oxidative stability. In light of these findings, a range of studies was performed to utilize the unique chemistry of the D5 unsaturation.

Meadowfoam fatty acids and oil was cyclized in high yield (75-90%) to d-lactones. d-Lactones are kinetic products that are formed through the capture of a D5 carbocation in an acid catalyzed cyclization. Strong mineral acids such as perchloric and sulfuric promote the reaction with optimum reaction temperatures near 40° C. Polar non-participating solvents such as methylene chloride aid in the formation of d-lactone over the preferred thermodynamic product, g -lactone. d-Lactones are useful as reactive intermediates which lead to derivatives of 5-hydroxy fatty acids. d-Lactones were converted to a variety of amides in near quantitative yield with amines at 50° C in the absence of solvent. In a similar fashion, alcohols react with d-lactone to give 5-hydroxy esters. Both amination and esterification reactions proceed with observed relative rates of 7000 to 9000 times faster than meadowfoam fatty acids. This reactivity was also utilized to synthesize secondary ethers from d-lactones in high yield (70-94%) with a variety of primary alcohols in the presence of mineral or Lewis acids.

Estolides, esters formed from the addition of one fatty acid across the backbone of a second fatty acid, were also

synthesized form meadowfoam fatty acids with catalytic amounts of perchloric acid. The estolides are showing some utility in cosmetic applications.

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GENERAL CROPS 1

A NEW SUSTAINABLE PERENNIAL CROP SYSTEM DEVELOPED FROM NATIVE AMERICAN HIBISCUS SPECIES FOR PRODUCTION OF FRESH FOOD, VALUE-ADDED FOOD PRODUCTS, SEED OILS, NATURAL FOOD COLORS, NUTRACEUTICALS, PHARMACEUTICALS, INDUSTRIAL FIBER APPLICATIONS, AND BIOREMEDIATION OF COMPROMISED AGRICULTURAL AND INDUSTRIAL LANDS

Georgia A. Bost

Hibiscus Horticultural and Agricultural Products Production Company (HHAPPCo), Hibiscus Hill Farm, Waller county, TX a wholly owned subsidiary of The Village Botanica, Inc., 7500 Westview Drive

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Bostx HHHybrids are the result of an intensive breeding program begun in the summer of 1986 with species and subspecies of genus *Hibiscus* section Meunchhusia. Other Hibiscus sections subsequently selected for trials as agricultural plants include members of *Hibiscus* sections Azana, Bombicella, Calyphylli, Furcaria, Striata and Venusti. *Hibiscus* from sections Bombicella (except as a specialty food product for limited local markets) and Furcaria were eliminated from our trials as field production crops because of small size and inappropriate climate/soil preference, respectively, for production in USDA Zones 5-9. *Hibiscus* species and subspecies selected for breeding trials within section meunchhusia included *H. coccinier* (multiple populations); *H. dasycalyx* (multiple populations); *H. laevis* (multiple populations); *H. moscheutos moscheutos*, *H. moscheutos grandiflorus*, and *H. moscheutos palustris* (multiple populations of each subspecies); and *H. moscheutos* "southern Belle" cultivars.

At this writing we have 5 patented hybrids (patent Nos. 9311; 9838; 9851; 9852; and 10741); a utility patent for bioremediation of salt/metal contaminated soils (patent No. 5,270,130) using hybrids, species, and subspecies in Hibiscus Sections Meunchhusia and striata; and a food patent for use of *Hibiscus* sections Azanza, Bombicella, Calyphylli, Furcaria, Striata, and Venusli, and selected other Malvaceae, including Abelmoschus, Abutilon, Althaea, Alyogyne, Malva, Malvaviscus, Lavalera, Pavonia, and Urena, as natural food colorants (patent pending).

Primary harvestable products of this new crop include: 1) fresh flowers for gourmet food markets, nutritional supplements, and food colorants (Projected seasonal yield/acres [dry wt] ~1 ton, harvest period mid Apr-Oct); 2) fresh frozen green pods as "Petite Spineless Okra", harvest period mid May - Oct; 3) mature pod for seed oil and seed meal applications - projected yield (seed weight only) 0.75 - 1.6 tons/acre, oil yield ~12% (harvest period June - Nov); and , 4) end-of-season cane harvest, projected yield 6-10 tons/acre, harvest period Dec-Feb. All estimates depend on average crown age, variety and time since field establishment. Harvest data are based on preliminary biometric data for selected BOSTx HHHybrids in combination with a projected optimum field density of 2,500 crowns/acre (far less than the planting density of >100,000 seed/acre needed for comparable yields with kenaf (section Furcaria species *H. cannabinus*)).

MIMOSA: A PLANT WITH EXTRAORDINARY POTENTIAL AS A MULTI-PURPOSE CROP

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Mimosa (*Albizia julibrissin*) was introduced to the United States as an ornamental plant about 200 years ago. It is a leguminous tree that has become widely naturalized across the southern part of the country. Flowers vary in color, from almost white to dark pink, and an abundance of seed is produced in large pods. Mimosa trees usually grow no more than about 30 ft. tall, and are relatively short-lived (20-30 years). These statistics suggest that it is a slow growing plant, but if it is harvested frequently (at least every one or two years) the growth rate is usually extremely high.

Apart from the work at Auburn University over the past 10 years, research on mimosa has been mainly academic in nature, with applied research being restricted mainly to its role as an ornamental. Consequently, its value as a multi-purpose perennial crop has not been recognized. Our work has shown that mimosa can be used as a forage tree to provide high quality feed for livestock and deer, biomass for production of bioenergy, and possibly fiber to produce pulp and paper, and composite panels.

Over a 5-year period, small (12 × 30 ft) plots in which plants were grown in rows 3 ft. apart, with 1 ft between plants in the row, yielded an average of 4.7 tons/acre of dry leaf material/year when they were completely defoliated by hand every 6 weeks, starting on June 1. During this time the plots received no fertilizer. However, crude protein concentration of leaves was over 20%, indicating that this material was highly nutritious, and that plants were extremely effective in fixing nitrogen. In the subsequent 4 years these plants were cut to a height of 12 inches only once a year in fall to obtain total biomass (wood and leaf material) yield. This resulted in prolific coppice growth that ranged from 10 to 14 ft. tall, and yields were between 7 and 10 dry tons/acre/year, which is competitive with other short rotation, woody energy crops such as willow and hybrid poplar. About 70% of this yield was stem, and 30% leaf. Again, no fertilizer was applied to the plots during this period.

On several 2-acre fields mimosa was planted in rows 6 ft. apart, and stocked with cattle at various stages of growth. After becoming accustomed to browsing instead of grazing, cattle made efficient use of the foliage, even consuming leaves that were initially out of their reach by bending stems over. In addition, prior to stocking these areas with cattle in the fall, there was evidence of substantial browsing of the mimosa plants by deer, indicating that it could be a valuable source of protein for these animals at this time of the year. Finally, studies in the Pulp and Paper Research and Extension Center at Auburn University have indicated that fiber quality of mimosa is similar to that of other hardwoods, thus suggesting that it may well have potential for production of pulp and paper, and composite panels. In summary, mimosa offers considerable potential as a very low input, perennial crop for forage, wildlife feed and habitat, bioenergy and fiber.

QUINOA: A UNIQUE AMYLOPECTIN STARCH SOURCE

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Quinoa or quinoa (*Chenopodium quinoa* Willd.) was domesticated between 3,000 and 5000 years ago. Similar chenopod species were cultivated or harvested as grain around the world. Quinoa's popularity peaked in South America with the Incan Empire and declined rapidly with the Spanish conquest. The Spaniards introduced wheat and barley and displaced much of the Incan quinoa. In the 1980's, quinoa was reintroduced onto a global market as a well balanced food. It is consumed essentially like rice as a whole grain and has been Quinoa markets expanded rapidly during the 1980's and have since stabilized with world consumption estimated at 10 million metric tons annually.

With edible markets stabilizing, the question arose as to where could quinoa go to increase market share. The development of quinoa's almost unique starch may be a solution. Quinoa seeds contain 10-18% protein, average

6.9% fat, 2.4-5% ash, 2.1-4.9% fiber and 54.1-65.2% starch (K.M. Dahlin, 1991). The flour derived from quinoa was found to be acceptable in food products up to 5%. Beyond this level, breads did not rise properly, cakes had a grainy texture and extruded products failed to expand. Some of these failures were due to the higher than normal oil content but the majority of failures were due to the high amylopectin content of quinoa seed (Lorenz, et al., 1995). The amylopectins make digestion of the starch easier but are less useful in manufactured food products.

Amylopectins are a branch chained starch. Amylopectins are the "waxy" trait sought after by industrial applications. Protein isolation from quinoa has the potential of an excellent human food supplement. The oils, if isolated, are similar to corn oil. The ash is very high in calcium, iron, phosphorus and potassium. The question was, what to do with the starch. As an amylopectin, the starch is superior to common starches as a thickener (Lorenz, 1995).

Quinoa starch was isolated by steeping at 10C for 24 h in water buffered at pH6.5 (0.02 m acetate and rendered in 0.01 sodium chloride. The softened grain was wet milled in a waring blender and the magma screened through a sieve. The starch was retrieved by centrifugation of the filtrate, washed repeatedly in distilled water and air dried.

Quinoa starch granules were found to be complex conglomerates of 4 to six micro granules. The micro granules were, in turn, 10 times smaller than starch granules from wheat or corn. The starch size influenced water absorption. Quinoa starch granules were slow to initiate water uptake but after 5 days showed significantly higher water absorption than wheat, potato, or barley starches (Lorenz et al., 1995).

New applications for the starch in industrial applications will be explored and demonstrated.

CONTROL OF WEED COMPETITION IN *Grindelia chiloensis* (ASTERACEAE).

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Diterpene resin acids produced by *Grindelia chiloensis* and other related species could potentially be used in various applications in the naval stores industry. The value of the goods produced by the naval stores industry in Argentina is around 31 million US\$. *Grindelia chiloensis* could complement this industry allowing for new, modified products and is being studied as a crop for Patagonia, Argentina. Stand establishment can be achieved by direct seeding, by transplanting seedlings or by rooted-cuttings. Early plant growth is limited by weed competition (mostly dicots) until the plants accumulate enough biomass to out-compete the weeds. Mechanical control of weed competition can be used but results in removal of plant biomass, since *Grindelia* shoots are quite fragile.

As a part of a scheme to develop a weed control strategy for *Grindelia chiloensis*, six pre-emergent and five post-emergent herbicides were tested. Pre-emergent herbicides: Zorial 80 DF (norflurazon, 0.5, 1.0 and 2.0 lb ai/a); Dual 8E (metholachlor, 1.5, 3.0 and 4.5 lb ai/a); Karmex 80 DF (diuron, 1.0, 2.0 and 4.0 lb ai/a); Caparol 4L (prometryn 1.0, 2.0 and 3.0 lb ai/a); Treflan 5EC (trifluralin 0.5, 1.0 and 1.5 lb ai/a) and Astrex (atrazin, 1.0, 2.0 and 3.0 lb ai/a). Herbicides were dissolved in 45 ml of water and mixed with the soil at the time of seeding. Three seeds were planted in each of eight 4-inches pot/treatment. Seedling survival and plant dry biomass were evaluated 30 days after seed germination. Dual 8E in applications up to 4.5 lb ai/a, Karmex 80DF and Aatrex up to 2.0 lb ai/a, and Caparol 4L at 1.0 lb ai/a did not reduce seed germination, seedling survival or dry biomass when compared to control seedlings. Zorial, Karmex and Caparol at the highest doses applied resulted in total mortality of the seedlings. Post-emergent herbicides: Herbaglex (MCPA 0.5, 1.0, and 2.5 l ai/ha), Herbadox (Pendimentalin 3.0, 4.0, and 5.0 l ai/ha), Teliron (linuron 1.9, 2.0, and 4.0 l ai/ha), Agil (Propaquizifop 1.0, 2.0, and 4.0 l ai/ha.), Galant (haloxifop-metil 1.0, 2.0, and 4.0 l ai/ha) and Listo (Fuazifop-p-butyl 2.0, 3.0, and 4.0 l ai/ha) were applied to 15 plants each at two developmental stages during the growth cycle of *G.chiloensis* plants: at 6-10 leaf stage (December 1998) and at peak flowering (March 1999). Plant survival was evaluated May 10, 1999 and 5 plants per treatment were harvested, weight and resin extracted. Survival was 100% for all treatments except for MCPA (Herbaglex) at the highest doses (5.0 l ai/ha) and when applied at 6-10 leaf stage (0% survival).

Biomass accumulation was not affected by any of the herbicides applied except for MCPA when applied at the 6-10 leaf stage which significantly reduced the accumulated biomass.

The results of these studies indicate that pre-emergent as well as post-emergent herbicides could be used in commercial cultivation of *Grindelia chiloensis*.

PROGRESS IN DEVELOPING SEA WATER IRRIGATED CROPS

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We are developing field and pasture crops that are irrigated with undiluted sea water. Ninety-seven percent of the water on this planet is sea water. Sea water crops would allow farmers to tap this virtually limitless resource. It is estimated that sea water agronomy could add 130 million hectares of coastal and saline inland deserts to the world's irrigated farmland inventory.

The principal field crop plant currently under development on our 50 ha. research farms in Mexico and the U.S is the halophyte *Salicornia bigelovii* Torr. Products from this crop are oil, fresh and preserved vegetable products, and biomass for particle board and fire-logs. Genetic improvement of *Salicornia* is our major research effort. *S. bigelovii* is a protogynous cross-pollinating species. We are using recurrent selection to develop inbred lines for use in producing synthetic *Salicornia* varieties. Research on sea water irrigation, fertility, sustainable pest and disease control, and soil science is discussed. Research on other potential halophyte crops is discussed.

Our current sea water farming system consists of three parts: an animal component, a crop component, and a biodiversity component. The animal component is aquaculture, specifically shrimp and fin fish (tilapia) production. The crop component is salicornia and the biodiversity component is constructed marine wetlands. Effluent water from aquaculture is pumped on the *Salicornia* fields and the wetlands. In our sea water farming system nutrient and possible pathogen containing effluent is never returned directly to the ocean as it is in most commercial aquaculture systems today. The *Salicornia* production fields and the wetlands act as biofilters to remove eutrophic and pathogenic elements from the effluent and are benefited by the nitrogen and phosphorus in the effluent water. Income in this sea water farming system is derived from sales of sea food and plant products.

The purpose of an integrated sea water farming system at the present time is to spread the cost of capturing and pumping sea water over several income generating activities. Our plant breeding and agronomic research is directed towards reducing production costs of sea water crops to the point that future sea water cropping systems will profitably stand alone.

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OILSEEDS 1

PROTEIN CONTENT AND FATTY ACID COMPOSITION OF CHIA CULTIVARS IN MEXICO

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Salvias constitute the largest genus in the mint family, valued for their medicinal and culinary qualities. More than 900 species of *Salvia* exist, with more than half occurs in North and South America. For centuries, Native Indian peoples in the Americas have used chia seed (*Salvia hispanica* L.) as a staple food. Aztec warriors of Mexico subsisted on chia seed during their battles and hunting expeditions. Chia seeds contain beneficial long-chain triglycerides in the right proportion to reduce cholesterol on arterial walls. Cultivated varieties are grown in Central and West Mexico. Wild native forms are scattered through the Sierra Madre Occidental from Sonora and Chihuahua southward.

Chia have been commercially produced in the provinces of Morelos and Jalisco, seed yields in that site of up to 1500 kg/ha. The objective of the project was to determine the protein quantity, oil content and fatty acid composition of selected cultivars of chia *S. hispanica* L. These characteristics were analyzed by the Molinos Union del Yaqui S. A. in Obregon, Mexico. Three cultivars were analyzed, denominated: Altos and Acatic from Jalisco and Local from Morelos.

Chia seed is a complete source of dietary protein providing all the essential amino acids. Compared to other seeds and grains, chia seed provides the highest source of protein, in this study varying from 29.43% in Local to 22.87% in Acatic. The results showed a difference among genotypes in the average oil content: 31.47, 30.40 and 30.20% in Acatic, Altos, and Local, respectively. Chia seed contains three to ten times the oil concentration of most grains. Also, the seed contains the highest known natural source of linolenic acid, with linolenic acid having many uses in industry and cosmetics, cultivar Altos yielding a higher content 57.53%, and line Local 54.41%. Chia seed are rich in the essential unsaturated fatty acid, linoleic, which the body cannot manufacture for respiration of vital organ, making it easier for blood to glandular activity, and nourish skin cells, mucus membranes and nerves. Cultivar Local produced linoleic acid 23.30% those lines Acatic and Altos 22.04 and 20.86% respectively. The fatty acid composition of the oil in higher content is as follows: palmitic 7.98% (Altos), stearic 3.44% (Acatic), oleic 12.17% (Acatic), and arachidic 0.23% (Local). The average humidity was 6.37%. Chias are examples of potential new crops for the diversification of world agriculture.

SALICORNIA: A POTENTIAL OIL CROP

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Salicornia bigelovii Torr. Is an annual oilseed/forage halophyte crop in the Chenopodiaceae. It is a leafless salt marsh plant with green, jointed, succulent stems that ultimately form terminal fruiting spikes on the upper one-third of the plant. Seed contains 26-33% oil, 31% protein, and 5% of fiber and ash. The oil is mainly composed of linoleic acid (74%) that makes it an excellent candidate for vegetable cooking oil. The seed meal contains 33-43% crude protein and can replace soybean oil in poultry diets. The vegetative portion of the plant is high in salt (32%), as (30 - 40%), and relatively low in protein (6%). The fiber component is highly digestible and animal growth rates are equivalent to other animal feeds such as Rhodes grass, coastal Bermuda grass, wheat straw or mixtures of wheat straw and alfalfa.

Evaluation of phenotypic characteristics in *Salicornia bigelovii* in the greenhouse at Environmental Research Laboratory, The University of Arizona during 1998, has indicated that significant genetic variation for traits of agronomic performance exists both within and between the populations evaluated. Preliminary results show that *Salicornia bigelovii* can be improved for use as an oilseed crop plant. Development of *Salicornia* will achieve: (1) new business opportunities for industry; (2) new agricultural options and opportunities; (3) expanded economic opportunities for growers and seed suppliers.

**INFLUENCES OF BREEDING, SELECTION, CLIMATE, AND CULTURAL PRACTICES ON
GROWTH, HARVEST, AND SEED CHARACTERISTICS OF EUPHORBIA LAGASCAE.**

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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 studied *Euphorbia* because it is drought-tolerant and seems well adapted to the warm, dry, Mediterranean climate of SW Oregon. Use of "non-shattering" mutants developed in Spain has allowed us to study agronomic requirements necessary for commercialization. For this paper we examined the effects of agronomic practices such as planting date, seed age, plant density, and winter temperatures on plant growth and maturity, shattering, and seed size, yield, and oil content. In addition, single plant selections and simple hybrids were made to see if improved plant types could be developed.

A breeding and selection program has resulted in 18 different hybrids that were grown out through the F3 generation. For these F3 plants, seed shattering ranged from 0 to 100%, seed oil content ranged from 49.1 to 52.8%, 1000 seed weight ranged from 9.3 to 11.3 g, and mature plants varied in size, appearance, and maturity date. In addition, starting with 12 superior single plant selections from non-shattering mutants, three generations of plants were grown, including an additional round of single plant selection in the second generation. For the resulting seed, oil content ranged from 48.6 to 50.8%, 1000 seed weight ranged from 10.5 to 11.5 g. Plant size, appearance, maturity, and shattering varied. Based on observed characteristics, 11 hybrids and 4 non-shattering selections were planted in a replicated yield trial in 1999. Results from this planting will be discussed.

Our agronomic studies continued in 1998 and 1999. In 1998, seed yield exhibited a curvilinear response from 56 to 780 kg/ha as plant density increased from 25,000 to 865,000 plant/ha. Oil content did not change appreciably in this density range, with a mean of 50.3%. However, 1000 seed weight increased from 10.5 to 11.5 g as plant density increased in the observed range. Results from a larger density study in 1999 will also be discussed, as will the results of a 1999 field study measuring the effect of seed age on germination, seed yield, oil content, and seed weight.

In previous studies, *Euphorbia* survived and grew well after experiencing winter temperatures of between -9 and -6°C. To test *Euphorbia*'s cold tolerance, a comparison of fall planting dates under two environments was studied in 1998-99. At Klamath Falls, Oregon, where winter low temperatures fell to between -21 and -17°C on 3 nights in late December, *Euphorbia* planted on Sept. 4 and Sept. 29 germinated well, but all died after the cold weather occurred. In contrast, when planted on Sept. 30 and Oct. 30 in Medford, Oregon, where winter low temperatures fell to between -15 and -12°C on three nights in December, *Euphorbia* survived, grew well and set seed in the spring.

**EFFECT OF SALINE IRRIGATION WATER COMPOSITION ON GROWTH, SHOOT ION
RELATIONS AND SELENIUM UPTAKE BY LESQUERELLA FENDLERI (GRAY) S. WATS.**

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This study was conducted at the U. S. Salinity Laboratory, Riverside, CA to compare the response of lesquerella to irrigation waters differing in composition, namely, Cl-dominated salinity (NaCl:CaCl₂, 2:1 molar ratio), and mixed salt salinity (Na, SO₄, Mg, and Cl as the predominant ions). The Cl-system has been used extensively in evaluation of salt tolerance of various crops, whereas the mixed salt-system is typical of saline drainage waters commonly encountered in the San Joaquin Valley of California. A further objective of the study was to determine

the uptake of selenium by lesquerella irrigated with saline waters contaminated with this potentially toxic trace element.

Lesquerella was direct-seeded in 24 greenhouse sand tanks and irrigated with complete nutrient solutions. Salinity was imposed one month after planting; twelve tanks were irrigated with Cl-based waters and 12 with mixed salt salinity. The solutions were isoosmotic at each salt level: 0.070, 0.16, 0.30, and 0.52 MPa, with electrical conductivities (EC_i) of approximately 1.7, 4, 8, and 12 $dS \cdot m^{-1}$, respectively. One month later, selenium ($1 \text{ mg} \cdot L^{-1}$, 12.7 μM) was added to all solutions as Na_2SeO_4 .

Regardless of salinity type, shoot biomass production was not significantly reduced until EC_i exceeded 8 $dS \cdot m^{-1}$. At 12 $dS \cdot m^{-1}$, shoot dry weight decreased 60 % in response to chloride-salinity and 40% in the mixed-salt system.

Leaf tissue contained higher concentrations of Ca, Mg, Cl, S, and Se, than the stems; whereas concentrations of the monovalent cations, Na and K were higher in the stems than the leaves. Salt-stressed lesquerella shoots contained relatively low concentrations of Na and K compared to other cruciferous plants. In both salinity systems, the calcicolous nature of lesquerella was expressed by strong accumulation of Ca by both leaves and stems.

Selenium accumulation by lesquerella shoots was strongly influenced by the composition of the external media. In response to irrigation with Cl-dominated solutions, leaf-Se (mean = 500 $mg \cdot kg^{-1}$) tended to decrease with increasing salinity, but this effect was not statistically significant. In contrast, the competitive inhibition of Se uptake by increasing concentrations of SO_4 was evident in lesquerella irrigated with waters prepared to simulate San Joaquin Valley drainage effluents. Leaf-Se decreased from 220 to 13 $mg \cdot kg^{-1}$ and stem-Se decreased from 62 to 8 $mg \cdot kg^{-1}$ as salinity increased from 1.7 to 12 $dS \cdot m^{-1}$. Based on these preliminary results, lesquerella should be further evaluated as a potentially useful crop for the phytoremediation of Se-contaminated saline soils particularly in those systems where the dominant anion is Cl.

SINGLE CYCLE SELECTION FOR SALT TOLERANCE IN LESQUERELLA FENDLERI (GRAY) S. WATS.

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In a study conducted in 1997-1998, to determine the salt tolerance of *Lesquerella fendleri* (Gray) S. Wats., it was found that saline irrigation above 21 dS/m electrical conductivity resulted in high plant mortality. Replicate plots having a combined population of 216 plants yielded only five surviving plants at 24 dS/m and 13 survivors at 21 dS/m. In an effort to determine if lesquerella had heritable characters for salt tolerance, surviving plants were inter-mated under controlled conditions and seed was collected from these plants.

The following season, on 28 Oct 1998, seed of the selected salt tolerant full-sibs, designated line 'C', were direct seeded along with two other lines for comparison in a replicated randomized block salinity trial conducted in 21 outdoor sand tanks. Line 'A' was the original seed planted the previous year, and line 'B' was a check line. After seeding, the tanks were irrigated daily with complete nutrient solutions. Plant populations were thinned to 24 plants/line/plot on 21 Jan 1999, and salinity was imposed by stepwise additions of mixed salt salinity composed predominantly of Na, Mg, SO_4 , and Cl ions. Over a period of one week, salinity levels in the tanks were increased to 3, 7, 11, 15, 18, 21, and 24 dS/m, with three replications.

Plants were counted and plant heights were measured weekly. At the time of salinization C-line plants were already significantly taller than B- and A-line plants in all plots, 11.7, 6.62, and 4.09 cm, respectively. Within two weeks after salinization significant treatment differences in both plant height and survival were observed among lines due to salinity stress. Plant survival decreased as a function of time and salinity concentration. The parental

line A was most sensitive, C-line most tolerant and B-line intermediate. By 25 Feb none of the A-line plants survived at the 24 dS/m salinity level. Plants were harvested on 15 Jun and individual dry weights of plants and seed were recorded. Seed was saved for analysis of oil quality. Leaf samples were taken, dried, ground, and weighed to measure ion content.

Analysis of the final shoot dry weights indicated that salinity and line effects were significant but there was no interaction. Salinity decreased average shoot dry weights in all lines as a function of increasing salinity and ranked mean differences within lines were consistent across all salinity levels from 3 to 18 dS/m. At 7, 15, and 18 dS/m average shoot dry weights of the C-line was significantly greater than the parental A-line. The average mean shoot weight of B-line was intermediate but always lower than C-line. Our results showed that across all salinity levels, the C-line had higher average shoot dry weights (25.9 g/plant) than either the B-line (17.4 g/plant) or the A-line (11.2 g/plant). Our results indicate that a single cycle selection of lesquerella in salinized sand cultures resulted in a C-line that had higher absolute and relative salt tolerance as measured by shoot dry matter production, plant height and plant survival. Selected, surviving, C-line plants in the 18, 21 and 24 dS/m plots were either crossed or selfed to provide future information on the inheritance of the salt tolerance character.

ENVIRONMENTAL EFFECTS ON PLANT HEIGHT, BIOMASS, OIL CHARACTERISTICS, AND SEED YIELD OF LESQUERELLA FENDLERI (GRAY) WATS.

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Yield trials of plant families of *Lesquerella fendleri* were grown in both Tucson and Maricopa Arizona to compare the response of growth, yield components, and performance in different locations. Families were derived from seeds combined from half-sibs selected the previous season for both high seed yield and plant height. Germplasm lines from recurrent selections for seed-oil traits were also included for comparisons. Plants were transplanted into the field in single rows, with guard rows direct seeded at both locations in a completely randomized block design. This study was designed to describe and compare the interrelationships of plant height, plant weight at harvest, seed yield, and seed-oil and lesquerolic acid content for plant improvement. Significant differences were seen between locations in growth measurements of different families.

LESQUERELLA ESTABLISHMENT AND RESPONSE TO POSTEMERGENCE HERBICIDES IN WEST TEXAS

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Over 7 million ha of rangeland, desert, desert mountains, and irrigated cropland are included in the Trans Pecos region of west Texas. Irrigated farming is concentrated in the Toyah Basin area of Reeves County, the Coyanosa region of northwest Pecos County, and the El Paso Lower Valley region of Far West Texas. High irrigation expenses, saline water and soil conditions, recurring insect problems, a limited growing season, and changing government farm programs have idled thousands of hectares since 1975. The commercialization of new or alternative crops would increase farm profitability and promote economic opportunities in farming and rural communities, conserve and enhance natural resources, develop new industrial products, and increase international competitiveness.

The objectives of this study were to examine the effects of salinity on lesquerella establishment, and determine the tolerance of lesquerella seedlings to postemergence herbicides. An experiment was initiated on October 13, 1998

at the Texas A&M University Agricultural Experiment Station near Pecos, Reeves County, Texas. Lesquerella was planted with a Brillion seeder at a rate of 13 kg/ha. The study was sprinkler irrigated for 48 hours immediately following planting, and maintained by sprinkler irrigation throughout the growing season. Herbicide treatments were 2 m by 8m and arranged in a randomized complete block design with four replications. Ethametsulfuron (15, 23, 30 g ai/ha), and oxyfluorfen (0.3, 0.6, 1.1 kg ai/ha) were applied February 17, 1999 with a CO₂ powered backpack sprayer that delivered 187 L/ha at 172 kPa.

Irrigation water and soil salinity were 4.7 and 1.4 dS/m, respectively prior to planting. The seeding rate (13 kg/ha) was higher than recommended to account for expected mortality due to salinity. However, plant establishment was excellent and final plant populations averaged 2,800,000 plants/m². Total water applied was 46 cm, and at the last irrigation on March 1, the soil salinity averaged 4.0 dS/m. Lesquerella seedlings ranged in height from 2 to 6 cm, and had 5 to 30 true leaves when sprayed. Ethametsulfuron did not cause any visual damage to the seedlings regardless of size. Average lesquerella injury was 7% with the 1.1 kg ai/ha rate of oxyfluorfen.

Lesquerella can be produced with irrigation water over 4.0 dS/m when soil salinity is low. Establishment will be affected when both water and soil salinity are high. The research area had not been farmed for 10 years, and soil salinity on continuously farmed cotton land at the Experiment Station can be as high as 7.0 dS/m. Ethametsulfuron is a promising herbicide for the postemergence control of broadleaf weeds in lesquerella, but must be tested further.

STUDY OF SOLUBLE PROTEINS AS GRAIN YIELDING INDICATOR IN SUNFLOWER.

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The enzymatic system of sunflower corresponds to a C₃ plant. The CO₂ assimilation is performed by the RUBISCO enzyme, that is the most abundant of the soluble proteins of the leaves, and has a double role: catalytic and reserve, because on leaves senescence part of its carbon and nitrogen are used by the seed. Due to the protein reactions with the photosynthetic process, it may be considered that a high soluble protein content plant would have high grain yield as the proteins are related with the metabolism and biomass accumulation. The proteins also participate in the regulation of oil synthesis. In this work we report the relation between yielding parameters and the soluble proteins content, as well as the composition pattern obtained by electrophoresis, in six varieties of sunflower.

The experiment was carried out in the experimental field of the University Antonio Narro. Six sunflower genotypes, four from the university (SAN-3C, SANE-23578, SANE-1278 and GORDIS) and two from Argentina (RIB-77 and KLM-123) were seeded in June using a random block design with four replications. Two water applications were dispensed, one on seeding and the other ten days after seeding. The variables monitored were: dry weight of different sections, leaf area, grain yield, grain oil content, soluble protein content in the leaves and grain, and protein molecular weight.

The results showed higher leaf area at the start of blooming, the three higher values were attained by RIB-77 (3850 cm²), SAN-3C (3295 cm²) and GORDIS (3198 cm²). In dry matter production the order was SAN-3C (7.6 ton/ha), Gordis (7.2 Ton/ha) and RIB-77 (6.9 Ton/ha). For grain production the yielding was GORDIS (3.9 Ton/ha), SAN-3C (2.8 Ton/ha) and KLM-123 (2.1 Ton/ha). The harvest index was GORDIS (0.55), KLM-123 (0.39) and SAN-3C (0.36). The trend in protein and oil yielding was similar to grain yielding. The leaves soluble proteins varied between 33.17 and 217.1 mg/g leaf/plant while in grain the range was 313-869 mg/g grain/plant. The molecular weight of the proteins at different growing stages was variable but coincide with other authors reports. The protein pattern was integrated by 8 and 6 polypeptides for GORDIS and SAN-3C respectively which were the higher grain yielding varieties, confirming the relationship between the leaves soluble proteins content and yielding.

CANOLA RESULTS OF THE RESEARCH ACTIVITY IN SOUTH OF SONORA, MEXICO

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The canola *Brassica* sp., is a new introduction crop at México. Is a very important specie in relation to agronomy and oil quality characteristic, and because his wide adaptation to the climatic conditions to this area, however, this crop can be also adapted of north area of Sonora, as well to some others agricultural areas of México due to the wide adaptation of this specie as well to wild forms. The wild canola forms existing in this area, is a representative example of the good canola adaptation. This situation makes México to ocupated the second place after Japan as a canola buyer from Canada and Australia. In south of Sonora there are three oil industries; the best industry have a capacity of 600 tons per day.

In the Yaqui Valley Experimental Station, canola research works has been done since 1988 in yield trials evaluation of canola spring varieties came in from canadians universities. Such varieties like BN-00, BC-00, Candle, Tobin, Altex, Torch, among others. This varieties has shown a satisfactories yield grain, however, during the last four years, a new group of spring canola types how Hyola serie is being testing with good agronomic production, agronomics characteristics, good quality oil, and excelent yields, upper to others types canola varieties come in Spain, Australia, and others. During the last cycle, 1997-1998, canola was introduced to commercial explotation in small area (1.5 ha). Three varieties of the Hyola serie were tested, with a yield of 2500 kg/ha in the best variety. During the 1998-1999 cycle, the canola area was 400 hectares with good results. Because of this results, the canola will grown 20,000 hectares as less during 1999-2000 cycle.

The 400 hectares of canola during 1998-1999, were planted in a different of soils types from the clay to the aluvial, as well in salinity soils; in differets seeding dates, seedings rate of plants, and differents crop systems, fertilized and water managements, amongs others. The commercials plots was conduced with researches; the yield obtained in early planting date (1-15 december),was an average 3214 kg/ha, but the highest yield obtained was 3610 kg/ha with Hyola 401 variety. Durin the second period (16-31 december), the yield an average was 2749 kg/ha, but the highest yield was 3000 kg/ha. During the late period (1-15 january), the yield an average was 1941 kg/ha, but the highest yield obtained was 2500 kg/ha. Under salinity soils conditions the yield variation was form 2300 to 1350 kg/ha. Safflower yield under this conditions, is 800 kg/ha as much. In conclusion of this results, canola is a good alternative for the producers of Sonora, México, because the grain yield, oil quality, less water demand, salt tolerance, and good commercial opportunity.

APPLICATION OF HIGH PRESSURE LIQUID CHROMATOGRAPHY TO THE STUDY OF EDIBLE OIL HYDROGENATION

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Soybean oil was hydrogenated in a stirred batch reactor at 120 C at pressures ranging from 50 to 500 psi. The iodine value (IV) was reduced from 130 to 80 and during the course of the reaction, samples of triglycerides were taken and analyzed by high pressure liquid chromatography (HPLC). Non hydrogenated soybean oil contains three triglycerides accounting for over 50 % of the total triglycerides including trilinolein (LLL), dilinoleyl-olein (LLO) and dilinoleyl- palmitin (LLP). The HPLC data showed that the reaction rates of these triglycerides are markedly affected by pressure. At 500 psi the reaction is truly non selective, since fully saturated triglycerides are formed at IV of 70-80 whereas at 50 psi trisaturated triglycerides are not formed at similar IV s. Analysis of the reaction products clearly show that under the conditions employed, hydrogenation proceeds through definite pathways rather than random saturation of individual fatty acids within the triglyceride molecules. Reactivity was

shown to be LLL > LLO > LLP. Linolenate containing triglycerides were shown to react slower than linoleate triglycerides. The HPLC data allows modeling of the reaction kinetics either by considering the reaction rate of the individual fatty acids within the triglycerides or by triglycerides individually. Other applications of the HPLC method include iodine value determinations, quality control within processing streams, and catalyst screening. High pressure hydrogenation shows promise for preparation of low trans margarine, spreads and shortening oils.

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OILSEEDS 2

ISOLATION OF FREE FATTY ACIDS AND MONO-, DI- AND TRIGLYCERIDES FROM SEEDS

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Solid phase extract is a useful technique for the quantitative extraction of naturally occurring compounds in agricultural products. This paper presents a method for the isolation and purification of free fatty acids and mono-, di- and triglycerides from seeds. The method is optimized using a propylamino silica phase, and a variety of solvents were tested. Since the two classes of compounds (fatty acids versus glycerides) differ with respect to their ability to hydrogen bond or "ion pair" with the silica surface, separation of these two compounds can be achieved by judicious selection of elution solvents.

The objective of this study was the isolation of total free fatty acids as well as mono-, di- and tri- glycerides of vernolic, linoleic, stearic, oleic, and palmitic fatty acids from *Vernonia galamensis* seeds. Vernolic acid is commercially important, since it is an epoxy fatty acid (easily polymerized, useful for metal coatings, and potentially useful for paint). The oil is of a higher quality than that which is currently used for these applications (epoxidized linseed and soybean oils). The method was developed using small amounts of seeds (<120 mg) to conserve seed and to scale down oil extraction.

Oil is extracted from the seeds with hexane. Fatty acids and glycerides are extracted from the hexane using a solid phase extraction procedure. An aminopropyl phase was used for the extraction to retain analytes from the non-polar matrix through interactions between the amino groups on the modified silica surface and the carbonyl groups on the fatty acids and glycerides. For the elution step, advantage is taken of the differences in the lipophilic character between the fatty acids and the glycerides by eluting each of these fractions with solvents of different polarity. The naturally occurring fatty acids are quantified using a colorimetric analysis based on cupric acetate. A GC analysis of the methylated glycerides is used to determine the fraction of vernolic, stearic, oleic, linoleic and palmitic acids produced.

HYDROXY FATTY ACIDS AND HYDROXYLATED FATTY ACIDS

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Castor oil is an important, unique plant oil because it contains up to 85% ricinoleic acid (12-(R)-hydroxy-cis-9-octadecenoic acid), which is the only commercial natural fatty acid bearing an additional functional group. Two other oil crops containing monohydroxy fatty acids (*Dimorphotheca pluvialis* with about 60% 9-(S)-hydroxy-cis-10,cis-12-octadienoic acid and *Lesquerella fendleri* with about 60% 14-(R)-hydroxy-cis-11-eicosenoic acid) may be commercialized in the future. All these natural hydroxy fatty acids that are or may become available for non-food applications have similar structures and are therefore currently complemented by modified hydroxy acids. Castor oil is hydrogenated to obtain a saturated hydroxy fatty acid and dihydroxylated fatty acids are obtained industrially by ring-opening of epoxidized oils with water. Conditions for this epoxide-opening are usually drastic (e.g. 200 °C, sulfuric acid) which causes selectivity to be unsatisfactory. The enantioselective epoxide ring-opening under mild conditions is possible by epoxide hydrolases.

We developed various methods to hydroxylate fatty acids:

- Dihydroxylated fatty acids (and the corresponding oils) were obtained by direct vicinal hydroxylation of unsaturated fatty acids with hydrogen peroxide catalyzed by Mo-, Re- and most conveniently W-oxides; thus oils and acids with hydroxyl values of 340 and more are accessible. A variation of this reaction is the Mo-catalyzed alkoxyhydroxylation of C=C bonds by *tert*-butyl hydroperoxide leading directly to hydroxy ethers.
- Monohydroxylated fatty acid were prepared by catalytic hydrogenation of epoxidized fatty acids with Raney-Ni.
- Mixtures of regioisomeric hydroxy fatty acids were recently synthesized by oxidation of saturated fatty acids with peroxy trifluoro acetic acid in-situ. This method is a new route to hydroxylated fatty acids with various chain lengths (e.g. starting from lauric or stearic acid) or even branched hydroxy fatty acids (from Guerbet acids).

Whereas all these methods yield secondary hydroxyl groups similar to natural hydroxy fatty acids, more reactive primary hydroxyl group are also of interest. Primary hydroxyl group can be introduced in a fatty acid chain by Co- or Rh-catalyzed carbonylation of unsaturated fatty acids with subsequent reduction of the carbonyl to a methylhydroxy group.

In conclusion, synthetic hydroxylated fatty acid have a far larger range of structures, properties and potential applications. On the other hand, they lack the structural and especially stereochemical homogeneity of natural hydroxy fatty acids.

USING GENES FROM WILD SOYBEANS TO INCREASE POLYUNSATURATED FATTY ACID CONTENT OF SOYBEAN OIL

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Soybean [*Glycine max* (L.) Merr] oil typically contains ca. 55% linoleic acid (18:2) plus 8 % linolenic acid (18:3). However, the reactivity of soybean oil in certain industrial applications could be enhanced by an increased concentration of polyunsaturated fatty acids. Such a goal may be achieved through genetic manipulation of genes that govern the expression and activity of various w-6 and w-3 fatty acid desaturase enzymes in soybean. Two genes that encode major oleic (18:1) and 18:2-desaturases of soybean have been cloned, but molecular genetic approaches to over-express these genes in transgenic soybeans have not been successful. Another approach has been employed which involves use of natural genetic diversity in soybean to develop higher polyunsaturated oil through conventional plant breeding. The wild ancestor of modern soybean, *Glycine soja* (Sieb. & Zucc.), typically exhibits twice the 18:3 concentration of commercial soybean varieties and appears to be best source of genes for this purpose. Prior work has shown that wild soybeans carry alternative w-6 and w-3 desaturase genes,

which apparently were lost in the domestication of soybean. Three populations, created by mating pairs of three wild soybean accessions, were developed to identify allelic differences among these alternative desaturase genes. Analysis of progeny from each population revealed epistatic inheritance patterns, which indicates interaction of more than two gene loci. At this time, genetic variants of three desaturase genes appear to determine polyunsaturate levels in wild soybean. This hypothesis has been confirmed by analysis of wild soybean DNA with gene probes that specifically encode the major desaturase genes. *G. soja* genotypes have been selected with combinations of these genes that produce oils with 17% 18:3 and 73% total polyunsaturated fatty acid concentration. These genes are being transferred into cultivated soybean varieties exhibiting genes for very low (less than 7%) total saturated fatty acid concentration. Preliminary evidence suggests that the resultant gene combinations will provide novel breeding lines for development of soybean varieties having higher 18:3 concentration plus greater than 80% total polyunsaturates.

COMMERCIALIZATION OF VEGETABLE MOTOR OIL: THE MICHIGAN PROJECT

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Development of a new crop or product is as dependent upon marketing as upon the research that makes marketing possible. The Michigan Project is a joint venture between Agro Management Group (AMG) of Colorado Springs, Colorado, the Thumb Oilseeds Processors Cooperative (TOPC) of Ubyly, Michigan, USDA-Alternative Agricultural Research and Commercialization Corp. (AARC), and the United Soybean Board (USB). AMG had developed an environmentally benign motor oil derived from canola, soybeans, safflower and/or sunflower and utilized additional vegetable oils from jojoba, castor, lesquerella and meadowfoam to improve oil performance. TOPC had developed an oil crushing facility to process primarily soybean oil and meal. The two companies have joined in a joint ventured called "Great Lakes Oil Company" to manufacture and market their vegetable based motor oil and associated bio-based products.

Great Lakes Oil Company has aggressively pursued markets for the bio-based motor oils. Due to packaging costs and costs related to consumer education, fleet management systems were targeted. Fleet systems currently using the motor oil include the Great Lakes U.S. Postal Service, the State of Michigan, The Michigan State University system, Rural Electric, the Michigan Soybean Growers Association, TOPC and the Cities of Ft. Collins and Denver.

Great Lakes Oil is designed to promote and produce of bio-based lubricants and to enhance rural economic development. AMG and the USB joined forces to develop a "drive across America" called the Inter STATE 2000 to promote the use of these oils and to demonstrate the feasibility of vegetable oils as lubricants. The trip involved a month of driving (3 may to 3 June) covering over 11,000 kilometers. Two new 1999 Ford F150 4X4 trucks were purchased. Vehicles were matched as closely as possible and were made at the same facility within two days of one another. Engines were tuned to the same specifications. One vehicle utilized the bio-based engine oil while the second utilized conventional petroleum motor oil. AMG maintained a website through the duration of the trip. Prior to the trip, AMG received an average of 35 hits per day at the website. Within twop weeks of the launching from Los Angeles, California website hits had increased to 350 per day. By the time the two vehicles had reached Washington, DC, the website was achieving over 2,000 hits per day. The USB coordinated media events throughout the soybean production states and was able to obtain from the State of Nebraska a declaration of "Soybean Motor Oil Day". In Michigan, the USB was instrumental in passing a bill in the state legislature mandating the use of vegetable-based motor oils in the state fleet.

The project was able to attract national and international media attention throughout the trip. The American Broadcasting Corporation even interviewed the U.S. Postal Service Maintenance Center in Grand Rapids, Michigan and on-camera confirmed AMG's earlier reports of reduced vehicle emissions using the bio-based oils. The network MSNBC conducted a poll of consumers through its website and found that 76% of respondents would utilize the oil, even at an additional cost because of its environmental safety.

It is the goal of AMG to develop additional "Michigan Projects" in numerous rural communities both in the

United States and in foreign countries. Improvements in oxidative stability of the oils used, the advent of genetically engineered oils and a rural awareness of what "value added" really means have stimulated interest in these communities.

THIN FILM - HIGH TEMPERATURE OXIDATIVE, THERMAL AND DEPOSIT FORMING BEHAVIOR OF OILS FROM DIFFERENT ORGANIC ORIGIN

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The oxidative and thermal behavior of vegetable and mineral oils differs mainly due to their organic origin and hydrocarbon composition. The triglyceride structure associated with most vegetable oils have poor oxidative stability with a completely different mechanism and texture of insoluble deposit formation as compared to mineral oils, which are primarily hydrocarbons of different shapes and sizes. Since oxidation and deposit forming behavior for any base oils, irrespective of their origin, is crucial for their being considered for lubricant application, a clear understanding is required of the molecular composition of such oils and their plausible behavior under high thermal environment. The high temperature thermal and oxidative degradation pathway have been mapped for a series of vegetable and mineral oil base stocks, for their use as lubricant base oils. The current study was conducted under thin film condition in a micro reactor (25ml, 175, 200° C, 1 hr and high carbon steel catalyst), and the thermal behavior of oils were determined on the basis of their structural diversity. Significant variation in the evaporation rate (using micro reactor) and nature of insoluble deposit was observed through Scanning Electron Microscope (SEM). Gel Permeation chromatography (GPC) with an IR and UV detector was used to obtain the molecular weight distribution of the tetrahydrofuran (THF) soluble oxy compounds generated during oxidation.

The structural parameters obtained using quantitative ¹H and ¹³C NMR spectroscopy on the oxidized and unoxidized oils gave valuable information on the molecular composition and reaction pathway of the oils in terms of average structural parameters. The novelty of this approach is to explain the various thermal, oxidative and deposit forming phenomena of oils in terms of their structural diversity.

SOME STUDIES OF BIODEGRADABLE FUELS AND LUBRICANTS

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Environmental concerns worldwide have resulted in increased research activity on Environmentally Friendly Fuels and Lubricants (EFF&L). Several continuing studies are in progress at Penn State University to develop and evaluate various EFF&L. The research has resulted in development of marine and hydraulic fluids and vegetable base engine oils with performance approaching current mineral oil based lubricants. Use of both synthetic and vegetable oils studies are discussed. This includes improvements in low temperature properties and deposit forming tendencies of vegetable oils. In single cylinder and multicylinder tests in diesel engines, use of EFF&L gas resulted in reductions in engine particulate emissions. This has been due in part to the reduction in the soluble organic fraction (SOF) of the particulate materials. Some differences in morphology are noted. The advantages and disadvantages of various EFF&L base fluids are discussed.

MOBILE MEMBRANE TECHNOLOGY TEST TRUCK: RESULTS FROM FIELD EVALUATIONS

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The overloaded municipal wastewater treatment facilities are restricting the food processors to reduce BOD and COD levels of their wastewater to meet the federal limits. The edible oil refineries generate a variety of wastewater streams and consequently some of the individual streams increase the overall BOD level above the acceptable limits set by the municipal authorities. Cooling tower, barometric condensers, and refinery wash water streams are the major contributors to the overall BOD increase. In order to comply with the federal, state and municipal regulations, the edible oil refineries have given first priority to their waste treatment problems.

One of the most promising applications in edible oil industry is in the area of waste treatment. However, the nature and composition of the individual wastewater streams make it difficult to find a universal solution to all of these streams. Therefore the membrane separations must fit individually to each stream if the concentrate is considered as the saleable by-product.

A truck-based waste treatment demonstration unit was set-up at the plant and wastewater was pumped into the feed tank via separate line. This demonstration unit contains high and low pressure units, stainless steel fittings, and pipes. The test units can handle a wide variety of membrane types and materials in evaluating the potential of membrane separation to meet specific process flow requirements at host sites.

On-site membrane separation tests were performed at various edible oil refineries indicate that the wastewater can be recovered and reused as feed for water washing of the degummed oil. The membrane was very stable and effective in separating residual soapstock and other impurities. Quick tests at the refinery and detailed analysis in our labs indicate that the clean water permeate flux at 500 psi and 73°C was 50 l/m² hr. The second phase of this project evaluated recovery of cooling tower water using ultrafiltration membranes. The permeate flux at 200 psi ranged from 50 l/m² hr to 80 l/m² hr. The permeate quality was excellent. The residual free fatty acids in the feed formed a fatty layer on the surface of the membranes and this consequently reduced the overall flux. Recovery and reuse of waste water from the second centrifuge and cooling tower water is technically and economically feasible for the new plants.

COMMERCIALLY VIABLE PARTICLEBOARD ADHESIVE FROM SOYBEANS

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With the continual population growth in the United States, the need for suitable building materials has continued to grow at a phenomenal rate. To satiate this increasing need, wood composites are being used in place of whole lumber. To create indoor products, for example, composites are made using an urea-formaldehyde (UF) adhesive. Although, UF produces composites with good physical strengths, it is a source of formaldehyde emissions that are classified as a hazardous air pollutant.

To offset the harmful effects of formaldehyde, our research focused on the design, synthesis, and evaluation of soybean protein based adhesives for wood. Through the introduction of other environmentally-friendly materials, namely oil-based derivatives, substantial improvements to soybean protein's water resistance has been established. Blending of the various components to achieve synergy has allowed the development of a formaldehyde-free adhesive for particleboard composites with physical strengths equaling commercial boards. For instance, a measure of particleboard's strength is the internal bond value. To be commercially viable, particleboard must exhibit a strength greater than 90 lb/ft³. Particleboard using the novel soybean adhesive produces boards with values ranging from 90 to 225 lb/ft³. Furthermore, soybean-based particleboard submerged for two hours has water absorption values equal to that of commercial boards. This paper will describe our latest results in the area of soy protein derived adhesives.

EVALUATION OF CRAMBE, MEADOWFOAM, AND MILKWEED SEEDMEALS FOR CONTROL OF THE COUMBIA ROOT-KNOT NEMATODE ON POTATO

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The Columbia root-knot nematode, *Meloidogyne chitwoodi* is a serious problem to potato production, blemishing tubers and rendering them unmarketable. Control is heavily dependent on soil fumigation. The continued availability of these nematicides is a major concern to potato growers. Crambe (*Crambe abyssinica*), meadowfoam (*Limnanthes alba*), and milkweed (*Asclepias syriaca*) seedmeals were evaluated as soil amendments for control of *M. chitwoodi* on Russet Burbank potato. Crambe and meadowfoam seedmeals are processing by-products of the oil extraction of the seeds that contains high levels of glucosinolates. When the seedmeal is incorporated into the soil, the glucosinolates undergo an enzymatic hydrolysis to release isothiocyanate that is toxic to certain insects, fungi, nematodes, and weeds. Isothiocyanate is similar to the active ingredient of the soil fumigant metham sodium. Milkweed is a new crop being produced for its fiber in pillows and comforters, and industrial quality oil extracted from the seed. The toxic compound(s) is not yet known.

In 1997 crambe and meadowfoam, and in 1998 crambe and milkweed were evaluated at 11.2 and 22.4 MT/ha. In 1998 crambe was also evaluated in combination with MocapTM 6EC (ethoprop). Treatments were crambe 11.2 MT plus MocapTM 13.6 kg ai/ha, and crambe 22.4 MT plus MocapTM at 6.8 and 13.6 kg ai/ha. In both years Telone IITM (1,3-dichloropropene) at 187 l/ha and MocapTM 6EC at 13.6 kg ai/ha served as standard soil fumigant and nonfumigant nematicide checks, respectively, and untreated plots served as controls. Telone IITM was applied 3-4 wk. before planting as a broadcast by tractor-drawn chisels 46 cm. deep, spaced 46 cm. apart and packed immediately with a cultipacker. MocapTM was applied just before planting as a broadcast spray with a CO₂ pressurized backpack sprayer and incorporated 15 cm. deep with a rototiller. The seedmeals were applied 3-4 wk. before planting as a broadcast and incorporated 15 cm. deep with a rototiller and packed immediately with a cultipacker. Certified Russet Burbank potato seed-pieces were planted and harvested approximately 5 mo. later. Nematode counts, yield and tuber infection data were obtained from the middle row of each plot.

In 1997 crambe was more effective than meadowfoam seedmeal in reducing tuber damage caused by *M. chitwoodi*. However, only Telone IITM produced tubers with < 10% culls. Tubers with > 10% culls may be rejected or severely downgraded. In 1998 crambe at 11.2 and 22.4 MT provided good control with 10 and 11% culls, respectively, and milkweed at 22.4 MT (3% culls) gave excellent control. Crambe at 11.2 and 22.4 MT in combination with Mocap 13.6 kg gave excellent control with < 5% culls. Results show that crambe and milkweed seedmeals may be an effective management strategy for reducing tuber damage caused by *M. chitwoodi*.

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GUAYULE 1

NATURAL RUBBER (*Hevea brasiliensis*, Muell Arg) GERMPLASM COLLECTION IN THE AMAZON BASIN, BRAZIL: A RETROSPECTIVE.

Oghenekome U. Onokpise

Hevea brasiliensis whose center of diversity is in the Amazon basin, is the the major source of commercial natural rubber in the world. In the 1970s, the need for *Hevea* germplasm collection arose from the realization that there was a gradual erosion of the genetic variability of the rubber clones in many natural rubber plantations. This was because, most of the clones in cultivation were derived from the few surviving seedlings obtained from seeds collected by Henry Wickham in 1876. Thus, to broaden the genetic base of the natural rubber plantation industry in Asia and Africa, the major producers of natural rubber, it became necessary to undertake an expedition to the Amazon basin to obtain materials for the replenishment of the 'gene pool' in these plantations.

This expedition called 'Germplasm 81', was organized in four stages: 1. A 1976 seminar organized by the International Rubber Research and Development Board (IRRDB); 2. A 1977 workshop also organized by the IRRDB; 3. A 1978 preliminary mission by IRRDB officials, to several countries in south America and the Carribeans; and 4. The germplasm exercise by scientists from IRRDB countries (Cote d'Ivoire, Indonesia, Malaysia, Nigeria and Thailand), China and Brazil, from January to April, 1981. A 'dummy run' to test the viability of seeds from Manaus, Brazil was undertaken in 1980. The germplasm collection covered three states (Acre, Mato Grosso and Rhondonia) in Brazil.

Collection teams traveled into the remotest parts of the Amazon rain forests looking for high yielding and disease resistant trees from which to collect seeds, budwood, and seedlings growing around the trees. A total of 63,768 seeds, 1413 meters of budwood, and 1160 seedlings were collected by the three teams. Following agreements with the Brazilian government, collected seeds were divided on a 50% basis between IRRDB and Brazil. Materials for Brazil were retained in Manaus, while those for IRRDB were initially sent to Britain for phytosanitary treatment and then to Guadeloupe for further quarantine in 1982, before being sent to Asian and African reception centers. Scientists who participated in the exercise had to quarantine in a temperate country for at least one week before returning to their research institutions. This was done in order to avoid the spread of the deadly South American Leaf Blight (SALB) disease that has prevented Brazil from becoming a major world producer of natural rubber, inspite of efforts by Goodyear and Firestone Rubber Companies in the early 1900s.

As a retrospective to this unique international excercise, this paper revisits the activities undertaken in the state of Mato Grosso while providing an overview of the entire germplasm collection exercise. Although, other smaller expeditions have since been made to the Amazon basin, none has been as comprehensive as 'Germplasm 81'. Given the cost and logistics, it may be necessary to delineate an area in the Amazon rain forest for in situ natural rubber germplasm preservation. Existing genebanks in Africa, Asia and Europe will complement these efforts.

DATA FOR SELECTION OF MEXICAN GUAYULE SITES WITH INDUSTRIAL EXPLOITATION POTENTIAL.

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The actual conditions of plant population, rubber, resin and biomass production of wild stands of Guayule in Mexico are not well known. This information is of capital importance for raw materials supply for Guayule industrial exploitation. In this project four sites were monitored to evaluate their potential as guayule rubber and coproducts yielding.

Samples from the sites, low land and hills, were collected every month during October 1998-September 1999. The sites correspond to two sites previously detected as high yielding and two sites from where no information was available. The high yielding sites were: Rocamantes (Coahuila state) and Noria de Guadalupe (Zacatecas state) the other two were at Gomez Farias site (Coahuila state). Samples consisting of seven plants were collected and transported to the laboratory for analysis, the plants were measured, weighted and separated in root and stem and branches. Plant parameters such as stem and primary branches, diameter, height, spread, rubber and coproducts content were determined.

The results up to date indicate that all four sites are high yielding, around 11-12% rubber, and that the plants from the hill are broader than those from the valley although rubber and resin content were similar. It is interesting to note that rubber percentage decreased during the rain season (June–October), these results are consistent with our previous determinations carried out at other sites, and the rubber cyclic production. Differences in rubber production are expected because plants have different height and weight depending on the site.

ESTABLISHING GUAYULE BY DIRECT SEEDING UNDER SALINE CONDITIONS IN WEST TEXAS

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The Toyah Basin area of Reeves County Texas supports over 8,000 ha of irrigated cropland. Average annual rainfall (25 to 30 cm) is not sufficient for dryland crop production; therefore, cotton and other crops (sorghum, small grains, melons, and vegetables) must be produced under irrigation. Surface water sources are very limited, and most of the irrigation water is pumped from underground aquifers. Irrigation water (4.7 dS/m) and soil (7.0 dS/m) salinity can be high in some areas, which usually limits crop production to cotton. The majority of producers still in business are experiencing serious financial stress and are attempting to survive in one of the more costly cotton production regions of the country. The commercialization of alternative crops would increase farm profitability and promote economic opportunities in west Texas farming and rural communities.

Guayule has been successfully direct seeded in west Texas when irrigation water salinity averaged 1.3 dS/m, but studies have not been conducted under saline conditions. The objective of this study was to establish guayule by direct seeding with irrigation water of 4.7 dS/m. An experiment will be initiated in August 1999 at the Texas A&M University Agricultural Experiment Station near Pecos, Reeves County, Texas. Conditioned guayule seed will be seeded with two types of planters: (1) Gaspardo SV255 pneumatic planter, and (2) Planet Jr. Seeding will be on raised beds in a variable row spacing configuration with 86 cm between plant rows and a 107 cm dry middle. The seeding rate will be 100 seeds/m. The study will be irrigated with sprinklers until seedlings emerge, and furrow irrigated thereafter.

Spring environmental conditions (high wind and evaporation, and air temperatures exceeding 38°C) coupled with salinity make direct seeding of small-seeded crops difficult in west Texas. Late summer seeding may be successful if seedlings can be adequately hardened before frost.

EFFECT OF 8'-METHYLENE ABSCISIC ACID AND COLD ON GROWTH OF, AND RUBBER AND RESIN PRODUCTION BY GUAYULE SEEDLINGS

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Rubber transferase, the enzyme that catalyzes the biosynthesis of rubber, is highly active during the winter months and is thought to be induced by cold temperatures. However, rubber is still made during the summer by field-grown plants and rubber transferase activity is present in all lines tested. Activity levels are substantially lower in the summer than during the winter. Fluctuations occur in the summertime activity level that may be related to the water status of the shrub. The involvement of cold and possibly water status, suggest that the endogenous plant growth regulator abscisic acid (ABA) might play a role in the induction of rubber transferase activity. Therefore, we used controlled environment chambers to investigate the effect of cold and an exogenously applied stable analogue of ABA, 8'-methylene-ABA, on the growth of seedlings of the guayule line O-16 and the hybrid line AZ101, and quantified the rubber and resin levels in the roots, stems and leaves of the plants.

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JOJOBA

TECHNICAL, ENVIRONMENTAL AND SOCIO-ECONOMIC OBSTACLES OVERCOME IN THE PRODUCTION OF JOJOBA OIL BY PALESTINIANS IN THE HILLS AND ARID REGIONS OF THE WEST BANK: A COMPARISON WITH USA TECHNOLOGY

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Jojoba was introduced to the West Bank in 1983 by the author as an appropriate technology transfer program of the Arab Scientific Institute for Research and Transfer of Technology (ASIR). Lack of plant propagation facilities dictated use of seedlings from seeds. The genetic variant of jojoba trees most suitable for its dry-farming in the hilly and marginal lands of that arid region were selected for obtaining the cuttings used for seedlings propagation. The naturally multi-stem jojoba bushes were yearly pruned to only one or two stems forcing these bushes to adapt and form trees which are planted 3.5 meters apart. Most male plants - which are made to be 15% of the total B are only slightly pruned.

Palestinian environmental conditions in the West Bank region (except for the little or no rainfall from May to October) has similarities to the US Southwest in Arizona and Southern California, the areas which are the wild natural habitat of jojoba. Taking that into consideration, plowing after each rainy period is undertaken to conserve moisture for the jojoba trees, remove weeds and distribute the added organic manure. The ripe jojoba nuts (seeds) which easily fall on the ground by the end of the summer are handpicked and cold-pressed to obtain a clear light golden yellow jojoba oil.

These practices are similar to those used for olive cultivation and production in Palestine and - up to 1999 - over 25,000 jojoba trees have been planted in this manner in Palestine thus far. The extra virgin Palestinian jojoba oil produced in a local screw press is exported to Europe and the USA as well as to the neighboring Arab countries through Jordan. This is unlike jojoba cultivation in the USA where jojoba plants are planted closely in rows, nourished by chemical fertilization and irrigation with no pruning done except for straightening the jojoba bush hedges. Weeds are eliminated by herbicides. The fallen jojoba seeds are harvested by pushing them with irrigation floodwaters and using a tractor-pulled vacuum. Pressing is usually done at high temperature producing yellowish brown jojoba oil.

In contrast to that in the USA, there is availability of labor in Palestine for cultivation and hand pruning with the participation of family labor for the yearly handpicking of the jojoba seeds in the summer - with no water contact whatsoever. This practice allows Palestinians to produce clean, fresh and dry jojoba seeds yielding an organic extra virgin jojoba oil under dry-farming conditions of 300-500 mm rainfall just as their forefathers have olives for thousands of years.

It is true that the socio-economic conditions and the lack of available water for irrigation in this semi-arid region

necessitates a wide spread cultivation of this highly expensive oil tree crop in a poor third world emerging country as Palestine. However, there is a resistance to growing jojoba dictated by the fact that it is a new tree crop, its marketing channels are also few, and governmental support and financial loaning institutions for investors are currently not easily accessible in Palestine. The establishment of such an economic water conservation industrial crop in Palestine suits the environmental and socio-economic conditions I that arid and hilly region of the Middle East.

SIMMONDSIN AND WAX ESTER LEVELS IN 100 HIGH-YIELDING JOJOBA CLONES

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This three-year study examines differences in simmondsin and wax ester production in 100 high-yielding jojoba clones. These clones were the top producers of 1,200 clones that had been mass-selected from more than 1,200,000 female plants by the Purcell Jojoba International (PJI) Variety Trial program. Broad selection criteria were applied to retain a healthy degree of the wild plants heterogeneous vigor. In this study, certain female clones produced 64% higher simmondsin levels than the mean. Other clones produced 16% higher liquid wax esters levels than the mean. A few clones had high levels of both simmondsins and wax esters. In addition, differences in fatty acid and fatty alcohol production among the clones were determined. These results provide a strong foundation for major growth of the jojoba industry.

EVALUATION OF JOJOBA CLONAL CULTIVARS IN CENTRAL ARIZONA

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Jojoba clones selected from superior female plants are now being grown at various locations in the United States and in other regions of the world. However, comparison plantings of these selected clones have not been made in regions where commercial production is occurring. Selected female clones are currently being evaluated at two locations in Arizona as part of a joint project between the University of Arizona and the University of Chile. Eighteen clones obtained from the University of Arizona, the University of Chile and Australia were planted in the spring of 1995 at the University of Arizona's Maricopa and Citrus Agricultural Centers. The Maricopa location has air temperature minimums as low as -8 C in the winter and is being used to evaluate clones for cold hardiness, while the Citrus Farm location is warmer and supports growth and production comparable to commercial growing areas in Arizona.

Frost damage to jojoba has occurred at Maricopa every year during the study period (1995-1999), but very little damage has occurred at the Citrus Farm. The clones being evaluated have shown a wide range of tolerance to freezing temperatures. Seed yields and seed wax concentration data for the clones will be reported for 1997, 1998 and 1999. Data on plant volume estimates will be reported for 1996, 1997 and 1998. In 1998, seed yields from clones ranged from 89 to 900 g/plant at Maricopa and 72 to 742 g/plant at the Citrus Farm. Wax concentration ranged from 48 to 56% at Maricopa and 46 to 57% at the Citrus Farm. Plant volumes ranged from 0.8 to 3.5m³ at Maricopa and 0.5 to 1.6m³ at the Citrus Farm.

LIQUID WAX CONTENT AND WAX ESTER COMPOSITION OF TEN JOJOBA CLONES GROWN IN TWO ARID ECOSYSTEMS OF SOUTH AMERICA

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Jojoba (*Simmondsia chinensis* L.) is an industrial crop suitable for Arid and Semiarid lands having warm summers and mild winters. Jojoba was introduced in 1976 in Argentina, in the Arid Chaco, and in 1982 in Peru, in the Atacama Desert. Today, jojoba is commercially grown in both countries. The seed's liquid wax (LW) is used in the domestic cosmetic industry, and is exported.

Seeds from ten jojoba clones, five from each location, were harvested in 1996 and 1997 and evaluated in the laboratory. LW percentage was significantly different ($P < 0.05$) between locations and within locations among clones. The highest and lowest values of LW content were 58.75% and 49.85%, respectively. The Peruvian and Argentinian clones yielded average LW contents of 56.61% and 52.01%, respectively. The main wax ester isolated was C:42, followed by C:40, C:44, C:38, C:46, and C:36. The LW and wax ester balance was significantly different ($P < 0.05$) among clones at each location, and between locations. LW content and wax ester composition were compared between years at each location, and between different plants of the same clone. Some clones showed variations in LW content and wax ester composition between years: clone A-SF5-121 was significantly different ($P < 0.05$) in LW content, and in C:36, C:38, C:42 and C:44 wax ester content; however, clone A-SF-40 did not show a significant difference ($P < 0.05$) in LW content or wax ester composition. Comparing plants grown from the same clone showed significant differences ($P < 0.05$) in only in the C:40, C:44, and C:46 wax ester content.

The data show that jojoba clones have significant variability in LW content and wax ester composition between and within locations. Also the data indicate that jojoba clones growing in the Atacama Desert of Peru produce significantly ($P < 0.05$) higher yields of LW and C:42 wax esters, than do clones growing in the Arid Chaco of Argentina.

YIELD PARAMETERS IN YOUNG JOJOBA PLANTS AND THEIR RELATION TO ACTUAL YIELD IN LATER YEARS

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Thirty jojoba clones, among them six already commercial clones and 24 newly selected ones were characterized in terms of yield parameters, chilling requirements and morphological traits. The aim was to supply farmers (from Israel and abroad) better yielding clones.

Considerable variability was found among the clones in all the parameters. Some clones exhibited excellent vegetative traits related to yield potential, such as a high survival rate, rapid growth, extensive branching, high node density, while others exhibited outstanding reproductive traits, such as earliness, high flower density, high percentage of fruit set, high seed weight, and high wax content in the seed. The clones also differed in their wax composition. Plants began to yield two years after planting in the field, some having commercial yields as early as their third year. The best clones with respect to wax yield were Hazerim, Negev, BGU, Forti, and Gvati, all new clones not yet planted in commercial plantations. An attempt to relate yield parameters at the third year to wax yield at their sixth year was made. The height in the third year and the flower index, relative fruit set and seed weight were related to yield. Flowering pattern of all the clones was followed up during the season 1993/94, which was characterized by a combination of cool night temperatures with warm days. This weather enabled the clones that broke dormancy to flower during the winter instead of spring. We were thus able to identify clones with different chilling requirement. In conclusion some very promising clones with high yields can be added to our commercial clones. Owing to the new information gathered on depth of dormancy and flowering pattern, clones can also be allocated to environments differing in climatic conditions

IN VITRO HARDENING OF JOJOBA PLANTLETS

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Micropropagation of jojoba (*Simmondsia chinensis* L.) is a very promising means of mass production of superior clones for commercial plantations. However, problems of acclimatization of the micropropagated plantlets have still to be addressed before this method of propagation can become commercially viable. We therefore attempted to harden the cultured plantlets in vitro by changing the atmosphere of the cultures. To this end, jojoba plantlets were cultured under different ventilation conditions, the rate of ventilation being determined by the pore-size diameter of the gas-permeable membrane used to cover the growth vessels. The effect of the ventilation rate on hardening was evaluated in terms of growth of plantlets (elongation and biomass), rate of water loss under room conditions, structure of leaf epicuticular wax (scanning electron microscopy) and leaf anatomy. It was found that a high ventilation rate promoted hardening of jojoba plantlets in vitro: Plantlets grown under high ventilation rate were shorter and had fewer, but larger, leaves than control plantlets. A higher ventilation rate was also associated with a slower rate of water loss under room conditions. Scanning electron microscopy showed the rate of water loss to be related to the appearance of the concentrations of epicuticular wax. Finally, for the plantlets grown under high ventilation, the vascular tissue was more developed and there were more lignified cells. Although high ventilation had a beneficial effect on the hardening of the plantlets, its ultimate effect on acclimatization and success in transferring plantlets from culture to the field is still to be determined.

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GUAYULE 2

GUAYULE RUBBER AND LATEX CONTENT - VARIATION WITH TIME

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This project, sponsored by the USDA Foreign Agricultural Service, began in 1996. The overall goal of the research is to speed up guayule commercialization by providing two crop seasons per year in which guayule can be analyzed and evaluated since growing and testing would take place in both the northern and southern hemispheres.

Results of the latex and rubber analyses conducted in Argentina have shown their percentages to vary with season, with the winter values being somewhat greater than the summer values. Variations among lines also exist, with two of the old USDA lines (N565 and 11591) proving consistently superior than G7-14 in terms of latex and rubber percentage.

Mean shrub mass for the three lines increased over the duration of the trial, with G7-14 increasing much more than the other two lines. If the rubber and latex percentages are combined with shrub mass, minimal differences in

rubber and latex production per plant were found to exist among the three lines.

GUAYULE, RUBBER AND BIOMASS PRODUCTION RESPONSE TO DIFFERENT WATER MANAGEMENT CONDITIONS

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In order to promote the increment of guayule cultivated areas, it is desirable to know the crop management particularly water management. In México there is lack of knowledge about water management effects on Guayule crop, the present study is focused on this topic and the effect of watering on rubber and biomass production.

Guayule seeds were collected at Noria de Guadalupe site in Zacatecas state during November 1997 and the experiment performed at the University field. Guayule seeds were grown in a greenhouse during February 1998, in April the plants were transferred to plastic bags and transplanted to the field by the end of June. Four plots (170 m², 15 × 12 m) were planted observing a distance between rows of 0.9 m and 0.36 m between plants. The plant density was 30,000 plants per hectare. Each plot represented a watering condition: 1.- Monthly, from February until the rain season starting. 2.- Every 45 days from February until the rain season starting. 3.- Two water applications (February and March). 4.- Non irrigated. An aluminum tube (2" diameter) was placed in each plot to introduce the neutron moisture meter (Troxler-4300) for soil moisture measurements. Moisture readings were acquired every 7-10 days. During the experiment four collects consisting of seven plants each were obtained from each treatment for rubber and biomass determination. The response of the plants to water treatment was measured in terms of height, spread, stem diameter, as well as rubber, resin and biomass production.

Difference between treatments was observed, well irrigated plants were taller, broader than the non irrigated or partially irrigated plants. Rubber, resin and biomass production is being measured and correlation between variables will be presented.

EFFECT OF TEMPERATURE AND DEHYDRATION ON LATEX YIELD

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We investigated the effect of post-harvest storage conditions on extractable latex content of guayule branches.

We found that harvested guayule branches can be stored at 4 °C for at least two weeks without compromising latex yield, provided that dehydration does not occur. However, even though latex levels were stable for two weeks at 4 °C, they declined quickly at warmer temperatures, even when fully hydrated, and were adversely affected by even mild dehydration. The investigation was extended to examine the effect of dehydration and temperature on the stability of latex in small, medium and large diameter guayule branches and to determine to what extent loss of extractable latex reflects latex coagulated into solid rubber in situ as opposed to overall degradation of the rubber.

MAINTAINING LATEX LEVELS IN HARVESTED AND GROUND GUAYULE SHRUBS

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A decrease in extractable latex from guayule branches has been observed in laboratory-stored samples, which could be prevented by refrigeration, but would be impractical for processing large quantities of shrub. Similarly,

the solid rubber contents of field-stored shrubs are reported to be lower than those processed immediately after harvest. As noted, the primary cause of the decrease appears to be related to the water status of the shrub. We found that drenching the freshly harvested shrubs with water and storing them in a moist condition in the shade could maintain the latex level of the shrubs for a period of at least 14 days.

Degradation of rubber is further accelerated by grinding the shrub and is a problem when the ground and flaked material cannot be processed immediately. Several methods have been proposed for storing this processed material for the organic solvent extraction procedure, but they are not suitable for the water-based latex extraction. By directing the chipped shrub from the grinding equipment straight into a pH 11-adjusted solution containing an antioxidant (NaSO_3), the latex content of the shrub could be maintained. We also found that even a short delay in the time between the grinding and the soaking of the chipped material could lead to a large decrease in extractable latex.

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SIMMONDSINS

HEMATOLOGICAL AND PATHOLOGICAL EFFECTS AFTER CHRONICAL ADMINISTRATION OF 0.25 % PURIFIED SIMMONDSIN TO RATS

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160 young male Wistar rats (160 - 180 g) were housed, two by two, in plastic cages and divided in 3 groups. Controls (n = 40) had free access to normal rat chow (C-group). A second group (n = 60) was offered normal rat chow supplemented with 0.25 % of purified simmondsin (S-group). A third group (n = 60) was pair-fed to the S-group (PF group). Food intake (FI) of the C- and S-groups was measured three times a week, while the PF-group received the same amount of food eaten by the S-group the previous 2 - 3 days. Body weight (BW) was controlled weekly. 4 rats of each group were killed for hematological and pathological examination 1, 2, 3, 5, 7 and 10 weeks after the start of the treatments. After the 10th week, the remaining 36 rats of the S- and PF-groups were divided in 2 groups of 18 rats each, one continuing the treatment (S- and PF-groups), the second group being allowed to eat freely normal food (RS and RP groups). Their FI and BW were followed as described above. At weeks 12, 15 and 18, 4 rats of each group were killed for examination. At week 20, 6 rats of each group were sacrificed. At necropsy, blood was taken by heart puncture. Hematological parameters (RBC count, hemoglobin concentration, hematocrit, MCH, MCHC, WBC and platelet counts) were determined. Biochemical parameters for liver and kidney function (GOT, GPT, creatinin) and for possible hemolysis (LDH, bilirubin), were measured. Heart, lungs, pancreas, kidney, liver, stomach, small and large intestines, mesenteric lymph nodes, spleen and thymus were dissected, weighed and fixed for pathological examination. Technical grade simmondsin was obtained from the USDA (Dr. T. Abbott) and purified further by a recrystallization cycle in methanol/acetone to obtain a purity of + 99 %.

Simmondsin treatment induced a sustained FI reduction of about 25 % of controls. Compared to the C-group, growth was similarly decreased in the S- and PF-groups. After refeeding, the RS- and RP-group increased their FI immediately. The FI however was lower than in group C, most probably because the RS- and RP-animals were smaller than the C-rats. Consequently, the difference in FI of S and RS was only about 15 %. The RP-group ate

more than the RS-group during the first week of refeeding, but afterwards no statistical significant difference was seen anymore. RS and RP-groups showed a similar growth increase compared to the S- and P-groups. After 3 weeks, a slight but statistically significant macrocytic, normochromic anemia was installed in the S-group compared to the PF-group, which remained unchanged for the entire treatment period. Also a small decrease in WBC's and a transient decrease in platelet numbers was observed. Compared to the PF-group, the relative weights of pancreas, liver and kidney were increased in the S-group from the 3rd week on, while their relative lung weight increased only from the 10th week on. Upon pathological examination, no differences were seen between the 3 treatment groups except for the lymph nodes in the S-group in which the peripheral sinus was filled with RBC's. Also, the studied biochemical parameters remained unchanged. After refeeding, the hematological parameters returned to normal in the RS-group. The relative weights of the organs also normalized, except for the kidneys which remained relatively higher in the RS-group than in the RP-group, although their absolute weights were the same. The RBC's in the mesenteric lymph nodes of the RS-group disappeared leaving only some iron pigment.

We conclude that the observed phenomena suggest that +99 % pure simmondsin induces very rapidly a slight, sustained but reversible macrocytic, normochromic anemia. No other toxic effects on the studied organs could be observed, except for a slight lung congestion at the end of the treatment period. These observations, including the lung congestion, are suggestive for a lack of vitamin B12 and/or folic acid or for a disturbance of their metabolism. Taking into account the very rapid onset of the anemic reaction, folic acid is more likely to be involved than vitamin B12.

THE ACUTE AND CHRONIC RESPONSES TO SIMMONDSIN

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We have undertaken a series of experiments to explore the characteristics of the anorectic response to simmondsin. An acute dose response study (0.10 to 2.0% in diet) showed a significant inhibition of food intake at 24 hours at 0.5, 1.0, and 2.0% but not at lower doses. By pairing the administration of simmondsin with saccharin solution we were able to show that the anorectic response was not related to the induction of any conditioned taste aversion. However, unlike previous data, we were unable to block the anorectic response to simmondsin with the CCK antagonist Lorglumide.

Two long-term feeding studies have been completed with oral simmondsin. The initial study was a seven week chronic feeding study in Sprague-Dawley rats fed rat chow given simmondsin (0.5% in diet) and compared to an ad-libitum fed control group and also to a pair-fed non-drug treated group (n=10/group). Average daily food intake was reduced by approximately 40% in simmondsin treated rats over the first 28 days of the study. Body weight was decreased slowly by dietary simmondsin but at a faster rate than in pair fed controls whereas ad libitum controls gained >30% body weight during the experimental period. However, from days 38 to 48, 8 rats treated with simmondsin died, death being preceded by sudden and very rapid weight loss. No infection was evident and there were no deaths in any other group. At sacrifice, the remaining simmondsin treated rats (n=4) were characterized by pancytopenia and relative increases in the weight of kidney and liver compared to the pair-fed controls.

To study the effect of simmondsin on blood cells, we undertook a second chronic feeding study with a range of Simmondsin doses (0.015% to 0.5% in the diet) for 28 days. Again, only the two highest (0.15 and 0.5%) doses reduced weight gain. At sacrifice, rats treated with the two highest doses of simmondsin (0.15% and 0.5%) had both reduced hematocrit values below the normal range whereas rats receiving lower doses of simmondsin that did not lose weight had hematocrit values within the normal range.

These studies suggest that doses of simmondsin that affect feeding behavior may be associated with toxic effects on the development of blood cells. Further work is required to understand the mechanism through which simmondsin affects the production or turnover of blood cells.

MODIFICATION OF SIMMONDSIN AND ITS ANALOGUES

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Simmondsin and its analogues, demethyl-, didemethylsimmondsins and the 2'- and 3'-simmondsin ferulates are components isolable from jojoba (*Simmondsia chinensis*) seed meal. Like the parent compound, simmondsin, is reported to exhibit anorexic properties, all its analogues not only lack this behavior, except the ferulates, and have no identifiable market value. For a new industrial crop to be profitable, it is important that most of its components have unique marketable properties in order to justify the initial investment of capital. Thus, the goal of this research project was to chemically functionalize demethyl- and didemethylsimmondsins thereby imbuing them with characteristics for economic potential.

A two pronged approach was conceived for converting these materials to useful compounds. The first was a selective remethylation of the 4- or 4,5-positions, respectively, of the demethylated isolates in order to regenerate simmondsin. And secondly, to modify the cyano function either reductively to generate the amine derivative of simmondsin or by an analogous pathway to the amides. In this vein, simmondsin and the demethyl analogues have been partially and exhaustively methylated, as well as acetylated to give the respective intermediates. Because of the sensitivity of the parent compound to both acidic and alkaline environments, the permethylated ether was converted to the imidates via the cyano function. The imidates were then condensed with fatty amines as substrates in the formation of simmondsin amides.

INTERLAB COMPARISON OF SIMMONDSIN ANALYSIS

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Eleven samples containing various amounts of simmondsin (S), simmondsin ferulate (SF), demethyl simmondsins (DMS) and didemethyl simmondsins (DDMS) were sent to four different laboratories for analysis. The samples were made from chromatographically pure simmondsin, animal feed formulations containing jojoba meal, defatted jojoba meal, water extracts of jojoba meal and combinations of these ingredients. Where mixes were made, all materials were ground together in a coffee mill and sieved. Three labs analyzed for at least 3 components and one lab analyzed for only S. The means of the S, SF, DMS and DDMS percentages in the samples were determined to be: sample #1, 96.0% S, 0 SF, 3.16% DMS, 1.23% DDMS; #2, 100 % S, 0 SF, 0.36% DMS, 0 DDMS; #3, 31.9% S, 2.37% SF, 9.34% DMS, 4.92% DDMS; #4, 21.8% S, 1.78% SF, 7.46% DMS, 5.23% DDMS; #5, 0.72% S, 0 SF, 0 DMS, 0.02% DDMS; #6 7.22% S, 1.44% SF, 3.14% DMS, 2.14% DDMS; #7 16.9% S, 3.19% SF, 0 DMS, 0 DDMS; #8 12.9% S, 0.90% SF, 0.06% DMS, 0.04% DDMS; #9 4.73% S, 0 SF, 0 DMS, 0 DDMS; #10 44.9% S, 0 SF, 1.70% DMS, 1.13% DDMS; #11 8.17% S, 1.44% SF, 2.99% DMS, 2.09% DDMS. The implications of the amount of the components for these sources will be discussed. There were no significant differences between laboratories, but, with more analyses from other labs, smaller differences may appear statistically that do not appear with the results from these four labs.

SYNTHESIS OF ACARBOSE TRANSFER PRODUCTS BY BACILLUS STEAROTHERMOPHILUS MALTOGENIC AMYLASE WITH SIMMONDSIN

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Simmondsin, a material related to food intake inhibition from jojoba (*Simmondsia chinensis*) was transglycosylated by *Bacillus stearothermophilus* maltogenic amylase (BSMA) reaction with acarbose to synthesize an antiobesity compound with hypoglycemic activity. Ten percent each of acarbose and simmondsin were mixed and incubated with BSMA at 55° C. Glycosylation products of simmondsin were observed by TLC and HPLC. The major glycosylation product was purified by using Biogel P-2 column. The structure was determined by using MALDI-TOF MS and ¹³C-NMR. The major transglycosylation product was pseudotrisaccharide(PTS)-simmondsin in which PTS was attached by an a-1® 6 glycosidic linkage to simmondsin. The transglycosylated simmondsin reduced the food intake and postprandial blood glucose response in mice. The results indicated that the transfer products would be effective in lowering both food intake and blood glucose.

CAPILLARY ELECTROPHORESIS: NOVEL TOOL FOR SIMMONDSINS ANALYSIS AND ITS APPLICATION TO JOJOBA BREEDING

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The jojoba plant (*Simmondsia chinensis*) is naturally occurring in desert regions of Mexico and southern United States. Jojoba is successfully grown in other part of the world, for example, Peru, Israel and Argentina.

The interest in jojoba seed is due to the unique oil present in its seeds. Unlikely the majority of other seed, the content of triglycerides in jojoba seed oil is relatively low. However, high levels of wax esters make this oil a valuable product for the cosmetics market.

Simmondsins, anti-nutritional components present in jojoba meal, have attracted the attention of several research groups and their possible application as animal feed additive. The food intake suppression has been demonstrated when simmondsins were added to animals diet.

The analysis of simmondsins level is of interest to plant breeders, jojoba processors, animal feed industry and researchers conducting animal nutrition studies. Simmondsins represent a group of closely related cyanogenic glycosides: simmondsin, demethylsimmondsin and didemethylsimmondsins, along with corresponding ferulates.

Growing interest and potential for application of simmondsins as feed additives calls for efficient and quick analytical methods both for quantitative and qualitative analyses. The HPLC is commonly used for simmondsins analysis, however, the presence of chiral ferulates may require more precise analysis, especially for animal studies. The action of chiral compounds and recognition of molecular chirality are important subjects, especially in the nutritional studies, because stereochemistry can have significant effects on the biological activity of given components. Further, it is necessary to develop a chiral analysis method for the determination of the optical purity of bioactive components from the viewpoint of quality control. The characterization of chiral drugs is important because many drugs have only one active enantiomer while the other is either inactive or, in some cases,

potentially harmful. The antipode of a chiral drug is regarded as one of its impurities, and may be responsible for drug side effects. The U.S. Food and Drug Administration (FDA) has set guidelines for marketing chiral drugs which require pharmaceutical companies to show proof of chiral composition.

Chiral isomers might be formed during processing or storage of bioactive material, or be a result of altered biosynthesis pathways in plant due to environmental stress or genetic manipulation. Therefore, optical purity might provide a valuable information to plant breeders as well as processors.

Capillary electrophoresis (CE), a powerful separation procedure based on physical size and charge, has recently emerged as a convenient technique for chiral drugs because of its increased separation efficiency compared to HPLC. Major active components in jojoba meal were detected and quantified using CE methodology. Capillary electrophoresis presents novel versatile tool for simmondsin analysis and its application to breeding programs and jojoba meal processing will be presented.

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FIBERS

THE KENAF CROP AT THE YAQUI VALLEY, SONORA, MEXICO

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Most of the southern Sonora, Mexico farmers, mainly for the Yaqui and Mayo Valleys, it's important to have several species to be growth in the spring-summer cycle, this is because important crops like sesame and soybean has been eliminated for a biological problem, due to the devastating attack of the white fly *Bemisia argentifolii*. The kenaf crop *Hibiscus cannabinus* L. could be a good option in the economy of the Sonora producers, because this is a fiber crop highly tolerant to this insect, it's planted in may and harvested in October. By the potential importance of this crop, is necessary to implement a production technology, that's why this job it's been doing at the experimental field at the Instituto Tecnológico Agropecuario No. 21.

In 1989, came in from Texas, U.S., the varieties Everglades 41 and Everglades 71, this were planted experimentally in two kinds of soils: one of them was deep clay of good quality predominant in the experimental field, and the other one with strong problem of salinity located at four kilometers from the see. The planted surface in each location was a half hectare per variety. The genetic material was characterized in both conditions and the yield of biomass was evaluated. In 1993, were received 8 additional varieties: Cuba 2032, Tainung No.1, Xiang, 45-9X. 45-9X harvested, CV-34, RS-10, and G-45. At the same time that they were characterized it was made a plan of diallelic crosses between the 10 introduction varieties, and with this, the kenaf breeding program, started. The progeny was handled under the pedigrí system for self pollinated plants. However, at the same time, together with the improvement plan, it's been working with the most important agronomical aspects.

From the planted plots in 1989, with the Everglades varieties, good results were obtained. In salinity conditions from Bahía de Lobos (Lobos bay), the biomass yield was 15.5 Ton/ha in average, meanwhile the yield in the experimental field was 19.6 Ton/ha, this give us the opportunity to keep working with this crop. As a result of the crossings realized in 1993, actually the segregating material goes in F6 generation, and in this time, some families are homogeneous i.e. palm form leaves and single leaves genotypes. Is in this F6 generation were the selected lines will be harvest on bulk form for the yield trials. By the other hand it is working with fertilizing and

herbicides responses, populations densities, and others factors.

FIBERCANE: A NEW, PERENNIAL, NON-WOOD FIBER CROP FOR THE SOUTHERN UNITED STATES

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Fibercane (*Arundo donax*) is a warm season, perennial grass that produces most of its growth between April and September in the northern hemisphere. It grows widely as a naturalized ornamental plant in the southern part of the United States and looks somewhat like sugarcane, but stems are hollow like bamboo, and much taller than sugarcane. In one season, growth in Alabama averages about 16 ft, but stems over 20 ft tall are not uncommon. Even though fibercane produces large seedheads in fall, it does not produce viable seed. Therefore, like sugarcane, it needs to be propagated from vegetative material such as stem sections or rhizomes. Commercial propagation and harvesting of fibercane can be accomplished with exactly the same technology that is used for production of sugarcane. The plant is tolerant of both drought and periodic flooding, and is adapted to a wide range of soils, although it seems to thrive on alkaline soils.

Huge yields of biomass are produced by fibercane with little or no fertilization: yields reported in the scientific literature range from 5 to 30 dry tons per acre per year, and small samples taken from actively growing portions of clumps in Alabama fall into this range, with an average of about 20 tons per acre. (Average hay and forest yields for Alabama are 2 to 3 tons of dry matter per acre per year.) However, it is not known how representative these fibercane yield estimates are of commercial scale fields, but it seems entirely reasonable to expect total annual dry matter yields of around 15 to 20 tons per acre from mature (3-year-old) stands. Fibercane is not a weed threat (except in very localized areas in southern California and along the Rio Grande) because it does not produce viable seed, and is easily killed by plowing or with applications of Roundup at the early stages of growth. It also is eaten by deer and cattle, which will further limit uncontrolled spreading.

Research has shown that fibercane has similar fiber quality to that of hardwood. However, commercial use of fibercane is still relatively limited. Perhaps its best known commercial use is for making reeds for musical instruments, such as clarinets and saxophones. Rico International Inc. is the company that dominates the world market in this field, and it owns commercial plantations of fibercane in Italy, southern France and Argentina. In the U.S.A. fibercane has been used mainly as an ornamental, although Rico International has harvested some in California for making instrument reeds. Because of the increasing popularity, demand and development of non-wood fiber products, tests with fibercane were conducted at the Wood Materials and Engineering Laboratory at Washington State University. This work resulted in composite panels that were equal or superior in certain features to similar wood-based products. A Canadian company, Econotech Services Ltd., also produced high quality pulp and paper from fibercane, and found that it required less chemicals and less bleach than wood to make pulp and paper of similar quality. In summary, fibercane has distinct advantages over wood and other non-wood sources of fiber, and it offers enormous potential as a new non-wood perennial fiber crop for the southern United States.

FLAX: BIOMASS RESPONSES TO WATER AND NITROGEN STRESS

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Natural and renewable products are increasingly needed in the framework of a sustainable economy. Thus, flax

becomes an interesting crop which merits to be bred for higher yields of fiber and oil. Consequently studies on crop responses to the main environmental factors (i.e. water and nitrogen) are useful, especially regarding biomass production and partitioning. Data from the literature on flax responses to water and nitrogen, are not applicable to the possible crop area of Argentina. Our purpose was to generate information on flax growth and partitioning on individual plants under controlled conditions as a base for the corresponding studies at crop level.

Plants of two flax varieties, Linott (oilseed) and Regine (fiber) were grown individually in 2.5-L pots filled with a mixture (1:1, v:v) of sand and loamy soil. The pots were placed under an automatic rainsheiter at the experimental field of FAUBA, Buenos Aires. Two levels of nitrogen (0 and 0.5 g N pl⁻¹, Control (C) and nitrogen (N) treatments, respectively) and water (field capacity (FC) and 1/3 of field capacity, FC and S treatments, respectively) were established. At flowering plant and organ biomass were determined by harvests followed by drying to constant weight at 75°C.

Water stress reduced in the same proportion (76%) plant, leaf, and reproductive organ biomass while branch biomass was more reduced (96%); stems were the organs less affected (18 %). Significant differences (P<0.05) were detected in plant biomass, leaves and stem (increments of 25%, 34% and 18%, respectively) in response to nitrogen. Although both cultivars had similar plant biomass, biomass differed among organs: Regina had higher biomass in branches and leaves while in Linott biomass in reproductive organs was higher. Partitioning of biomass among organs, as measured by the ratio organ:plant biomass, was affected by water stress: partitioning to stem increased and partitioning to leaves diminished. Nitrogen had significant effects only at P<0.1. Cultivars differed in biomass partitioning: Linott had higher partitioning to stem and Regina to branches.

The marked water stress effects on biomass production precluded to elucidate the effects of nitrogen or differences between cultivars. Significant interactions N × FC were only detected in leaf biomass of FC plants. Moreover, interactions N × cultivar were detected in partitioning to reproductive organs: significant (P<0.05) differences were detected only in FC treatments.

Water stress was the main factor in reducing biomass production, with branches being the most affected organ. Our results indicate that, as a consequence of the role of branching, crop density is a crucial factor to be considered in favor of evaluating cultivar differences in studies at the crop level under potential conditions.

CORN STOVER--APPROACHING ITS REAL WORTH

James R. Hettenhaus

Converting corn stover to ethanol can be a win-win-win. The farmer can win from sale of the excess stover. The corn processing industry wins by expanding the market for low cost sugars used in fermentation and refined to sweeteners. The environment wins from reduced greenhouse gas (GHG) emissions and improved agricultural practices.

Corn stover consists of the stalks, leaves and cobs remaining after the corn kernels are harvested. About one pound of stover is produced per pound of corn. In addition, its lignocellulosic composition can provide the same amount of sugar as an equivalent amount of corn. Its lignin contains enough energy to meet the steam and electrical needs of the process. It is by far the largest biomass feedstock in the US. More than 250 million dry tons were produced in the 1997/1998 crop year.

Innovative corn stover harvesting, collection and transportation practices have reduced the cost to \$32/dry ton delivered in Western Iowa where collection occurred over a 50 mile radius in the '97 and '98 crop year. Further reductions to less than \$30/dry ton are projected.

What is "excess" corn stover varies by region, dependent on soil type, crop rotation, topography and other factors, often including value judgements. In "Powering the Midwest," published by the Union of Concerned Scientists, leaving one ton per acre was estimated to be adequate for erosion control.

If 50% of this "excess" is collected from the Corn Belt -- where the ethanol industry infrastructure is largely in place - 77 million dry tons results, providing the industry a low cost feedstock to grow by 5 to 8 billion gallons of ethanol without using any additional cropland. Just 30% of the total stover is used, adding more than \$2 billion to rural farm income at \$30/dry ton.

Collecting the excess stover can be environmentally beneficial. Today, the excess corn stover decomposes on the surface with most of the carbon content going to the atmosphere. The National Soil Tilth Lab reports most of the surface material is lost as CO₂. Just 11 to 19% of the carbon in the surface stover contributes to the formation of soil organic matter while roots contribute 32 to 44 % of their carbon to the soil matter.

Excess stover on the surface can cause a major reduction in crop yields, especially on poorly-drained soils and in cooler-than-normal growing seasons due to lower soil temperature in the spring: a detriment to plant germination and emergence. Cold soil temperatures associated with residue coverage are often given as the primary reason for tillage operations. More than 80% of the stover is tilled under to remove surface material.

The benefits of reduced tillage on increasing soil organic matter and reducing erosion have been widely reported. Because of plowing, a carbon deficit can occur in the soil. The plowing activity exposes soil carbon to oxidation, increasing organic carbon loss with the release of CO₂. For example, a recent study reported by the USDA ARS showed no difference in soil carbon when silage and corn were harvested over a 30-year period using identical cultivation practices. Both soils contained the same soil carbon although all the stover was tilled under in the plot where the corn was harvested.

Recent advances in research supported by the DOE are moving the use of stover closer to commercialization, lowering the cost of sugars processed to sweeteners and used in fermentation to less than \$4/cwt. The low cost can open new market possibilities.

While not expected in Y2000, many envision this scenario to occur within the next five years. For all to win depends on accomplishing the following:

- Sustainable harvest of corn stover in sufficient quantities.
- Attainment of corn stover conversion technology targets.
- A worldwide commitment to reduce GHG emission.
- Increase in the price of petroleum.

ACCELERATED PULPING & FRACTIONATION FOR THE COMPLETE SEPARATION & UTILIZATION OF AGRICULTURAL RESIDUALS

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UP's novel pulping process particularly effective at delignifying straw and other residuals in a low temperature, non-pressurized, dilute chemical process that is environmentally benign. The fast, gentle process preserves the integrity of fiber bundles allowing for the easy and efficient drainage of the cellulose pulp.

The nitric acid/alkali extraction pulping process was conceived and patented by Eric Prior. The process has potential to pulp nonwood and hardwood materials over a wide range of yields and lignin removal levels. Using a single stage process under mild conditions, temperatures below 100°C, and low chemical usage, the process can yield a pulp suitable for corrugation medium or linerboard production.

Laboratory testing results on the chemimechanical pulping of straw using the Universal Pulping nitric acid process are presented.

A two stage process can produce bleachable pulp suitable for printing and writing papers is also reviewed.

The potential of reusing the spent liquor, with fortification, has been evaluated. There is an opportunity to isolate lignin from the spent liquors and use of the carbohydrate material for fermentation to alcohol and yeast feed can be considered. Other value-added end-uses for the waste liquors include chemicals, enriched feed, fertilizer and

adhesives.

Issues involved in the construction of an operating production facility are discussed including:

- Recycling liquors
- Digestion conditions
- Washing, pressing, refining needs
- Balance the nitrogen compounds

Future steps to commercialization are reviewed.

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GENERAL CROPS 2

TEMPERATURE AND PHOTOPERIODIC EFFECTS ON BIOMASS PRODUCTION AND PARTITION, AND SEED YIELD IN GUAR (*Cyamopsis tetragonolobus* L.).

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Argentina imports around 700 tons of guar-gum annually and there is no domestic production of this or other industrial gums except of that of *Cercidium* gum extracted from native stands. The objectives of this study were to evaluate the potential for guar production in Buenos Aires, Argentina, as well as to determine the effect of environment on yield components in cv. Brooks. To evaluate the effects of temperature and radiation, a factorial experiment was set-up with two factors: date of sowing (early and late) and year (1997/8 and 1998/9). There were a combination of 4 sowing dates (11/20/97, 12/30/97, 11/30/98 and 01/12/98) with four replicates of each which consisted in 7 6-m-rows separated by 0.50 m. Plants were watered (twice a week as needed) and fertilized (three times with urea). Plants were harvested at full maturity (0.25 m² subplots) and height, number of nodes on the main stem and branches, number of branches, number of pods, biomass and number of seeds per plant was recorded.

Differences in plant height were only significant in the first year. The number of branches and the number of nodes on the main stem were similar for both sowing dates but were lower for year 2. Pods/plant and seeds/plant (both number and weight) were both significantly higher for the first sowing dates of the first year (27.0 g of seed/plant for 97-1 vs 13.0, 2.1, and 1.1 g of seed/plant for 97-2, 98-1, and 98-2, respectively) as a result of the higher total biomass/plot (106.4 g DW/m²) and largest harvest index (58%) found for 97-1 compared to those found in the other three sowing dates (48%, 33% and 24% for 97-2, 98-1, and 98-2, respectively).

These results can be explained in part by changes in the growth cycle. The total length of the growth cycle was reduced in the second year, specially for 98-2 (151, 140, 149, and 126 days for 97-1, 97-2, 98-1, and 98-2, respectively). The number of days to flowering were significantly higher for 98-2 (52days, which equals 708

°C/day with base temperature =10°C) than for 97-1, 97-2, and 98-1 (41, 40, and 42, respectively), probably as a consequence of the photoperiod available to these plants. Also, the period of flowering to seed maturity was significantly shorter for 98-2.

The results show that the introduction of guar in Buenos Aires may be possible, since economically feasible yields can be obtained, although the interaction of temperature and photoperiod on guar biomass production and partition needs to be better understood before further agronomic work can be pursued.

EARLY RESPONSES OF PROSOPIS (MIMOSACEAE) PLANTS TO DIFFERENT ENVIRONMENTAL CONDITIONS

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Domestication of wild plants needs efforts focus specially on the development of the theoretical basis of plant responses to environmental conditions. Among plants proposed as new crops there are many species of the genus *Prosopis*, native to semi-arid environments. In sub-optimal environments the only way of predicting the consequence of any particular action is to understand the physiological responses of plants to environmental stresses.

The objective of this study was to assess the influence of contrasting environmental conditions (light, growing media, nutrients and water) on growth variables, allocation patterns and physiology of three South-American and three North-American species of *Prosopis*.

Prosopis species are hard seeded and require external stimuli to promote seed-coat rupture. The effect of three scarification methods (mechanical; thermal -TM- and chemical) and three growing media (*Prosopis* soil -PS-; *Prosopis* soil +N -PSN- and commercial nursery mix -NM-) was assessed on germination, seedling growth and survival in a factorial experiment. No differences in seed germination were found among scarification methods for South-American species. TM decreased germination of *P.velutina* (97%) and *P.pubescens* (92%). Germination of seeds in NM was 57% higher than in PS. Plants in NM showed the highest ($P<0.01$) rate of leaf appearance (RLA) while those in PS and PSN did not differ and showed the lowest ratio. Plant height in NM was higher than those in PSN or PS (12.9 cm; 9.4 cm and 7.0 cm respectively). Total plant biomass (TB) decreased 36% and 58.5% for plants growing in PS and PSN, with respect to those in NM ($P<0.01$). Species did not differ in the shoot:root ratio (S:R). Plants in PS and PSN showed a lower S:R than those in NM ($P<0.01$). An inverse relationship between the proportion of root biomass and total plant biomass was found ($r^2=0.54$). Plant survival at harvest time was affected by soil type and differed among species ($P<0.01$). NM was the soil type with highest survival (95% or more) independent of plant species. Survival of *P. pubescens* was higher than 80% in all soil types.

Nitrogen and radiation availability did not affect RLA or plant height, while reductions in water availability reduced both variables. TB was reduced 24% and 38% for plants growing under 52%-sun and 38%-sun. S:R significantly increased with reductions in radiation availability ($P<0.05$). Shoot content of total non-structural carbohydrates (TNC) decreased with reductions in light availability in all species but in *P.chilensis*. Changes in TNC among species were balanced with changes in protein contents, resulting in similar C:N ratios among species.

The understanding of the eco-physiological responses of early plant growth should help not only in matching the most appropriate *Prosopis* species for each environment but also in the design of cultivation techniques.

INTRASPECIFIC HYBRIDIZATION IN VERNONIA GALAMENSIS

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To date there is no cultivar suitable for cultivation in cold-prone non-tropical zones. The main objective of the hybridization trials was to combine some characteristics of ssp. *galamensis*, var. *ethiopica*, such as large flowerhead, large seed, high seed retention (low shattering), and high self compatibility, with the characteristics of other subspecies or varieties, such as numerous flower heads and neutral day flowering. We carried out 887 crosses, most of them between ssp. *galamensis* var. *ethiopica* (V-001) and two other varieties, *petitiana* (V-029) and *galamensis* (V-004), but also some between var. *ethiopica* and three subspecies, *nairobensis* (V026), *afromontana* (V-020) and *mutomoensis* (V-018). In most cases ssp. *galamensis*, var. *ethiopica* served as the male parent, but in crosses with ssp. *galamensis*, var. *galamensis* it also served as the female parent. When screening the descendants, crosses of var. *galamensis* with var. *ethiopica* were found to be the most promising. While descendants of all crosses were gradually dropped, descendants of V004 x V001 were evaluated till the F5 generation. Two of these F5 lines are predominantly characterized by features intermediate between the two parents. They are 60-70 cm tall, bushy-type plants with long, narrow leaves (length/width = 8.5); the involucre is about 16 mm long, and receptacle diameter is about 12 mm (larger than in var. *galamensis* and but still much smaller than var. *ethiopica*). The hybrid plants flower three months after sowing in summer, about two weeks longer than var. *galamensis* (var. *ethiopica* does not flower in summer). F5 hybrid lines have more flowerheads than plants of var. *ethiopica*, but seed filling is lower.

ASSESSMENT OF FODDER POTENTIAL FOR FIELD PEA/BARLEY, FENUGREEK AND LOW-THC HEMP

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The commercial cattle feeding industry in Alberta has experienced dramatic growth in the past decade. Total production in 1996 was 2.5 million cattle, which accounted for almost 60% of the Canadian total. The feedlot industry has grown significantly in the province for several reasons: a large supply of feeder cattle, good marketing location, large supplies of feed grain at competitive prices, good water quality and excellent infrastructure. Dairy farmers in the province are seeking to improve the protein levels of feed fed to their herds. Producers in both the beef and dairy industries are very interested in improving the quantity and quality of their fodder crops in cost effective ways.

A three-year study was conducted on the feed value and biomass production of twelve field pea (*Pisum sativum*) lines in sole crop or as an intercrop with barley (*Hordeum vulgare*). These combinations were compared with sole crop barley silage, which is the current industry practice. In 1998, these trials were done at two levels of fertility. The intercrop systems resulted in an average increase in both biomass production (15.8-37.1%) and protein yield (11.3-29.9%) in comparison to sole crop field pea. In the low fertility trials, intercropping produced higher biomass and protein yields than sole crop barley.

Fenugreek (*Trigonelle foenum-graecum*) is an annual legume which has shown interesting potential as a fodder crop. Although it is grown in other parts of the world as a spice, trials in Alberta indicate that it is well-adapted to our growing conditions, and has excellent biomass yield and feed quality. Selections have been made from several fenugreek accessions which have excellent dry matter production (up to 12 t DM ha⁻¹). Yields and forage quality data from trials in north-central Alberta will be reported.

Low-THC hemp (*Cannabis sativa*) can now be commercially grown in Canada under license from Health Canada. Our research program initiated research in 1995 on fibre quality and biomass production. We continued the work to develop agronomic recommendations for seed production. In 1998, a small trial was established to

evaluate fodder potential of the crop. Forage quality analysis indicated high biomass protein levels (16.7-23.4%). In 1999, further evaluation of the crop for forage potential will be conducted at three locations in Alberta. A feeding trial has been set up to assess harvesting and palatability issues.

PLANT COMMUNITY CULTIVATION AND PLANT BREEDING

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Plant cultivation is the art of management techniques of plants and their habitat. There are individual cultivation, colony cultivation, and community cultivation, according to the set level of plants.

Individual cultivation is the management techniques of individual plants and its habitat, i.e. cultivation of a rose in a pot. The management includes plant management, such as sowing and thinning, as well as habitat management such as soil improvement and pest control.

Colony cultivation is the management technique of many individual plants and their habitual environment, i.e., rice sole cropping. On top of the management required for individual cultivation, it also requires land planning as well as rational close planting. In fact, almost all plant cultivation is colony cultivation today.

As early as in the beginning of the century, the interplanting cropping of pulse and melon was recorded in China. This pattern of planting was greatly improved through thousands of years of practice and developed into stereoscopic cropping, which is the disposition mode of time and spatial structure of cultured plant community, in the 1980's. Stereoscopic cropping, integrated with other planting techniques, forms the plant community cultivation, which is defined as the management technique of different kinds of plant colonies and their habitats. In addition to the techniques of colony cultivation, community cultivation also includes colony selection, time and spatial structure disposition of the community, readjusting and controlling of community growth and coordination of colony cultivation techniques. One example of this pattern of planting is the stereoscopic cropping of Chinese cabbage, garlic, cotton and melon. It is characterized by the improvement of technique level, productivity and the scale of production. Community cultivation is a comprehensive management technique of plant ecological system and represents a new stage in the development of plant cultivation.

Some new requirements of plant breeding emerged when the plant cultivation developed into this new stage.

1. Under community cultivation, there are several special traits of plant colony besides high yield and quality. Here we present two new concepts: 1) complemented traits, which means complement between the colonies such as water-needing and drought-evading, tall stalk and short stalk, 2) restrained traits, which means restraint between the colonies such as scrambling for water, light and fertilizer as well as endocrine-inhibiting. Within a community, the colonies should have some complemented traits and avoid the restrained traits.

Three basic principles should be considered when breeding new varieties for plant cultivation.

- 1) Ecological adaptability of colonies should be similar;
- 2) The traits of colonies should complement each other;
- 3) Higher overall efficiency.

2. Under human wills, the traits of cultivated plants tend to gradually become less diverse. So the colonies have less complemented traits. Using cultivated plants as the breeding materials and the common method of breeding can no longer satisfy the need to generate new varieties for community cultivation. Therefore, it is necessary that the breeder must extensively collect gene resources and take advantage of the non-routine methods such as genetic engineering, mutagenesis and space breeding to obtain new varieties.

3. Germplasm resource is the base of plant breeding. It is very important to investigate, collect and study the source materials. According to breeding objectives, breeders may get useful genes from wild plants, even animals, and transfer them into cultivars; meanwhile build long-term modernized gene pools for special plant breeding.

**HISBICUS SABDARIFFA NEW VARIETY "ROYAL JAMAICA " DEVELOPED IN VERACRUZ
MÉXICO AGRONOMICAL ISSUES AND THERAPEUTICAL PROPERTIES.**

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At the present time the cardiovascular diseases are considered like one of the most important causes of mortality in the world.

The flower of jamaica (*Hisbiscus sabdariffa*) is know in the whole world, although in Mexico exist an important tradition in the consumption among the urban ad rural families. Also it is known for the diuretic properties and to reduce the weight.

The jamaica concentrate is used to prepare a refreshing drink. The fresh jamaica drink is delicious, and has a string wine color and intense flavor (very similar to the cranberry juice).

The ROYAL JAMAICA variety was obtained through genetic crossbreedings among the 150 varieties of jamaica (*Hisbiscus sabdariffa*) that exist and that are cultivated in the world. The goal of these studies was to achieve a jamaica flower that had distinctive characteristics and therapeutical properties. The characteristics and properties that distinguish the ROYAL JAMAICA to the other kind of jamaica are:

- a) The ROYAL JAMAICA contains double the acidity (pH=2.2) level than the other varieties of jamaica. The ROYAL JAMAICA has an acidity degree of pH value greater than the one determined for the lemon.
- b) The contents of its acid such as: malic, tartaric, ascorbic, citric and hisbiscus are concentrated double as well.
- c) The investigation proved that the jamaica flower protects people against cardiovascular problems, it reduces the cholesterol and triglyceride levels.

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POSTERS

EFFECT OF GENOTYPE AND SALINITY ON WAX CONTENT AND COMPOSTIION OF JOJOBA

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The effect of genotype: Twenty jojoba clones, growing in a clonal test plantation were characterized during several seasons in respect to their oil content and composition. Average wax content in 1995 and 1997 harvests was high (35-54%) and a bit lower (52%) in 1998. Wax content of some clones was consistently higher than the average while that of others was consistently lower.

Genotypes differed not only in their wax content but also in the % of wax esters longer than 40 or 42 carbons, and in the % of fatty acids and alcohols longer than 20 carbons in the wax esters.

The clones, yarden, Gvati, Hazerim, BGU, and Negev, had a high percentage of long-chain wax moieties. The difference between genotypes in oil compositions resulted from the difference in the ratio of fatty acids elongated to the sum of those reduced and esterified.

The effect of salinity: Effects of salinity on the content and composition of jojoba wax was studied in three seasons on field grown plants. Salinity did not affect wax content of the seeds while it did affect wax composition as follows: the salt sensitive clone 64 was produced in a smaller percentage of long wax esters and long fatty acids and alcohols under salinity; no change in wax composition was recorded in seeds of clone Q-106, and an increase in the chain lengths of wax moieties was found in seeds of clone 874-154 under medium salinity.

We concluded that jojoba clones differ in wax content and its composition due to a genotype as well as due to an influence of environmental factors such as temperature and salinity. The differences in wax composition in jojoba clones may affect wax properties such as viscosity, boiling point, and thermal stability.

A KINETIC STUDY OF NOVEL VEGETABLE OIL MONOMERS FOR USE IN LATEX COATINGS

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Emulsion polymers properly formulated into latex coatings reduce volatile organic compound (VOC) emissions in comparison to contemporary solvent soluble coatings. However, even though contemporary emulsion polymers reduce VOCs, their levels continue to remain too high. In fact, most latex coatings require solvents for continuous film formation and sufficient particle coalescence. However, environmental regulations and consumer opposition to chemical odors are rapidly moving the coatings industry towards no-VOC coatings by seeking emulsion systems that completely coalesce with little to no externally added VOCs.

An approach to the resolution of this matter involves the development of novel, multi-functional vegetable oil derived monomers. In particular, acrylate and methacrylate derivatives of castor oil (CAM: castor acrylated monomer) and soybean oil (SAM: soy acrylated monomer). The monomers polymerize readily via their acrylate/methacrylate moieties and further function as internal plasticizing agents, thereby removing the requirement for film forming cosolvents. Their multifunctionality extends to their alkyl chain unsaturation to give ambient crosslinking. The kinetics of polymerization of these monomers with a variety of comonomers have been studied and is reported herein. The effects of temperature and concentration were analyzed with photo-differential scanning calorimetry (photo-DSC). Nuclear magnetic resonance spectroscopy has been used to determine the reactivity ratios. The novel vegetable oil monomers have shown good compatibility and reactivity with many conventional monomers traditionally used in emulsion polymerization.

4-DEMETHYL SIMMONDSIN FROM SIMMONDSIA CHINENSIS

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An acetone extract, obtained by continuous extraction of deoiled jojoba seeds, was separated by column chromatography on silica gel to obtain different compounds. Further separation of one of the isolated fractions by preparative HPLC allowed to isolate a new simmondsin derivative, 4-demethyl simmondsin. Its structure was determined using NMR spectroscopy, LSIMS and 2D-correlation techniques.

ESTOLIDES FROM ADMIXTURES OF MEADOWFOAM AND OLEIC ACID

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The development of a new crop often depends on the synthesis of novel compounds. Estolides are one such derivative of new crop oils which show promise in industrial applications.

Estolides are formed when the carboxylic acid functionality of one fatty acid links to the site of unsaturation of another fatty acid to form esters. Estolides were derived from a number of unsaturated fatty acids in the presence of varying equivalents of acid with little or no solvent with varying temperatures. Estolides were also linked to different acids. The estolides were converted to their corresponding hydroxy fatty acid and the degree of polymerization was determined by GC analysis.

The free acid estolides were then converted to the esters under standard conditions. Physical properties (pour points, viscosities) of admixed estolide acids and esters were compared to the homo-estolides, which have current industrial applications.

A PILOT STUDY OF EXPELLED AND SOLVENT EXTRACTED MILKWEED OIL

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Pilot-scale tests were performed with wild type milkweed seed (*Asclepsia speciosa*, *A. syriaca*) to identify processing conditions to generate refined, bleached, and deodorized oil in good yield with acceptable odor and color properties. Milkweed seed represents a potential alternative source of triglycerides for industrial application. Milkweed seed is harvested commercially for seed floss that is used as a hypoallergenic fiber fill material. The seed typically contains 25% triglycerides with 50% linoleic, 20% 18:1 (D 9) and 14% 18:1 (D 11).

Press oil was generated by extruding raw seed with an Anderson Expander Cooker followed by expelling with an Anderson Lion 90-model expeller. Solvent extracted oil was generated by extrusion of the seed and then extraction with hexane in a Crown Model 2 Extractor. Press oil and solvent extracted oil were both refined using a modified caustic treatment.

ANALYSIS OF JOJOBA EXTRACTS BY GC

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In order to evaluate plants with varying amounts of liquid wax composition, seeds from 150 cultivars of jojoba, grown in 1998, were provided by Purcell Jojoba International, LLC. The seeds were extracted using a Butt extraction method with petroleum ether as solvent for 24 hrs. Extract was first analyzed by short column GC to

determine the wax components of each extract. Then each extract was transesterified to determine the ratio of alcohols and acids composing the wax extract. Results correlate the wax components as well as composition for each extract to the selected cultivars.

PRODUCTION OF SELFED LESQUERELLA SEED BY BUD POLLINATION

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Self-seed production is prevented in *Lesquerella fendleri* by sporophytic incompatibility, where pollen from the same plant is unable to fertilize. Self-seed is important for production of segregating populations for use in genetic studies and also in developing probes for breeding with molecular markers. Bud pollinations were utilized to circumvent self-incompatibility, specifically by early application of pollen to unopened flower buds.

The purpose of this study was to identify variables that maximize seed yields of lesquerella from bud pollinations. This was done by controlled hand-pollinations in a greenhouse in Spring 1999 on 47 plants from 29 different plant families. Individual floral buds were pollinated at various times before anthesis and the number of days before anthesis was recorded. Floral bud lengths were also measured to determine the optimum timing of pollination. Mature siliques were harvested eight weeks post-pollination and the number of seeds per silique recorded. Best seed yields occurred between one and three days before anthesis and when bud lengths were between five and seven mm.

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