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POSTER SESSION

LIPASE ACTIVITY IN *VERNONIA GALAMENSIS* BREEDING LINES

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The epoxy oil produced by *Vernonia galamensis* is of interest to industry for paints and metal coatings. This oil contains an unusually high percentage of free fatty acids (FFA) which are likely generated when oil is subjected to seed lipase activity. Oil quality is diminished by the presence of these FFA for both chemical characteristics and the capacity for storage.

A method has been developed to quantify FFA in vernonia oil. Using solid phase extraction(SPE) columns, FFA are separated from the oil fraction. FFA are quantified using gas chromatography(GC). The remaining oil fraction is used to assess oil quality (i.e. percentage trivernolin) also by GC. Repeated analysis has demonstrated that this method is reliable, efficient and repeatable.

Our data shows that these lipase enzymes act both before and after the seed flaking process necessary for oil extraction. Preliminary measurements also indicate adequate variability of this trait both between and within our breeding lines for use in our breeding program.

CH₃ReO₃-CATALYZED EPOXIDATION AND HYDROXYLATION OF FATTY ACID METHYL ESTERS AND PLANT OILS BY H₂O₂

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Epoxides made from unsaturated fatty acid methyl esters or plant oils (especially soybean oil) are used as plasticizers and stabilizers for PVC on industrial scale. By hydrolytic epoxide ring-opening vicinal diols and polyols are accessible, that can be applied as starting materials for polyurethanes. Using the system $\text{CH}_3\text{ReO}_3/\text{H}_2\text{O}_2/\text{tert-butanol}$ epoxidation as well as direct hydroxylation - depending on reaction conditions - could be achieved.

At room temperature oleic acid methylester was epoxidized quantitatively by 30 % H_2O_2 . The addition of 2,2-bipyridine prevents the ring-opening of the epoxide and enables a distinct acceleration of the reaction. Under the same conditions high oleic sunflower oil (85 % oleic acid), linseed oil and those fatty acid methyl esters, that can be obtained by interesterification with methanol (56 % linolenic, 15 % linoleic and 21 % oleic acid methyl ester), were epoxidized quantitatively, too.

At a slightly elevated temperature (50°C) and without 2,2-bipyridine, vicinal diols and polyols were formed. Thus oleic acid methylester was converted to 9,10-dihydroxystearic acid methyl ester and high oleic sunflower oil resulted in a hydroxylated triacylglycerol with 6 hydroxyl groups. The reaction of linseed oil and linseed oil fatty acid esters led also to polyhydroxylated products. Because of an intramolecular cyclisation of epoxy-diol intermediates to tetrahydrofuran derivatives, the amount of hydroxyl groups in a given molecule was lower than predicted by theory. Linseed oil for example was oxidized to a polyhydroxylated triacylglycerol with 8 hydroxyl groups, whereas 14 hydroxyl groups would be theoretically possible.

CHANGES IN FLAX STEMS (*Linum ussitatissimum* L.) BY THE ACTION OF ENVIRONMENTAL FACTORS OVER PLANT DEVELOPMENT

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Oil flax, after seed harvesting, leaves a straw with high C/N relationship. Fiber of less quality than textile flax can be obtained from this straw, but it is useful for bags, filling material, for cigarettes and paper making, etc.

In this crop, without water and N shortage, the first management factor for dry matter production is the sowing date, because changes in dates make the plants to grow and develop in different climates with variation in the temperature, photoperiod and vernalization regimes.

Thirteen sowing dates were made in 34° 35' S, 58° 29' W and 25 m (o.s.l.). These sowing dates were from autumn until spring with subplot of vernalized and not vernalized seeds. Three Argentine varieties were sown: Areco, Salto and Rojas. The straw production was assessed through the averaged main stem height of plants and diameter, and number of ramifications in dry plants, after seed harvesting. Ramifications were divided into: a) Reproductive, b) Non reproductive long, and c) Non reproductive short.

The latter the sowing date the smaller the main stem height and diameter of main stem in the 3 varieties. Height varied from 100 cm in the first sowing until 20 cm for the last. The diameter varied from 1.9 cm to 0.8 cm. This trend accompanied the decrease of duration of emergence-first flowering period, where the temperature available affected the development. Vernalization only gave differences among treatments in autumn sowings.

Photoperiod effect was studied by analyzing this period in thermal time (TT), in vernalized plants. Photoperiod acted in a similar way as temperature; the delay in sowing date reduced TT. The environment (thermal and photoperiod) regulated the height and diameter of main stem through changes in development.

Vernalization did not show important effects on height and diameter but did show influence on the number of

ramifications. Reproductive ramifications were more in the 13 sowings and in the 3 varieties. Non reproductive long and short ones had a similar behavior. Vernalization influenced development only in the very early and the latest sowings but affected the growth ramifications in all the sowing dates.

VARIATIONS IN *Crotalaria juncea* VEGETATIVE STAGE LENGTH BY PHOTOPERIOD AND TEMPERATURE EFFECTS

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Crotalaria juncea is an annual crop that provides textile fiber similar to *Corchorus* sp.. Variations in stem length (from 2m to 4m) have been observed at different sowing dates and latitudes, for the same variety. The different vegetative stage duration and stem length has generated the following question: Do this plants possess a long juvenile period (JP) with a little photoperiodical influence or a short JP with greater photoperiodical influence?

To begin the species characterization (using a Hawaiian variety) 3 sowing dates were made at Buenos Aires (BS AS)(34° 35' S, 58° 29' W, and 25 m. o.s.l.). Emergence dates were: 10/14/96, 11/24/96 and 1/1/97. One sowing (2/2/97) was made in Costa Rica (10° 02' N, 84° 10' W and 1060 m. o. s.l.). The experimental design was similar in both countries; complementary irrigations were made in BS AS and Costa Rica, BS AS soil was fertilized with N (because the nodulation was not efficient). In BS AS, on 1° and 2° dates, plant stands were poor; nevertheless, dates of emergence and 50% of flowering were recorded in both countries. In Costa Rica fenometric observations were also made.

Plants evidenced a quantitative short day response, since flowering dates for 1° and 2° sowing dates in BS AS was 3/10/97, and 3/20/97 for the 3° date; being thermal time accumulated until flowering (using a base temperature of 10°C): 1990 °Cd, 1580 °Cd and 1150 °Cd (respectively) and 738°Cd in Costa Rica, so a photoperiod effect is clear. Photoperiod was always short in Costa Rica so, the plants were soon induced to flowering (4/4/97) and achieved a mean height of 94 cm. In BS AS, stem length values were only valid for the 3° date; the mean height was 150 cm. For the 1° date the few plants were 270 cm. height; some of those plants had a little flow of flowers on 12/2/96 but thereafter they aborted and plants blossomed in March.

Photoperiod at emergence for the first date was 13.88 hs. while for the 2° and the 3° dates it was greater than 15 hs.. By the flowering stage the photoperiod was about 13 hs. for all the sowing dates. Costa Rica's emergence photoperiod was 12.45 hs. and in flowering: 13 hs.. The critical photoperiod is around 13 hs.

KENAF YIELD RESPONSE TO PLANT DENSITY

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Kenaf (*Hibiscus cannabinus* L.) is an annual crop whose stems are a potential source for paper pulp. With the objective of assessing the optimum population for the maximum biomass production, an experiment was carried out at the Faculty of Agronomy experimental field in Buenos Aires, Argentina (34° 36' lat S, 58° 29' long W and 25 mosl).

Two cultivars Everglades 41 and Tainung 2 and eight population densities from isolated plants to 100 plants/m² in plots of four rows were seeded in a Complete Randomized Block Design. Plants were harvested at ground level at the beginning of flowering. The height, diameter, biomass, and percent of bast and core fibre were recorded in individuals plants; these are important parameters that determine both yield and quality of the harvested product.

The optimal density changed with genotypes being 20-40 pl/m² for Tainung 2 and 40-60 pl/m² for Everglades 41. Tainung 2 was the cultivar with greatest yield. The height of stems did not change with different densities and only slight differences were detected between genotypes, being Tai2 the tallest. The stem diameter decreased with the highest plant population determining an easier harvest, without any difference between cultivars. Bast fibre percent was superior at higher densities resulting in a raw material of better industrial characteristics for paper making.

AGRONOMIC AND VARIETAL KENAF TESTS IN THE SOUTH OF EUROPE

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Kenaf (*Hibiscus cannabinus* L.) technical viability as a resource of cellulose raw material for different European industrial sectors has been tested during the 90's. However, the species ecological requirements have limited its cultivation to South Europe countries. It is Andalucía, the southern most region of Spain, where the greatest productive potential for growing kenaf can be expected.

From the end of the 80's, different tests have been carried out with the kenaf, but since 1994, studies have focused on the evaluation from the productive point of view, of cultivars, whose sewing seed multiplication is usual in Europe, and on the thorough examination of different aspects (effect of the harvest time, optimum irrigation doses) concerning the optimization of the crop under Andalusian conditions.

The evaluated materials belong to cultivars of different earliness cycles, although results tend to give a greatest productive potential to cultivars of latest cycles (from 20,000 to 32,000 kg/ha) in relation to earliest cultivars (from 8,000 to 19,000 kg/ha). There are other data as the values of indexes related to long fiber content of plants of kenaf produced (bark content, bark index) that corroborate the optimum Andalusian conditions from growing kenaf.

Tests concerning the optimum irrigation doses carried out during the first years showed a tendency to a high consumption of water, which made difficult the crop expansion because it would depend largely on a scarce resource. However, during the last year, it has been proved that with acceptable doses which are usual for other traditional crops of the region, kenaf has showed very high yields, similar to those obtained with irrigation doses which are completely out of proportion outside the experimental field.

The effect of the crop harvest time is very important, because the tendency, in Andalucía in particular and in Europe, in general, is to do it at the end of the vegetative cycle which means not further than October. The test objectives were to be able to determine that if they were harvested in an earlier period than the natural cycle, the yields would be similar to those harvested in the optimum date, so that in this way the necessary conditions for the kenaf straw storage (dryness) could be assured before the autumn rains. The results prove the viability of harvesting a fortnight before the natural time, with no loss of yields or quality.

NEW CROPS RESEARCH AT NCAUR-ARS-USDA

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The National Center for Agricultural Utilization Research in Peoria, Illinois, United States of America is part of

the Agricultural Research Service, the research arm of the United States Department of Agriculture. There are 10 research units at NCAUR and one of them is the New Crops Research Unit (NCR). The mission of the NCR is to develop new industrial products from meadowfoam, lesquerella, jojoba, crambe, milkweed, cuphea, Euphorbia lagascae, vernonia or other potential new crops; to solve seed processing or product quality problems; and to develop new methods to evaluate germplasm and breeding lines for the proposed crops in collaborative programs with plant scientists. NC's four permanent research scientists and support staff work closely with our customers through Cooperative Research and Development Agreements (CRADA's), confidentiality agreements and public reports. The NC progress report and group information is displayed on the Internet at www.ncaur.usda.gov/nc/nchome.html. This includes a searchable database of the composition of oilseeds collected over 38 years. The poster describes the role of the NC team in new crops development.

PLANT PROTECTION AND FARMER'S RIGHTS

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A lot of concern has been growing about plant genetic erosion in agriculture. More and more people think that the problem is a multi-agent one. Part of the problem stems from new technological developments that have changed the nature of the debate and caused a need for the redefinition of the role of the industrial sector. Existing agents set up to deal with these issues, such as plant protection systems, government intervention, and network conservation of plant genetic resources have not been able to reduce genetic erosion satisfactorily.

Debates have been taking place in different international forums. Among them, the Commission on Plant Genetic Resources for Food and Agriculture of FAO, the Trade Related Intellectual Protection Systems within the World Trade Organization, the Union for the Protection of New Varieties of Plants, and the Commission on Biodiversity.

The main proposal of this paper is to discuss the different positions of the actors involved, taking into consideration the goal of sustainable development of agricultural systems. The paper also discusses the point of view of the agricultural sector in a country such as Mexico where the majority of the farms are still small-size production units. It also deals with Farmer's Rights and the ethical and political implications of current philosophies towards intellectual propriety systems.

Recommendations are made about reducing genetic erosion in agriculture: More analytical studies need to be done about the implications of orthodox intellectual property systems on plant genetic resources.

A new 'sui generis' system needs to be developed that deals with agricultural producers of all levels and goes against trends towards monopolization of the seed industry.

THE EFFECT OF TEMPERATURE AND PHOTOPERIOD ON DEVELOPMENT OF *Borago officinalis*

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Borago officinalis is an important source of g-linolenic acid used in several medicinal applications. Its flowering responses to environmental factors is not readily understood. The objective of this study was to assess the effect of temperature and photoperiod on development and flowering. Field experiments of white-flowered *B. officinalis* were established in Buenos Aires, Argentina (34° 35' S, 58° 29' W) during three consecutive years. The first year comprised 3 sowing dates each from June to October. On the third year three late season planting dates were chosen from September to November. Thermal time was used to characterize the flowering response. The selected model was that of Summerfield et al (1989) using T (mean air temperature of the period emergence-flowering)

and P (mean photoperiod).

The best fitting equation was $1/d = -0.029 + (-0.00234 \times T) + (0.0057 \times P)$, indicating a clear response to long days. The three late season planting dates did not fit into this model. The plants under these conditions accumulated about three times more biomass than the plants in previous experiments and they flowered poorly and unevenly. This confirms the qualitative-type of response that this species has to photoperiod. Nitrogen availability was higher for these third-year experiments than for the two previous years. Although N is considered a secondary factor in the regulation of flowering phenology its effects should be considered in this experiment. Vernalization was not a critical factor influencing flowering in *Borago officinalis*.

LATEX PRODUCTION IN GUAYULE GERMPLASM

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Guayule produces a high quality hypoallergenic latex that is of interest to the medical industry. Toward the end of understanding latex production and finding higher yielding plants, we have screened guayule germplasm lines for latex production over the past two years. We have previously reported fresh weight, dry weight, percent dry weight, percent latex and latex yield in lines O16-1 and G7-11 (newly released germplasm line AZ-2) for five stem diameter classes. From this work we have shown that for these two lines at a single harvest, 65% of the fresh weight, 77% of the dry weight, and 76% of the latex were found in branches of diameters 2.0 to 10.0 mm. This suggested to us that hedging might be the most economical harvesting method for latex.

We also found and have reported that percent latex in the 2.0 to 10.0 mm diameter branches was highly correlated (0.93) with percent latex in the whole plant, and fresh weight, dry weight, and latex yield in the same sized branches were highly and positively correlated with latex yield for the entire plant. This suggested that these diameter branches could be harvested to estimate latex content and yield in the entire plant. We harvested these same sized branches every two weeks for lines G7-11 (now AZ-2), O16-1 and Cal-6 from December, 1995, through December, 1996. The three lines averaged about 2% latex in December, 1995, raising to a maximum of 10% in March 1996, and dropping to less than 1% in July 1996. From these data latex production certainly appears to be cyclical.

The biweekly harvests were discontinued at the end of March, 1997, due to lack of funds. However, over these three months the following new lines were evaluated: AZ-R1, AZ-R2, AZ-R3, C16-1 (newly released germplasm line AZ-1), G7-15 (newly released germplasm line AZ-3), N7-BK (newly released germplasm line AZ-4), N7-11 (newly released germplasm line AZ-5), P2-BK (newly released germplasm line AZ-6), P3-1, N576, 11591, P10-13, N565, G7-14, N9-5, C16-11, C16-2, C16-4, and G7-4. Although preliminary, these are the first latex data on most of these lines. Plants of line Cal-6 that were established by both direct-seeding and transplanting, were harvested six times from January through March, 1997. In January until the end of February, the latex content in the direct-seeded plants was lower than in the transplants. However, by March the latex content was essentially equal. Although interesting, because of the lack of data points and the small numbers of plants evaluated, these results may be nothing more than sampling error. Also of possible interest was that the same peak latex production observed in March 1996 was not reached in 1997 (by the time the harvests were terminated). The potential interesting aspect of these preliminary data is the potential role of environment (temperature and water) on latex production.

EVALUATION OF SEEDLING CHARACTERS IN CRAMBE

Sathya Kuruvadi and L.A. Bustamante

Crambe (*Crambe abyssinica*) belongs to the Mediterranean region and produces high content of erucic acid in its seed oil and has several potential industrial uses. In this study 12 accessions of *crambe* originated from four countries Sweden (4), Ethiopia (3), U.S.A. (3) and Israel (2) were evaluated in the Seed Technology Laboratory using three check varieties *Brassica juncea* (Japan), *Brassica napus* (Sweden) and *Sinapis alba* (Israel) which also manifests erucic acid in its seed oil. These 15 accessions were evaluated for seedling characters at two temperatures 20°C (T1) and 25°C (T2) with + 2°C separately. A random sample of ten well formed seeds of each accession were arranged in a row, embryos facing downwards on a wet germination paper. Another moistened germination paper was placed over this, so that the seeds were sandwiched between the two papers. These papers containing the seed were kept in an incubator maintaining a temperature of 20°C + 2°C and 25°C + 2°C for seven days. On eighth day morning five seedlings from each accession were randomly picked up for recording the data on hypocotyl and root lengths. The experiments T1 and T2 were conducted separately in a completely randomized block design with three replications and the data were statistically analyzed individually and combined.

The analysis of variance of each experiment and combined analysis showed significant differences among the genotypes for the hypocotyl and root lengths in T1 and T2 excepting hypocotyl length in T1. This reveals a considerable variability for hypocotyl and root lengths among the accessions at seedling stage. The interactions between accessions and temperatures were also significant for the two traits studied. The length of the hypocotyl in different accessions examined varied from 2.1 to 8.9 cm with a mean of 6.6 cm in T1 and 5.5 to 11 cm with an average of 8.1 cm in T2. The following accessions were identified for larger hypocotyl lengths, *S. alba*, 305283 and 384522 (7.9 to 8.8 cm) in T1 and 247310, 305283 and 326569 (9.2 to 9.6 cm) in T2. The hypocotyl lengths increased by 22.7% in T2 when compared to T1. This may be due to the effect of higher temperature. Generally accessions with longer hypocotyls produces a better seedling emergence in the field conditions. Tall varieties with longer hypocotyls might be favored for cultivation under deficit moisture to ensure uniform and appropriate population per unit area. The seedling root length varied from 6.1 to 15.8 cm with a mean of 11.2 cm in T1 and 5 to 17.6 cm with a mean of 11.3 cm in T2 and the accessions *S. alba*, 384522 and 305283 (13.9 to 14.5 cm) in T1 and V29, 384525 and 384522 (13.6 to 14.5 cm) in T2 manifested with longer root lengths. The performance of root length of the accessions were more or less similar in T1 and T2. The influence of higher temperature were not detected in seedling root lengths.

NEW METHOD OF JOJOBA PROTEIN EXTRACTION RESULTANT PRODUCTS AND APPLICATIONS

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New process can provide 100% native vegetable source for the Personal Care and Cosmetic Industry to satisfy the need to replace animal sources with all vegetable sources.

The Protec process is a new and unique way of obtaining an extract, rich in native proteins that is water soluble and exhibiting biological activity. The Protec process can be used to provide high yields of concentrated proteins in an extract form which may be used directly in cosmetic compositions.

The Protec extract is obtained from Jojoba meal after the cold pressing process. The meal remaining after defatting jojoba seeds in a reactor-extractor is treated by extraction reagents in several stages: a) penetration into the meal, b) concentration of extraction products and c) separation from solid phase. The resulting extract requires no further concentration, purification or desalination to be included as a raw material into cosmetic compositions.

The Protec protein product is sufficiently concentrated (~5%), to be used as an additive or active ingredient in cosmetic formulations. The final forms of the extract may be either a) liquid form with ~5% concentration, b) concentrated liquid, ~20% concentration or c) powder form.

Several extragents are proposed, among them the group of known buffers. These are selected such that they retain enzyme activity of the obtained proteins. With buffer and condition variations we can obtain protein extracts

characterized by catalase, peroxidase, phosphodiesterase, phospholipase activity, all of which are of interest to cosmetic applications. Furthermore, the Protec protein products obtained by this technology have significantly lowered the simmondsine content to levels of less than 1%.

Protec is completing the initial R&D stage of product development and will start pilot studies. Protec is currently operating as an independent company within the Mofet B'Yehuda Technological and Business Incubator in Israel. The initial R&D program has been sponsored by the Office of the Chief Scientist, Ministry of Industry and Trade, State of Israel. Joint Venture - Strategic Partner - Investment - Marketing inquiries invited.

INFLUENCE OF TEMPERATURE AND PHOTOPERIOD ON THE DURATION OF THE STAGE EMERGENCE-FLOWERING IN *Lesquerella fendleri*

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Several species of *lesquerella* are currently under investigation for the production of hydroxy fatty acids. Among this, *L. fendleri* seems to be the most promising for development. In its native environment this species is a winter annual. In southern Argentina, *lesquerella* could be tested as a summer annual. In this context understanding photoperiodic and temperature responses becomes important.

The objective of this study was to determine the influence of temperature and photoperiod on the duration of the stage emergence-flowering in *Lesquerella fendleri*. A field experiment was carried out in Buenos Aires, Argentina (34° 36' S, 58° 29' W) that included 8 seeding dates from March to November 1996 in a complete blocks design with 3 replicates. Each replicate consisted of a 6 5-m rows with a plant density of 1,000,000 pl/ha. The length of the period emergence-flowering (35-50 % of the plants with at least one flower open) was recorded. Thermal time was calculated using a base temperature of 0°C.

There were significant differences in both days and thermal time to flowering between seeding dates. The results suggest that temperature is the most important factor in determining the length of the emergence-flowering period and consequently the crop length in *Lesquerella fendleri*. There is also a response to photoperiod. We are currently evaluating this response but including the effect of vernalization, to separate both responses. Growth chamber experiments are needed to thoroughly separate temperature and photoperiodic responses.

REPRODUCTIVE SUCCESS IN DIFFERENT SPECIES OF *Lesquerella* Sp

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Lesquerella species are presumed to be cross-pollinated largely by bees and flies. A preliminary study on *Lesquerella gordonii* reported that bagged flowers produced 0.1 seeds per fruit, whereas open-pollinated flowers produced 6.3 seeds per fruit. Experimental evaluation of different species of *Lesquerella* sp. has been made using framed cages for each plot in order to avoid pollination between species. Little is known, however, about the effect of cross-pollination between different species over seed production. The purpose of this work was to evaluate the efficiency of self and cross-pollination within and between species of *Lesquerella* sp. on seed production.

Plants of *Lesquerella fendleri*, *L. grandiflora*, *L. gordonii* and *L. argyraea* were grown in a pollinator free glasshouse and ten flowers per plant were manipulated by hand pollination. Three different treatments were established for each specie: a) Self pollination with pollen produced by the same plant, b) Cross pollination with pollen of other plants of the same specie and c) Cross pollination with pollen proceeding of another specie. Since

flowering date differed between species, two pairs of species (*L. grandiflora*-*L. gordonii* and *L. fendleri*-*L. argyraea*) with similar flowering dates were selected for this purpose. Reproductive success (RS) was quantified as the product of the fruit/flower ratio (Fr/FI) and the seed/ovule ratio (S/O).

In all the species studied, RS was higher when cross pollination within specie were made, ranging between 38% in *L. fendleri* and 80% in *L. gordonii*. Under self pollination, RS ranged between 0% in *L. fendleri* and 11% in *L. argyraea*, in accordance to previous reports suggesting that this genus is cross pollinated. When cross pollination was made with pollen proceeding from another species, however, RS was 0 in *L. grandiflora*, *L. argyraea* and *L. fendleri*, and only 6% in *L. gordonii*. The results obtained with the four species studied indicate that the probability of cross pollination among species of this genus is low, suggesting that physical barriers such as framed cages would not be necessary to prevent hybridization among species in contiguous field experiments.

DNA ISOLATION PROCEDURE FOR *Lesquerella* Sp.

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A prerequisite for molecular genetic studies is, by definition, the ability to isolate DNA. In plant species with high content of polysaccharide and polyphenolic compounds, this basic requirement becomes a challenge. In these species, the carbohydrates co-precipitate with the nucleic acids forming large pellets, in which the DNA is trapped in gum, and is no longer retrievable. A species that exemplifies the problem is *Lesquerella fendleri*, a new industrial crop which has evoked interest for it's unique oil and hydroxy fatty acid (lesquerolic acid). The difficulty to isolate DNA from this species was an impediment for applying new methods of molecular breeding to the improvement process. We are describing a novel DNA isolation method developed by the New-Crops group at U.S Water Conservation Lab in Phoenix. In this procedure, after breaking down the cell walls, the cell nuclei are being separated from the cytoplasmatic and intracellular fluids, by differential centrifugation in a viscous medium, this preparatory step, separates between the cellular compartments which contain the desired DNA, and the problematic carbohydrates. The DNA is then isolated from the nuclei without interference. High quality DNA was obtained and used successfully in various analyses.

MOLECULAR MARKERS ASSOCIATED WITH MALE STERILITY IN *LESQUERELLA FENDLERI*

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Emasculation is one of the most costly and labor intensive components of hybrid seed production. The most efficient and effective substitute for emasculation is introduction of male sterility into elite germplasm. Therefore, a significant step toward commercialization of *Lesquerella fendleri* will be identifying genes and mechanisms responsible for genic and gene-cytoplasmatic male sterility. We have initiated a genetic search with the objective of identifying molecular markers diagnostic to male sterility. A sample of 20 plants, composed of ten male sterile plants, and 10 male fertile plants are used for the initial screening. Two molecular markers systems: Random Amplified Polymorphic DNA (RAPD) and Amplified Fragment Length polymorphism (AFLP) are used in search for markers that identify chromosomal segments associated with male sterility. Primers amplifying DNA segments known to be associated with male-sterile cytoplasm in other Brassicaea are applied as well. An up to date report of potentially diagnostic markers, as well as, a discussion of plausible male sterility mechanisms in *L. fendleri* will be presented.

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PLENARY SESSION

RECONQUERING NATURAL PRODUCTS FOR MODERN LIFE

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Mexico is a country where biological mega-diversity is matched with cultural diversity and history. Thus, there is a long tradition of use of natural products, especially as remedies for "every day" ailments.

However, this century's innovative tendencies have created an unprecedented scenario in which the use of patented medicines and of technological processes are slowly but effectively replacing traditional medicines, especially in urban areas. Interestingly enough, the active components of these new drugs, quite often are discovered through the study of traditional medicines, and then synthesized from natural products. That is why transnational pharmaceutical companies are now investing in conservation of tropical forests.

This loss of traditional knowledge leads us to propose a number of urgent actions to preserve the lore of our ancestors. Although natural products do not come only from plants. One such action is the creation of new herbaria in regions where they are lacking, as well as supporting the growth of those already existing.

Herbaria are non replaceable tools to identify potentially useful plants, especially medicinal ones. But natural products are not just medicines, they are also food, cosmetics, tints, textiles, natural pesticides, oils, scents, fibers, alcohol, rubber, etc.; neither are natural products exclusive to tropical forests, for they can be obtained from arid zones, temperate vegetation, mangroves, grasslands, and so on. This means that developing countries ought to consider the exploitation of natural products as a feasible way to achieve sustainable development.

This talk aims to show the development and perspectives of the Mexican industry based on natural products, and to analyze the progress of a field basic to our country's medicinal culture.

RENEWABLE RESOURCES FOR INDUSTRIAL APPLICATIONS FROM A EUROPEAN PERSPECTIVE

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The development of non food applications of agromaterials has attracted a considerable and increasing interest in European industries and governments. In this, issues such as a sustainable society based on renewable resources, combined with environmentally sound processing and a responsible care with respect to waste stream management are very basic. To stimulate this development and implement potential applications in industrial practice several strategies have been followed.

Firstly, governmental organizations in Europe have initiated research programs to generate new outlets for agromaterials. Besides national programs in several European countries, especially the European Community has demonstrated a large commitment in this field. For more than 10 years research programs, acronymed ECLAIR, AIR and FAIR, targeted research and development of renewable resources based products. Projects eligible for funding under these programs typically included partners from several member states. Additionally, in most cases such projects dealt with complete production chains, from agriculture to end use, and required the active participation of industrial partners as well. Current discussions on a Fifth Framework Program, that will cover the R&D efforts over the period 1998 2002, will later this year lead to decisions on the particular focal points of this

program.

Secondly, a number of non food applications of renewable resources have recently seen market introduction in Europe. These include some high volume markets, such as rapeseed methyl esters in biodiesel or organic solvents and flax fibers in the reinforcement of composites (such as car parts). Also some smaller volume markets are now being targeted, such as wheat protein binders in coatings and starches in various disposable consumer products.

Furthermore, to facilitate the introduction of agromaterials the European Community has opened up the possibility to use set aside acreage for the cultivation of non food crops, with accompanying agricultural subsidies.

INDUSTRIAL USES OF SOYBEAN

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United States agriculture produces over 12 billion pounds of soybean oil annually, and frequently carry-over exceeds 1 billion pounds. Only 300 million pounds of soybean oil are used in industrial applications. Non-food uses of soybean oil and other vegetable oils have grown little during the past 40 years. Although some markets have expanded or new ones added, other markets have been lost to competitive petroleum products. Development of new industrial products or commercial processes are objectives of continued research in both public and private sectors. Through these efforts vegetable oils should maintain or even add to their market share as non-renewable petroleum becomes more expensive.

Industrial applications include plasticizers, emulsifiers, surfactants, plastics, resins, lubricants, coatings, corrosion inhibitors, adhesives, cleaners, cosmetics, water repellants, and fuels. At the Oil Chemical Research Unit (ARS, USDA, NCAUR), we investigate and develop economically feasible new industrial products from soybean oil and thus, enhance its domestic and export market. Our principal effort focuses on modifying chemical and physical properties of soybean oil to enhance its use as an additive or as a major component of lubricants, surface coatings, printing inks, fuels and industrial chemicals. Approaches include both chemical and biological techniques to modify soybean oil or its constituents and introduce new functionalities. Up to date progress of the above technologies will be summarized.

BIORENAISSANCE PROJECT IN JAPAN

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The degradation of the ecological system and environment of the earth are getting to be increasingly serious problems. We must revise our socioeconomic system of mass production, mass consumption, and mass disposal based on the fossil resources and create a society that the primary industries, agriculture, forestry and fisheries, are flourishing as well as the secondary and tertiary industries (AFF). AFF in Japan, however, is in a slump due to internationalization of trade, and the reduction of tariff for AFF products. So as to promote AFF industries and activate rural communities, it is necessary to create new uses for AFF commodities. Under these circumstances, this project has been undertaken to develop technologies for conversion of AFF commodities to value added industrial products, fuels and new fiber products. The emphasis have also been put on the development of environmentally benign process which will be attained by using the functions of microorganisms and enzymes.

(1) Development of environmentally benign products from AFF commodities, (a) bio degradable plastics from

starch, silk, and protein; (b) chemicals from wood and wood fiber; © engineered woods from under utilized woods; (d) bio energy (ethanol) from sugar beet and sweet sorghum. (2) Creation of new demand by development of value added products, (a) new chemicals such as pigment flavor, etc; (b) health foods such as oligosaccharides, carotene, etc, © physiological active substances as cosmetics, medicine, etc., (d) new type foods such as allergy less soybean, fiber rich sweet potato, (e) special fine silk. (3) Environmentally benign crops (a) breeding of non pollen grasses; (b) plant solubilizing soil bound phosphate,(4) Development of activating system for rural AFF industry

ONE PERSPECTIVE ON THE FUTURE OF NEW CROPS

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The last two decades have seen a startling increase in the establishment of new industrial oil seed crops. This list includes crambe, jojoba, and meadowfoam. Why have these crops seen sustained growth and economic viability and other proposed crops, such as dimorphethica, calendula, vernonia, cuphea, and lesquerella languished? The reasons for each are not all the same nor are they obvious. In order for a crop to have a future there are several important factors that must be present. Included in this list is sufficient agronomic yields and on farm profit, both a public sector and private sector champion, favorable statutory factors such as the environmental improvement, social pulls such as animal rights issues, etc. If the champions take advantage of favorable factors, progress towards sustained growth can be made and a new crop developed.

What is the role of government - the private sector? The attitude of protectionism posed by some new crop developers (and governments) is a pitfall that can be, in the long run, disastrous for the developer, and subsequently the crop. Realizing that agriculture is global in nature will go a long way in sustaining the crop's development.

The problem with discussing new crops as one unit is that they are not one unit. Some produce material that already has a market, but are not developed agronomically and others can be grown with good yield but no market has been established for their unique materials. I will try to give my version of a future scenario for new crop development.

EVOLUTION OF SOME NATURAL RESOURCES INDUSTRIALIZATION IN MEXICAN ARID AND SEMIARID LANDS

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México has a great diversity of plants growing in its different climatic regions. These plants have been used as food, medicine, source of construction and industrial materials, etc. In particular there are 1,028,055 km² of arid and semi arid lands from which several species are used in a limited commercial form. Industrialization and commercialization of raw materials from plants have had diverse degrees of development in our country. In some cases the installation of processing plants have been reached, but in others only the recollection of raw materials or partial semi processing is attained. Despite the effort of universities, research centers and government agencies there is only a moderate success in industrializing species from the mentioned regions, although there is an important international market.

In this work we make a review of the development in industrialization and commercialization attained by several semi arid species, trying to identify the possible causes that prevent to reach the degree of development accomplished by these species in other countries. The cases of study are such as guayule, zabila, candelilla, ixtle, jojoba oregano and nopal.

We obtained information about cropping/recollection activities, raw materials production, the possibility to develop other products (particularly with high aggregated value), the existence of industrial plants and technology is also documented. Besides, we identify the politics supporting the research and development activities. The role of private investment is also considered.

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MEADOWFOAM DIVISION

THE DEVELOPMENT OF MEADOWFOAM AS A SOURCE OF VERY-LONG-CHAIN OILS: AN UPDATE AND REVIEW OF BREEDING ADVANCES

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Meadowfoam (*Limnanthes alba* Benth.) oil is a source of novel unsaturated very long-chain fatty acids (20:1 D⁵, 22:1 D⁵, and 22:2 D⁵, 13), in addition to erucic acid (22:1 13). The steady growth of meadowfoam oil markets since 1993 has caused meadowfoam production to flourish in Oregon. New cultivars are needed to pace the growth of the industry and meet the demand for greater seed yields. Several experimental open-pollinated cultivars (OMF-69, 78, 86, 87, and 103) are presently being tested for commercial release. These honeybee-pollinated cultivars were developed by selecting for increased seed yield, oil content, and lodging resistance among half-sib families from strongly allogamous populations. Naturally self-pollinated progeny were discovered in wild populations of *L. alba* ssp. *versicolor*. Strongly autogamous lines were developed by directly selecting for self-pollination in these populations. Experimental self-pollinated cultivars are being developed by selecting among pedigreed inbred lines developed from crosses between allogamous and autogamous lines (*L. alba* ssp. *alba* x *L. alba* ssp. *versicolor*). Self-pollinated cultivars should boost profits by eliminating pollinator costs if they have seed yields on par with honeybee-pollinated cultivars. A genome map (x = 5) is being developed using amplified fragment length polymorphisms (AFLPs). DNA fingerprinting, genome mapping, and molecular breeding are aided by very high DNA marker polymorphism rates in this crop: 8 primer combinations produced 436 polymorphic AFLP bands between the parent inbred lines. The genome map is being used to map genes underlying agronomically important traits (fatty acid and oil content, flower morphology, self-pollination, seed yield, and lodging resistance). This work should shed light on the genetics of several important traits and speed the development of new cultivars by creating the basis for more precisely and efficiently introgressing genes from exotic to elite germplasm.

EXPANSION OF MEADOWFOAM PRODUCTION INTO THE MID ATLANTIC AREA OF THE UNITED STATES

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Consequent to research conducted at Virginia State University's farm located in Ettrick, Virginia indicating that meadowfoam can be grown in Virginia, two production fields were established during 1996/97 season. With support from Fanning Corporation, two farmers were contracted to produce 2.5 hectares each of meadowfoam. These fields were planted on December 12, 1996 with a grain drill with about 25 kg seed per hectare. The germination and stand establishment in both fields were excellent. Both fields received about 50 kg/ha nitrogen. The meadowfoam in both fields was in full bloom by May 9, 1997. Even though visual observations indicated that considerable numbers of pollinators were present in both fields, eight beehives were placed in each field to enhance pollen transfer. The meadowfoam is maturing satisfactorily. As of May 28, 1997, the developing seed had a moisture content of about 78 percent. We plan to harvest these fields when the seed moisture is about 42 percent. The yield levels and other details about this production effort will be presented and discussed. In addition,

results of experiments being conducted at the research farm to determine optimum fertilizer rates and row spacings for meadowfoam production in Virginia will also be presented and discussed.

FACTORS AFFECTING THE PROCESSING OF MEADOWFOAM SEED

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Enzymes in raw oilseeds interact with seed components when cells are crushed during oil extraction processes. Proper cooking normally destroys these enzyme systems and leads to more easily refined crude oils and higher quality meals.

Meadowfoam (MF) seeds (e.g., *Limnanthes alba*) contain an active thioglucosidase, which interacts with m-methoxybenzyl glucosinolate to release m-methoxybenzylisothiocyanate, an unstable aglucon that readily liberates thiocyanate ion as a detectable product. There is potential for sulfur-containing products to chemically or thermally decompose during processing and deposit contaminants in the oil, and these may poison hydrogenation catalysts and/or cause odor problems. Thus, we sought cooking conditions that would destroy thioglucosidase during processing prior to oil extraction. Whole-seed inactivation, though more difficult than in flaked seed, is preferred, because enzyme/glucosinolate interactions in flakes are possible in flake transit or during initial phases of flake cooking.

We conducted laboratory experiments in which whole MF seeds sealed in screw-capped vials were moisture equilibrated (6-16%) before being heated at selected temperatures (180-230°F) for predetermined time intervals (15-60 min.). These "cooked" seeds were then air dried, ground in a coffee mill, and the meal slurried with pH 7 phosphate buffer. The slurried meals were then checked for glucose using a glucose sensitive TesTapeR procedure. A positive test (green color development in the initial yellow paper tape), immediately or slowly over time indicated that thioglucosidase was still active in the cooked seed meal. A desirable negative test showed that the particular combination of time, temperature and moisture was adequate for enzyme inactivation in the cooked seed. In our experiments, the effective levels of moisture, temperature and time during cooking to inactivate MF thioglucosidase were >10% moisture, >210°F, and 45-60 min. These results were confirmed in field experiments and resulted in high-quality oil.

COMMERCIAL APPLICATIONS AND BENEFITS OF MEADOWFOAM SEED OIL AND SELECTED DERIVATIVES

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The unique fatty acid profile and consequent special properties of Meadowfoam seed oil and its derivatives have stimulated significant interest in several commercial areas. These include personal care products such as cosmetics and toiletries as well as industrial applications including lubricants and inks. Applications data will be presented for Meadowfoam seed oil and two of its derivatives, Meadowfoam estolides and silicone Meadowfoam esters.

THE POTENTIAL OF CRAMBE AND MEADOWFOAM SEEDMEALS AS SOIL AMENDMENTS FOR WEED AND NEMATODE CONTROL

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Crambe (*Crambe abyssinica*) and meadowfoam (*Limnanthes alba*) seedmeals are processing by-products of the oil extraction of the seeds. Both crambe and meadowfoam seed contain high levels of glucosinolates, sulfur-containing secondary plant compounds. Glucosinolates and their degradation products have limited the usefulness of the seedmeals as animal feed. Since some of the degradation products are similar to synthetic soil pesticides and are biologically active, the meals may be of benefit as soil amendments for alternatives to currently-available pesticides. We have shown that both seedmeals were phytotoxic to several plant species when added to soil at levels of 1% or more. 1-Cyano-2-hydroxy-3-butene (CHB) and (3-methoxyphenyl)acetonitrile (3-MPAN) were identified as the major phytotoxins from crambe and meadowfoam seedmeals, respectively. Both seedmeals were equally effective against *Meloidogyne chitwoodi*, a root-knot nematode species that blemishes potato tubers in the Northwestern states of the U.S. We suspect that CHB and 3-MPAN are primarily responsible for the toxicity of the seedmeals to nematodes. Presently, the utility of both seedmeals as environmentally-friendly nematicides is under investigation in the field.

LARGE IMPROVEMENTS IN THE OXIDATIVE STABILITY INDEX OF VEGETABLE OILS BY ADDITION OF SMALL AMOUNTS OF MEADOWFOAM OIL

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The poor oxidative stability of vegetable oils is one factor slowing the growth of vegetable oil markets in industrial applications. Consequently, there has been an increased effort to develop stable oils through the use of antioxidants. A relative new instrument for determining the oxidative stability of vegetable oils (OSI, Oxidative Stability Instrument) is now available. The OSI determines the oxidative stability of vegetable oils by measuring the conductivity change of a water solution as the volatile decomposition products produced from vegetable oil oxidative degradation dissolve in the solution. The OSI time (point of oxidative failure) is reported in hours at the point where a rapid increase in the conductivity occurs.

We have surveyed the oxidative stability of a range of vegetable oils and found that a developing new crop, meadowfoam (*limnanthes alba*) has a very high oxidative stability when compared to other vegetable oils. Unrefined meadowfoam oil has a high OSI time (110°C) of 246.9 hours when compared to other stable oils such as refined Jojoba oil, 31.4 hours and refined high oleic sunflower 49.8 hours. Refining of meadowfoam oil, however, greatly reduces its oxidative stability to 67.3 hours which is still higher than the other vegetable oils that were screened.

Binary mixtures of vegetable oils were also examined for oxidative stability. Of the binary oil systems that were studied meadowfoam had the most pronounced effect on jojoba oil by increasing the oxidative stability of jojoba oil by 40% with only 5% incorporation of unrefined meadowfoam oil. However, unrefined meadowfoam failed to improve the oxidative stability of refined soybean oil but did improve the oxidative stability of triolein (95%) greater than 21 fold.

The unusually high oxidative stability of meadowfoam oil could not be attributed to its tocopherol content (668 ppm tocopherol) nor its iodine value (93.0) when a relationship of oxidative stability versus iodine value and tocopherol content were compared to other oils.

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KENAF AND FIBERS DIVISION

HARD FIBER SPECIES OF AGAVACEAE AND NOLINACEAE FROM MEXICO AND THEIR PRODUCTS

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The natural distribution of the Agavaceae and Nolinaceae families is limited to America. For Mexico we recognize the existence of approximately 281 species, to which 232 belong to the Agave, Beschorneria, Furcraea, Manfreda, Polianthes and Yucca genera in Agavaceae. Meanwhile 49 species of genera of Beaucarnea, Calibanus, Dasyliirion and Nolina correspond to Nolinaceae.

The advantage of the fibers of these plants revise two modalities; the direct use of the leaves for the elaboration of basketry, hats, sweeping mechanisms, etc., It would be proper to mention species of Beaucarnea, Dasyliirion and Nolina. The extraction of fiber between the scraping of the leaves which is done with some Agave, Beschorneria, Furcraea, Hesperaloe, Nolina and Yucca species.

The fibers can be obtained from the sheets of the central cone of the rosette, called "cogollo", which happens in the exploitation of the lechuguilla (*Agave lechuguilla*), the comb agave (*A. striata*), the Samandoca palm (*Yucca carnerosana*) and the Jaumave ixtle fiber (*A. funkiana*).

Also it is implemented the external mature leaves to the rosette, which is the case of the henequen (*Agave fourcroydes*), the pulque agave (*A. salmiana*), the stiff leaves agave (*A. applanata*), the clothed agave (*A. schidigera*) the Quichee's hemp (*Furcraea quicheensis*) and the Guatemalan hemp (*F. guatemalensis*).

The traditional methods of extraction of fibers depend of the disposition of water. After the cut, the sheets can be scraped directly, or previous to this process it can be cooked or baked. Once they are obtained, the fibers can be used directly in the elaboration of products as small brushes and dishclothes, or they can be treated by the use of different twisting-wheel apparatus. With strings you can make different types of rope and many handicrafts, which in some cases are object of exportation, nevertheless, a lot of these products tend to be elaborated with derived plastics. The phisical properties of the fibers depends of the method of extraction used.

ALTERNATIVE USE OF THE HARD FIBERS FROM MEXICAN SEMIDESERT

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The hard fibers of mexican semidesert wild plants "lechuguilla" (*Agave lechuguilla* Torrey) and "Palma ixtlera" (*Yucca carnerosana* Trelease) has been traditionality an important resource for the inhabitants of the mexican semidesert and its primary proccesing a way of subsistence.

This hard fibers (that the peasants sales in bulk and to very low price) are industrially treated and transformed

into raw materials for brushes, cloth for sacks, and ropes for many uses in the rigging and hard fiber textile industries.

There has been little or no handcrafted transformation of this raw material into products however, and this process could be a very important alternative for increasing income.

This work is attempting to rescue some handcrafted transformations and to divulge innovations about techniques from this region. We are also working in the field of technological for species and suppliers of hard fibers.

WATER USE DURING STAND ESTABLISHMENT OF *HESPERALOE FUNIFERA*

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Hesperaloe funifera is a potential new fiber crop for arid and semiarid lands. It is a perennial native to the Chihuahuan Desert region of northern Mexico that produces very long, narrow leaf fibers suitable for use in speciality papers. *Hesperaloe* species are Crassulacean acid metabolism (CAM) plants with very high physiological water-use efficiencies which indicates they should have low water requirements. However, little is known about the water-use relationships of these plants. A study was initiated to assess the influence of irrigation delivery systems and water management on *Hesperaloe* production.

For this study, *Hesperaloe funifera* seedlings were transplanted to the field at the University of Arizona Maricopa Agricultural Center at Maricopa, Arizona in November 1994 and irrigation treatments were established in September 1995. Treatments included two irrigation delivery systems, subsurface drip and furrow, and four irrigation levels. Plant measurements taken in December 1996 indicated that the irrigation system had no significant effect on plant growth. However, the drip system required much less irrigation water than the furrow system to maintain the same soil moisture content. The wettest furrow treatment received 77 cm of irrigation water in 1996 while the comparable drip treatment received only 39 cm. *Hesperaloe* showed a strong response to water with treatments receiving frequent irrigations having the highest fresh plant weights. Although the plants appear to be able to survive with very little water, irrigation water must be supplied frequently to achieve rapid growth. *Hesperaloe* appears to produce a shallow, horizontal root system. At the end of two years, no roots had penetrated to a depth greater than 45 cm.

TOLERANCE OF SAMANDOQUE [*Hesperaloe funifera* (Kock) Trel.] TO POSTEMERGENCE HERBICIDES

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Hesperaloe is a potential new crop for arid and semi-arid lands, because it grows well in dry and hot environments. *Hesperaloe* produces high quality, very long, narrow fibers with thin cell walls that can be used by the specialty paper industry. The response of *Hesperaloe* to preplant-incorporated and postemergence herbicide applications was evaluated in greenhouse in 1994. *Hesperaloe* was very sensitive to preemergence herbicides at the early seedling stage, but 8 month-old transplants were tolerant to many postemergence herbicides. Ten postemergence herbicides were selected in order to evaluate the tolerance of *Hesperaloe* to foliar applied, postemergence herbicides in field conditions.

In the fall of 1995 at the Maricopa Agricultural Center ten postemergence herbicides were tested: bromoxynil, paraquat, glyphosate, oxyfluorfen, prometryn, fluzaflop-p-butyl, sethoxydim, clethodim, halosulfuron-methyl, and imazaquin. The herbicides were applied by spraying over-the-top of the plants three times in 1996, and two

in 1997. Treatments were applied with a compressed-air plot sprayer. During the course of the experiment, fresh weight was estimated nondestructively and herbicide injury was rated six times. Herbicide injury was visually estimated with 0 percent indicating no injury and 100 percent indicating plant death.

Hesperaloe is tolerant of all postemergence herbicides evaluated in this study. Fresh weight was not significantly affected by the herbicide treatments after three applications ($p = 0.05$). The highest fresh weight was 63 ± 24 (mean \pm Std. Dev.) and the lowest was 32 ± 9 g/plant. Analysis of variance of the injury data on June 6, 1996 showed that only three treatments resulted in significant leaf injury. Bromoxynil at the high rate of 1.5 lb a.i./A and oxyfluorfen at rates of 1.3 and 2.0 lb a.i./A caused significant leaf injury ($p = 0.05$) compared to control plants 43 DAT. Plants treated with bromoxynil had yellowish chlorotic leaves with white tips, while those treated with Goal had black-brown necrotic spots on the leaf lamina, leaf tips, and at the base of the leaves 43 DAT. Analysis of the injury data on November 18 (105 DAT) indicated that none of the treatments caused significant injury compared to the control. After the third application, on November 21, 1996, those plants treated with oxyfluorfen showed significant ($p = 0.05$) leaf injury compared to the control. Leaf injury increased as the rate of Oxyfluorfen increased from 0.6, 1.3, to 2.0 lb a.i./A. Plants treated with imazaquin at the highest rate were stunted, but no leaf injury was evident. The rest of the herbicide treatments caused no significant leaf injury. These preliminary results indicate that many herbicides tested in this experiment may be used safely in Hesperaloe to control most broadleaf and grass weeds. In order to obtain reliable conclusions, it will be necessary to continue this experiment for several more years to collect more injury data, to nondestructively estimate biomass, and to measure actual leaf biomass at the first leaf harvest five years after planting.

MECHANIZATION OF HESPERALOE PRODUCTION

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Equipment for mechanizing hesperaloe production has been under development at the University of Arizona since 1995, with the goal being to provide commercially viable equipment. The three types of equipment under development are for seed harvesting, leaf harvesting, and decortication.

Equipment for seed harvesting is being developed following two approaches. Cutting of the seed stalks with a conventional combine followed by threshing is one, vacuuming of shattered seed from the soil surface is the other. Each methodology has its advantages and disadvantages. Direct combining increases seed loss as the stalks must be cut before all of the fruits ripen, otherwise losses due to shattering are high. Vacuuming seed from the soil surface allows collection of most of the seed, provided heavy rains do not wash it from the field prior to collection.

Equipment for leaf harvesting is being developed following a three step process: cutting, decortication and compacting. Cutting studies are underway to evaluate three techniques: sawing, use a pair of counter-rotating plow coulters, and cutting with a disc mower. Energy requirements are similar for the three methodologies, but ground speed is limited with the coulters system.

Development of decortication equipment has centered on two methodologies. One involves adapting a sisal decorticator. In the other system, the leaves pass sequentially between two sets of paired, counter-rotating rollers, which have small grooves machined longitudinally on their surfaces. Tests have shown the roller system to be superior in capacity and simplicity of operation.

A large round baler was successfully used to compact decorticated leaves. In 1996, four tons of leaves were compacted with this system, with an average bale weight of 805 pounds recorded.

NITROGEN UPTAKE BY *HESPERALOE FUNIFERA*

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As a first step in determining the nitrogen fertilizer requirements for *Hesperaloe funifera*, we estimated the amounts of N taken up in leaves, crowns, roots, and flower parts for eight years at three stand densities. Stands were established in 1988 from transplants at densities of 6750, 13500, and 27000 plants ha⁻¹. All stands were harvested at the end of the 1992 (after 5 years) and 1995 (after 8 years) growing seasons.

For this analysis, "leaves" include those portions of the leaves obtained when harvesting above-ground biomass at about 3-5 cm above ground level. "Crowns" thus include both the true crown and the thick leaf bases. All plant organs were sampled to determine percent dry weight and percent N. Fresh leaves, crowns, and roots averaged 32.3 ± 0.7, 23.5 ± 0.5, and 18.8 ± 0.5 percent dry matter, and 1.42 ± .06, 0.85 ± .05, and 0.27 ± .03 percent N (dry weight basis), respectively. Green flower stalks, flowers, and capsules contained 0.29 ± .02, 2.26 ± .03, and 2.45 ± .03 percent N, respectively. Senescent flowers had lower dry matter and lower percent N, indicating that much of the N invested in flowers is recovered from unfertilized flowers.

Estimated N-uptake per year varied from 5-12 kg N ha⁻¹ in Year 1 to 383-833 kg N ha⁻¹ in Year 8. Estimated total N uptake over the 8-year period was 1555, 2493, and 3575 kg N ha⁻¹ at low, medium, and high densities, respectively. N-allocation to flowering and seed production varied from 17.5% in the high-density plots to 20.6% in the low-density plots. Fruits and seeds appear to represent a larger proportion of the N allocated to reproduction (67%) than of the carbon allocated to reproduction (18%), suggesting that fruit set may be N-limited.

THE EFFECT OF NO-TILL VS CONVENTIONAL TILLAGE ON KENAF GROWTH AND YIELD

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Northern Missouri loses on the average 5 ton/ha of top soil annually. Kenaf (*Hibiscus cannabinus*) has been introduced as an alternative crop for this area. It is a crop that fits in well after corn or soybeans. Research studies have demonstrated that the use of no-tillage in corn, cotton, soybeans, etc. reduces soil erosion and the cost of land preparation, and conserves moisture in the soil. A two-year study was established in Oregon, Missouri to determine the growth and yield response of kenaf to no-till soil conditions when compared to conventional tillage.

On 23 May, 1994 and 25 May, 1995, seeds of kenaf cultivar Tainung #2 were planted in Oregon, Missouri on a Van Meter silt loam soil (fine, illitic, mesic typic Eutrochrepts) using a sorghum planter. The Kenaf crop was planted following corn the previous year with the rows 76 cm apart. The crops were fertilized with 120 kg/ha of nitrogen as side-dress 45 days after planting. Two weeks prior to planting, the field was broadcast sprayed with Roundup [Glyphosate, N-(phosphonomethyl)glycine] at a rate of 1.12 kg/ha. Height and stem diameter were measured with a mm ruler at harvest. Ten samples (each sample contained 5 sub-samples) were used for yield, core and bast were separated, oven-dried, and weighed. The experiment was established on a completely randomized experimental design.

No significant differences (P = 0.5) were found on the average total yield of stalk between the no-till and the conventional tillage for both years. However, a slight yield increase was observed on the no-till treatment in 1995. May 1994 was noted as a wet period and may have influenced the growth of the kenaf under both systems. A yield of 6 to 6.5 ton/ha is considered to be normal for northern Missouri. There was no significant difference (P = 0.5) in plant height attributable to tillage methods. Also, no significant differences (P = 0.5) were detected on the stem diameter and percent bast of kenaf between tillage treatments in both 1994 and 1995. Since no significant

differences were detected among the different measured parameters, the growers will be much better off to use the no-till system for kenaf production in northern Missouri.

THE DAUPHIN PLANTATION

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The Dauphin Plantation, located around Ft. Liberty Bay in the semi-arid northeastern corner of Haiti near the Dominican Republic border, by the end of World War II, was the major source of sisal fiber for the United States Navy.

The Planation was the answer to a long-time dream of Andre de Coppet, a New York financier, who had a desire to own a tropical agricultural development. His interest was spurred during a brief visit to Haiti in February 1926 when he was told by W. W. Cumberland, Financial Advisor to the Government of Haiti, that an investment in sisal production would yield a “hunnerd percent” profit per year.

The first manager of the plantation was Robert L. Pettigrew, a Navy engineer recently resigned from service with the U. S. Occupation force in Haiti. On February 11, 1927, a crew of Haitians began clearing the dry, almost impenetrable thickets on the west side of Ft. Liberty Bay, the beginning of the 5000 hectare development that would become known as West Bay Plantation. With World War II, another 5000 hectares of sisal was planted on the opposite side of the Bay to become East Bay Plantation. At its peak, the Dauphin Plantation produced about 20,000,000 lbs of top quality sisal fiber per year and became very profitable.

De Coppet never faltered in his financial support of the plantation in spite of diminished value of sisal during the depression years. The price dropped from ten cents per pound in 1926 to about 2.5 cents per pound during the 1930s. The plantation broke even or made a small profit during this period of low prices but with World War II became a financial bonanza.

The decline of the plantation began with the death of De Coppet in 1953 after which it was sold to settle his estate. The buyer was the Haitian American Sugar Company of Port-au-Prince which subsequently sold the plantation to Lonnie M. Dunn, a California business man. The final owner was Elias Cassis, a Port-au-Prince merchant.

Today, the plantation is totally abandoned and in ruins. It is a ghost among other ghosts - ruins of old French forts, lime kilns and habitations built during French colonial times when Haiti was known as the “Pearl of the Antilles”.

The Dauphin Plantation is an excellent example of what is required to establish a new or “non-traditional” crop and bring it to profitability - total dedication to an idea and a committed financial supporter.

THE HENEQUEN - ITS PROPERTIES, APPLICATIONS AND POTENTIAL

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Recent reports in the literature show a growing interest in the use of natural fibers as reinforcing agents of polymeric materials composite materials. Henequen (*Agave fourcroydes*) have been used in different products ranging from cords to sacks and mats among others. However, the entry of synthetic fibers in this market and their applications have substituted those of the natural fibers. The physical and mechanical properties of henequen fibers have been studied systematically. The geometrical properties of the fiber such as perimeter and cross-

sectional area vary along the fiber length. There are, however, three distinct zones with similar properties. These zones are: butt end (the end of the fiber attached to the tree), the middle zone and the tip end (the free end of the fiber). More uniformity of geometrical parameters was noticed in the middle zone. A weibull statistical analysis was performed on measurements of the cross section at different points along the fiber to obtain representative values of the area. An equivalent fiber diameter of 0.18 mm was obtained from the measured areas. It was also evident that the mechanical properties of the fiber were dependent on the fiber cross sectional area. The middle area also showed more uniform properties than the other two portions of the fiber. Adhesion of henequen fibers and a polyolefinic matrix was studied and a considerable increase in the composite material properties was also obtained. To obtain fiber-matrix compatibility the fiber surface was modified. The surface topography was modified using an alkaline treatment which increased frictional interactions at the fiber-polymer interface. Secondly, a chemical compatibility by a matrix compatible silane coupling agent or by graft copolymerizing a matrix compatible polymer on the surface of the fiber resulted in an increase of fiber-matrix adhesion and thereby in better mechanical properties of henequen fiber/HDPE laminates. Cellulosic fibers were also extracted from the whole fiber. They have also been used as reinforcing materials for polymer matrix composites. Fiber surface modification of these fibers also played a very important role in the final effective material properties. The dynamical mechanical properties of Portland cement mortars have also been modified by the inclusion of henequen fibers.

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GENERAL CROPS DIVISION

GERMPLASM FOR NEW CROPS AND NEW PRODUCTS FROM THE NORTH CENTRAL REGIONAL PLANT INTRODUCTION STATION

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The North Central Regional Plant Introduction Station (NCRPIS) in Ames, Iowa holds extensive plant germplasm collections valuable in developing and improving new crops and new products. The NCRPIS is a major component of the United States Department of Agriculture - Agricultural Research Service's (USDA-ARS) National Plant Germplasm System and is cooperatively supported by the USDA-ARS, the twelve Agricultural Experiment Stations of the north central states, and Iowa State University.

Central goals of the National Plant Germplasm System are to preserve useful biodiversity and associated information and to make that diversity freely available for research to users world-wide. A curatorial team at the NCRPIS manages diverse populations of primarily cross-pollinated agronomic and horticultural crops and their wild and weedy relatives. Most of this germplasm requires controlled pollination, and the NCRPIS has developed expertise in the use of insects and other methods to accomplish this technique.

Our collections comprise more than 41,000 different accessions of about 325 genera, including potential new oil crops (*Calendula*, *Camelina*, *Crambe*, *Cuphea*, *Euphorbia*, and *Vernonia*), pseudocereals and vegetables (*Amaranthus* and *Chenopodium*), and sources of medicinal and specialty chemicals (*Echinacea* and *Tanacetum*). The diversity represented in our collections of established crops, such as *Brassica*, *Helianthus*, and *Zea*, can also aid in developing new uses and products. Information describing our collections is now made available through the Germplasm Resources Information Network, which can be accessed via the Internet at <http://www.ars-grin.gov/>.

THE USE OF PLANT PEROXIDASE IN POLYMER SYNTHESIS

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Introduction. Peroxidase enzymes are able to catalyze the polymerization of aromatic compounds in presence of H_2O_2 . Polymerization mechanism consist in the oxidation of the aromatics in presence of H_2O_2 , generating radicals which polymerizes. This systems can be applied in highly conjugated polymers synthesis and in the treatment of wastewater that contain toxic aromatics. The objectives of this work were to find an alternative use for peroxidases by applying them in wastewater treatment and the use of peroxidases in biocatalysis in organic media of aromatics like 4-aminoacetophenone (4-AAP) and 4-aminophenylmethylcarbinol (4-APMC) studying some reaction parameters.

A sweet pepper enzymatic extract was used to evaluate the removal efficiency of nine toxic aromatics in aqueous solutions and its effectiveness in comparison with a commercial peroxidase (HRP). In polymerization reactions of 4-AAP y 4-APMC using horseradish peroxidase (HRP) was evaluated, the effect of the H_2O_2 addition and the temperature application ($50^\circ C$) and its effect on the products molecular weight.

In experiments where the method of addition of H_2O_2 was considered as a parameter that will influence the molecular weight of the products, it was found that monomers, like aniline, which have an electron attracting character (4-AAP) no polymerizes in presence of peroxidases, therefore the 4-APMC monomer was quickly polymerized and oligomers with an average of molecular weight of 2475 were obtained. The use of high temperatures ($50^\circ C$) did not affect the catalytic capacity of the enzyme the molecular weight of the products was increased. In polymerization reactions made in aqueous solutions the efficiency depends in a big percentage on the nature of the aromatic compound used. The kind, position and number of sustituent presents in the aromatic ring influence directly on the reactions yield and the nature of the obtained products. The yields obtained in reactions catalyzed with sweet pepper peroxidases were lower than those obtained with HRP.

Sweet pepper peroxidases present a similar behavior in polymerization reactions of aromatic compounds in aqueous solutions, although their yields are lower due the presence of a big quantity of protein in the enzymatic extract without purification. It was possible the polimerization of 4-APMC using HRP as catalyzer considering the way of addition of H_2O_2 as a parameter that influence on the molecular weight of the product. According to the formed oligomers characterization the coupling was made by means of a condensation reaction with the participation of the functional groups. High temperature has a positive effect on the molecular weight of the obtained products.

MICROPROPAGATION OF INDUSTRIAL CROPS

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During the past few years, we have achieved the micropropagation of several industrial crops, including candelilla (*Euphorbia antispyhilitica* Zucc.), buffalo gourd (*Cucurbita foetidissima* HBK), cacao (*Theobroma cacao* L.) and vanilla (*Vanilla planifolia* Andrews). Currently we are working on the macropropagation of coconut palm (*Cocos nucifera* L.).

Shoot segments of candelilla were cultivated on MS medium supplemented with 1 mg/L BA, 0.2 mg/L IBA and 0.1 mg/L GA3, and we obtained the proliferation of multiple shoots. The shoots were transferred to a rooting medium containing 1, 2 or 3 mg/L IBA +/- activated charcoal (AC), with the best rooting observed on medium with 1 mg/L IBA + AC. The rooted shoots were transplanted and successfully acclimatated upon transfer to pots. Shoots segments of buffalo gourd were established on MS medium with 0 or 25 mg/L Farmakin-Ca + 0.2 mg/l IBA + 0.1 mg/L GA3, and we observed the best production of the shoot and root systems on the presence of

Farmakin-Ca.

Embryo axes of cacao were cultured on MS medium supplemented with 0.1 mg/l IBA + 0.01 mg/L GA3 + 0.5, 1.0, 2.0, or 4.0 mg/L BA +/- 5.0 g/L AC; and we induced a complete plant regeneration, with plantlets showing the best morphological characteristics on medium with 1.0 mg/L BA + AC and with 0.5 mg/L BA - AC.

Shoot apices of vanilla were cultured on MS medium containing 2.2 mM BA + 1 mM IBA + 0.3 mM GA3 +/- 5 g/L AC, and we found that % survival, % rooting, root number, root length and shoot length were superior when AC was present on the medium. Plantlets could be successfully transplanted and grown on soil mixture.

Excised embryos and seedling apices from a Malayan yellow dwarf hybrid and a normal tall variety of coconut palms, were cultured on MS medium containing 0, 1, 10, 20, 40, or 80 mg/L 2,4-D + 2.5 g/L AC; with the aim of inducing callus growth and eventually inducing somatic embryogenesis upon transfer to another medium. This study is currently in progress.

NEW CROP TRIALS IN THE PATAGONIA REGION OF ARGENTINA

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A project began in September 1996 to evaluate the potential of several new crops in the Patagonia region of Argentina. Two locations were chosen for the plots. One is near Hilario Acasubi, in the southernmost part of the province of Buenos Aires, and the other near Choele Choel, in the center of the province of Rio Negro.

The trial plantings were sown by hand, with no fertilizer or herbicides used. The spring plantings, which took place in November, consisted of replicated plots of several potential crops. These included: 8 varieties of crambe, 8 varieties of amaranthus, 3 varieties of quinoa, 2 varieties of milkweed, 2 varieties of guayule, and one each of evening primrose, cuphea, chia and grindelia.

The fall plantings, which took place in February in Choele Choel, and March in Hilario Acasubi, also consisted of replicated plots. The crops sown were: 4 varieties of lesquerella, 2 varieties of milkweed, and one variety each of kamut, meadowfoam, evening primrose, euphorbia lagascae and grindelia. In addition, transplants of guayule, evening primrose and grindelia were set out in March and April.

Results of the spring planting are encouraging, with yields up to 2400 kg/ha recorded for crambe, 3500 kg/ha for quinoa and 1800 kg/ha for amaranthus.

PEANUT CROP: CULTURE AND USES IN MEXICO

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Peanut is a very important legume crop which was grown by the prehispanic cultures like the Aztecs. Some archaeological evidences indicate that peanut was known and cultivated by the Mesoamerican people. In this century peanut has been cultivated on up to 100,000 ha in Mexican Republic. Currently only approximately 60,000-80,000 ha are being grown by Mexican farmers. Although peanut is grown in most states of Mexico, there are two main regions: Northern areas (States of Chihuahua, Sonora and Sinaloa) and Southern region (States of

Morelos, Guerrero, Puebla, Oaxaca and Chiapas). In the first region high technology (selected varieties, mechanized system, irrigation and good pest control) is used by farmers. On the other hand, in southern areas, due to the rainfed system very low levels of technology are used, except in coast of Oaxaca. In the other states, some topographic and economic aspects limite appropriate agronomic practices. Most of the peanut varieties (landraces) used are virginia types, although in state of Chihuahua and Oaxaca, selected varieties from U.S.A. are being sowed. Consequently, mexican pod yield are: northern areas, 2.0-4.0 t ha⁻¹, southern areas (rainfed conditions), 1.0-2.0 t ha⁻¹. Most part (85%) peanut pod harvested in Mexico is consumed in roasted shell and boiled peanuts. The res of peanut production is destined to candle industry and other regional uses like peanuts “in salmuera” (a water solution plus salt), “atole” (milled peanut mixed with mass of corn,sugar and milk), sauce (milled peanut plus chili pepper and other condiments).

Eventhough we do not have a national research about peanut marketing (trade) Mexico has to import peanut from another countries: USA, Argentine and Nicaragua. The snack peanut industry is very important in southern Mexico. In states of Puebla, Tlapanala is a very important town where peanut is processed for getting different kinds of candle pleanuts. In state of Morelos, Amilcingo, Temoac, Amayuca, Galeana, Xoxocotla, Mazatepec y Ahuehuetzingo are main locations where peanut is procesced in different forms: salad peanut seed, peanut seed mixed with salt and hot pepper. In Mexico City Nipon, Mafer, are important brands and factories that have very high levels of production. In Mexico, peanut oil is not procesced. It will be very expensive for human consumption.

Finally peanut crop in Mexico is a very expensive activity. Mexican goverment do not support peanut production.

ANTHROPOGENIC PRESSURE ON NATURAL POPULATIONS OF *Agave victoriae-reginae*

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The genus *Agave* contains about 310 species native to the American Continent, from which 272 are native to Mexico. Agaves have long been utilized for their leaf fiber and for beverage production In Mexico, agave usage has a long tradition. There is evidence of various human artifacts made from fibers of *Agave* date back 8000 years.

The *Agave victoriae-reginae* is an endemic species found in Coahuila, Nuevo Leon and Durango Mexico. In the past this *Agave* was used to make rustic strings but due to its morphological characteristics it became an ornamental plant of great interest for plant collectors. The great demand of this agave in the international market has contributed to the irrational use of this natural resource and as a result it has been classified as in danger of extinction. Hence this species is not only threatened by its endemic distribution but also by the over exploitation by ornamental collectors. Other factors that have contributed in a small proportion to the loss of natural agave populations are the agricultural development, road construction and fires.

The objectives of this study were: 1) to locate natural populations of *Agave victoriae-reginae* 2) to determine the current condition of natural populations, 3.) to ascertain the environmental conditions in which the *Agave* grows. Preliminary field work was carried out in Ramos Arizpe situated to the southeast of the state of Coahuila. This is a semiarid mountainous region with a range in altitude of 750 to 2200 m.

We located a complex of small isolated populations of *Agave victoriae-reginae* distributed on hillsides with medium slopes, where stony eroded soils are the predominant type. All natural Populations are characterized by very few young plants, this is, there is a lack of individuals of larger size(those with higher commercial and reproductive value). Thess findings suggest that plant collectors are making serious inroads on the surviving populations.

Evaluations of plant size, plant community and population characteristics were done. In the future some action will be taken to preserve this species.

SCREENING FOR ANTIINSECT ACTIVITY IN MEDITERRANEAN PLANTS

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A screening of plant extracts from wild species of southeastern Spain for insecticidal activity could lead to the discovery of new agents for pest control. Aerial parts of a group of 50 plant species belonging to different botanical families were harvested during 1995 and 1996. For each sample three extracts were obtained using organic solvents of increasing polarity. Activity was tested in bioassays using the stored grain pest *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae).

Larvae growth inhibition was significantly induced when extracts were incorporated into the diet at 0.05%, being the most active plants: *Anabasis hispanica*, *Senecio lopezii*, *Bellardia trixago* and *Asphodelus fistulosus*. However, only with *Ajuga iva* 70% of mortality was produced. Repellency was detected when extracts of *Pistacia lentiscus*, *Genista umbellata* and *Cachrys sicula* where mixed with the insect diet.

Polar extracts of *Cichorium intybus*, *Reichardia tingitana*, *Mentha longifolia*, *Zygophyllum fabago*, *Helleborus foetidus* and *Datura stramonium* and non polar extracts of *Chondrilla juncea* and *Ailanthus altissima* gave 70-100% of mortality when applied topically at 3 g/larvae.

Finally, it is included a discussion of results with reference to the literature and also to the problems in this field and approaches to study this biodiversity to develop new uses of plant materials to benefit the environment.

EFFECT OF BOTH THE TEMPERATURE AND SALINITY ON GERMINATION OF THREE SPECIES OF *ATRIPLEX* (*A. semibaccata*, *A. numularia*, *A. canescens*)

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Species of *Atriplex* are very common under arid and semiarid conditions of México. Some of them provide browse for ruminants through the year.

Research was conducted in order to assess the effect of three levels of temperature (10, 25 and 35°C) and different concentrations of NaCl solution (0, 2, 12, 45, 70 and 80 mmhos/cm) on germination of *A. semibaccata*, *A. numularia* and *A. canescens*. Temperature was held constant through experimentation. Fifty utricula per petri dish were kept on a piece of moisted filter paper. A randomized factorial design was applied to data and a statistical significance level was selected (P 0.05).

Statistical analyses showed that all treatments were highly significant ($P < 0.01$). *A. numularia* presented the highest percentage germination under different levels of temperature. The germination decreased from 25°C to 35°C (40%, 26% and 9%, respectively). Results for *A. canescens* were the lowest. Analysis of interaction species-salinity indicated that germination of *A. numularia* was the highest through the lowest three levels of salinity (50%, 20% and 6%, respectively). No germination was found for the three upper levels of salinity for any species. Again, the lowest values were for *A. canescens*. As both temperature and salinity levels increased, germination of all species decreased. Finally, lower temperatures provided the best percentage of germination when utricula were moisted with distilled water; whereas, 25°C was the best temperature for saline treatments.

COMMERCIALIZATION ALTERNATIVES FOR PRICKLY PEAR FRUIT

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Nopal (*Opuntia* spp.) is a plant widely scattered in Mexico farming, in some locations thick inaccessible forests as is the case in the cactological zone par excellence of the San Luis Potosí-Zacatecas highlands where plants with a height of up to seven meters can be found. These plants, along with magueys (*Agave*) and mesquite (*Prosopis juliflora*) represent a source for work and food for natives since pre-colonial times. Actually natives from the high lands profit by the nopal, mainly the cardón one (*Opuntia streptacantha*) a variety with a high economic importance since it furnishes the rural economies with fruit, vegetable and forage feed.

Industrialization of the nopal's fruit (tuna cardona) is a very important source of income for the peasants who take advantage of it. By the time being, due mainly to the lack of leadership, and of continuity of official programs that favor its exploitation, there are only a few agroindustries working as consolidated groups or associations.

Family agroindustries work more efficiently in the exploitation of tuna cardona, they are more stable since they are integrated by 2 or up to 5 families with a unique leader who makes all decisions concerning the activities to be performed during the day.

In this study it is presented a typical example of an integral utilization of the nopal plant, performed by a group of peasants -Mr. Daniel Oropeza and his family- from Ejido Cerro Prieto, a locality belonging to the municipality of Villa Hidalgo, in the state of Zacatecas, México. They take profit of nopal fruit and vegetable for family feeding and the fruit exceeding their needs is industrialized and commercialized in a family agroindustry scheme.

NOPAL FORAGE SPECIES AND ITS DISTRIBUTION IN THE MEXICAN STATE OF COAHUILA

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Possibilities of Cactaceae from the Chihuahuan Desert are multiple and diverse, from ornament and medicine to food and forage usage. As far as forage usage is concerned, the genre *Opuntia* concretely the subgender *Platyopuntia*, both of them known as nopal.

This work was performed in the Mexican northeastern state of Coahuila comprising three physiografic provinces; northern mountain range and plains, Western Mountain Range, and great north American flat lands. This assay's methodology consisted in collecting data of the genre *Opuntia* from already existing collections plus fresh data obtained through direct work with small private landowners and ejidatarios (collective landowners) who utilize nopal as forage for their cattle.

From the 25 species and 12 varieties of nopal reported for the state of Coahuila, only five species and 12 varieties are considered useful for forage, being its distribution as follows. *Opuntia lindheimeri* and its four varieties (*lindheimeri*, *aciculata*, *subarmata* and *tricolor*) are distributed in the eastern part of the state with a rainfall over 400 mm per year. *Opuntia phaeacantha* and its five varieties (*major*, *phaeacantha*, *discata*, *spinosibaca* and *nigricans*) are distributed in the western part of Coahuila, considered the most desertic part of the state with a rainfall under 200 mm per year and an altitude below 1000 m. *Opuntia cantabrigensis* (nopal cuijo) and *Opuntia engelmannii* (nopal rastrero) are distributed in the southeastern part the state with an average rainfall of 200-400 mm per year and an altitude between 1500-2500 m. *Opuntia rastrera* (nopal rastrero) is distributed in the southeastern and southwestern part of the state with an average rainfall of 400 mm per year and a height among 1000-2000 m.

Species with a minor forage importance are *Opuntia imbricata* (coyonoxtle or cholla), *O. leptocaulis* (tasajillo), *O. microdasis* (nopal cegador), *O. violacea* (nopal morado), and *O. rufida* (nopal cegador) which are profited in critical times such as extreme winters or long lasting droughts. *O. microdasis* and *O. rufida* are highly craved for

by ovine and caprine cattle but it represents a serious problem due to its small thorns (ahuates) that make its handling difficult and cause blindness to the cattle.

TWO CROPS A YEAR IN AN AGROFORESTAL SYSTEM WITH *Dioscorea remotiflora* IN THE STATE OF COLIMA, MEXICO

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Dioscoreas (the yam family) have been proposed as models for the study of the domestication of root crops, due that they have been domesticated or gathered simultaneously in different parts of the world. The genus has importance as medicinal and food plants, and are still important sources of farmaceutic drugs as diosgenin, specially in the tropics. In Colima state, gathering of the Camote del cerro (*Dioscorea remotiflora*) is a traditional activity which has socioeconomic importance for the rural families. To evaluate its reproductive strategy and to determine the impact of the digging for tubers on to the population structure of the species, an etnobotanical survey was carried out. Germination tests of seeds in laboratory, and of tubers and crowns on the fiel were established. The most important areas for recolection are in the counties of: Cuahutemoc, Comala, Colima, Villa de Alvarez, Coquimatln e Ixtlahucan in the state of Colima, Mexico. Here gatherers use a system of harvesting that considers conservation of the resource, which consists on digging for the tubers of the plant in the middle of the wet season (end of August or early September), cutting only the downer part of the tuber, and covering the rest (upper part) of the tuber with the product of the excavation, so that the plant does not die. Afterwards (four to nine months later) during the dry season, they dig again to obtain a second crop of the same plant. In the secon crop season, they repeate the operation of "castrating" the plant tubers and cover the hole again, so that the same plant could produce new tubers in the next rain season. Becoming this a sustainable activity. The reproductive estrategy of the plant is bassed on seeds and tuber. Seed germination rates are of 20 to 26%. Tubers in field have 83 to 100% of regeneration and crowns regeneration rates are of 4.16%. Sustainability of the activity depends on the indigenous knowledge of the reproductive strategy of *D. remotiflora*, its profitability and on the habitat conservation.

RECENT EFFORTS TO DEVELOP *Grindelia* SPECIES AS A RESIN CROP

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Preliminary studies have shown that *Grindelia chilensis* (Asteraceae) native to Patagonia, Argentina can produce more resin per plant than *G. camporum*. Several experiments were started in 1995 to evaluate *G. chilensis* potential to produce resin economically in temperate arid environments. Here, we report two experiments to determine biomass and resin production.

From a survey that included resin content as well as plant architecture characteristics of *Grindelia chilensis* plants growing in more than 40 natural stands in the Monte and Patagonia regions in Argentina, seven *G. chilensis* accessions were chosen for further evaluation. These were tested in a common garden experiment that included *G. camporum* from Central Valley in California. Plants were transplanted in September 1996 and were harvested according to three schemes: A. plants harvested before flowering and regrowth harvested at the end of the growing cycle (May 1997), B. plants harvested during peak flowering and regrowth harvested at the end of the growing cycle, and C. plants harvested only once at the end of the growth cycle. Individual plant biomass was recorded for 45 plants of each accession and harvest scheme. Resin content was determined on 15 plants per

accession and scheme. *Grindelia camporum* produced the maximum biomass (close to 400 g DW/plant) with harvest schemes A and B, while all accession of *G. chiloensis* produced more than double the biomass with scheme A than with C. The best *G. chiloensis* accession accumulated 260 g DW with harvest scheme C. All accessions accumulated the least biomass under scheme B. Resin content was approximately 60% lower for *G. camporum* than for any *G. chiloensis* accession. In another study the evolution of biomass produced by two accessions was followed over the growing season. The exponential phase of growth was maintained up to 4 mo after transplanting. This moment coincided with the production of flower-buds in most *G. chiloensis* accession included in the first experiment.

These results encourage further work on *G. chiloensis*. Plant selection for biomass and resin content as well as the study of environmental influences on resin production and its physiological bases, should be the next step towards domestication. Resin chemistry and its uses is also crucial in this process.

A PHYSIOLOGICAL EXPLANATION FOR THE INFLUENCE OF N AVAILABILITY ON BIOMASS AND RESIN CONTENT IN *Grindelia*

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The objective of this study was to determine the effect of N availability on biomass partition, terpenes (resin), and reserve carbohydrates in *Grindelia chiloensis* (Asteraceae). Plants growing in a sand media were irrigated 3 times a day with a modified Hoagland solution including one of four levels of N (0, 1.5, 3 and 6 mM). Plants were harvested 194 days after transplanting. CO₂ assimilation was less sensitive to N availability than biomass accumulation, generating an excess of assimilated carbohydrates available at N levels below 3 mM. This resulted in a higher terpene and reserve carbohydrate accumulation at lower N concentrations. The results are consistent with the hypothesis of the influence of the C:N relationship in the production of carbon based secondary metabolites. Environments with moderate to strong limitations in available N should result in *Grindelia* crops with higher resin content (probably reducing extraction costs) but, reduced biomass production (increasing production costs).

THE EFFECT OF IRRIGATION REGIME ON BIOMASS AND RESIN PRODUCTION IN *Grindelia chiloensis*

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Grindelia chiloensis (Corn.) Cabr. (Asteraceae) is native the Monte and Patagonia regions in Argentina. Capitula, leaves and stems bear diterpene acid contents as high as 30%. The resin acids produced by this and other species of *Grindelia* could potentially be used in various applications in the naval stores industry as a complement for pine rosin.

The objective of this study was to assess the effect of irrigation regime on biomass and resin production in *Grindelia chiloensis*. Two-mo-old seedlings were transplanted in October 1996 in a completely randomized design with three replicates consisting in six 6-plant-rows. The experiment was established in Trelew, Patagonia Argentina (43° 16' S, 65 21' W). Four irrigation treatments were tested 1) irrigation every 7 days, 2) 20 days, 3) 40 days, and 4) no irrigation for the length of the experiment. Plots were furrow-irrigated and 15 plants per treatment were harvested by hand on 8 January and 17 February 1997.

CO₂ uptake was significantly reduced for treatment 4 ($P < 0.05$). No treatment effects were found on biomass production for the first harvest. At the time of second harvest, biomass production was significantly higher for

treatment 2 (218 g DW; $P < 0.05$). Biomass production for other treatments did not differ significantly (182, 167, and 137 g DW for treatments 3, 1, and 4, respectively). Resin content was significantly lower only for treatment 4 ($P < 0.05$). Total plant resin was highest for treatments 3 and 2 (54.3 and 50.9 g per plant, respectively, $P < 0.05$). The lowest amount of total resin was found for plants under treatments 1 and 4 (33.4 and 17.9 g per plant, respectively).

Since water is probably not the most important factor in total cost productions in Patagonian valleys, the best irrigation frequency for total resin production in *Grindelia* is probably between 20 and 40 days, under these conditions.

***Kochia scoparia* L. SCHRAD AN ALTERNATIVE FOR THE PRODUCTION OF ANIMAL PROTEIN IN ARID LANDS**

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A restriction for the production of animal protein in Arid Lands through cattle is the scarce possibility of having quality forage to feed them. This is because this type of crops require quality edaphics and climatological conditions, as well as great quantities of water which is hard to find in arid lands. Because of this, since 1985 in the northeast of Mexico, a study on forage plants began without damaging the production and nutrients volumes, and considering its farming could be possible under extreme water, soil and weather conditions. A plant which has the characteristics mentioned before is the *Kochia scoparia* which has showed promising agricultural qualities, basically as a forage producing plant which harvested at 75 cm. produces 38,380 kg/ha of green matter with 15.23 per cent of dry matter which has 17.43 per cent of raw protein, 20.96 per cent of raw fibre and 3439 kcal/kg of crude energy, nutritional values similar to those of alfalfa, perennial rye grass and other forage crops with high requirements of water and nutrients, besides its digestibility may be classified as good. *Kochia scoparia*'s seed production has also been studied, from 1500 to 1600 kg/ha productions were found to contain a 26.35 per cent of raw protein and 10.56 per cent of raw fibre when cultivated in un watered land and under irrigation. This allows to consider this seed as a good food source as well as a sowing material, no matter its germination percentage is not very high (82.71) if we consider the low sowing density that this crop requires, the former effect is not significant.

Kochia scoparia's hay was used as a diet ingredient for growing lambs on a 60 per cent in relation to its protein requirements, replacing alfalfa hay on 0, 25, 50, 75 and 100 per cent levels and completing the food supply with Arid Lands natural ingredients. The results after the feeding period show for food consumption and weight increase on a daily basis per animal, ranks which go from 1.701 to 1.437 kg and from 0.204 to 0.134 kg respectively, which is a significant difference ($P < 0.05$), being the less favorable treatment the one having 100 per cent of *Kochia scoparia*. What happened here may be explained by the tasty difference between alfalfa hay and *Kochia scoparia* hay, which was a reason for a later study in which molasses as a flavoring was added to the diets and so hay's level increased to a 40 per cent of the food supply total. The results for food consumption and weight increase on a daily basis per animal varied from 1.158 to 1.068 kg and from 0.130 to 0.114 kg respectively with no significant existing difference ($p < 0.05$) between the different treatments. Thus allowing to affirm that *Kochia scoparia* may be a good forage alternative in arid lands.

THE NEEM TREE *Azadirachta indica* A. JUSS. AN EXCELLENT NATURAL RESOURCE FOR SUSTAINABLE AGRICULTURE IN MEXICO

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Neem is one of the most valuable multi-purpose species least exploited amongst tropical trees for its potential.

The utilization of neem and neem extracts is widely documented in several bibliographic reviews of scientific reports and research in more than 55 countries where these products are currently being used. In 1993 the neem tree was introduced to the state of Sonora, the purpose was to promote neem's adaptation and conduct research projects; also generate small industries related to neem products.

Approximately 700 trees are duly established in Sonoran farmers' fields in which some evaluations have been conducted, such as phenological development and production. Also, soil samples from the different sites of plantation were taken for soil analyses. In the same fashion laboratory determinations for industrial characteristics of the oil have been performed.

So far neem adaptation is satisfactory. Soil characteristics vary from sandy to clay loam, pH is alkaline and saline, deficient in nitrogen and organic matter content. Maximum blooming occurs in two periods: April, May and June and August and September. Currently seed production is regular and some trees reach 6 m in height. Within the project, neem reproduction is done by means of a tissue culture technique and also from seed selected from outstanding trees. At this time 20 thousand trees are about to be planted. Neem has impacted this region particularly in the integrated pest control of vegetable crops of exportation. Neem is also used as windbreaker to protect cultivated areas. Neem also is used for forestation in rural as well as in urban areas. Currently, *A. indica* A. Juss. represents a potential and a hope to solve world ecological, environmental and health problems for the human race.

ALOE: AN INDUSTRIAL CROP WITH POTENTIAL FOR THE SEMIARID ZONE OF SAN LUIS POTOSI, MEXICO

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Aloe (*Aloe vera*) native of south Africa was introduced to Mexico in colonial times by Spanish Jesuits. This drought-tolerant species has been prized for its multiple uses involving cosmetology, medicine, and food industry. In the last decade, there has been an increasing demand for aloe products. Thus encouraging research on ecological and agronomic characteristics of this species.

San Luis Potosi is one of the Mexican states where aloe grows almost wild, being distributed from sea level to 2,000 m. In the semiarid zone of San Luis Potosí, aloe is mostly found growing close to rural settlements, usually thriving under the canopy of mesquite trees, prickly pear, and other native species where it gets protection from freezing temperatures and takes advantage of other favorable environmental conditions. Starting in 1987, we established experimental plots with aloe under rain fed and irrigated conditions in an area located in Rio Verde, San Luis Potosi. We tested six provenances (treatments) all of them collected from different semiarid localities of the state. The objectives of these trials were to detect some possible phenotypic variations on the treatments and to observe the behavior of the species under agricultural management. After seven years of observations, we did not detect significant differences ($p > 0.05$) in agronomic characteristics of the treatments (i.e., survival, height, gross total weight, gel biomass, root suckers per plant, number of leaves per plant). Average biomass production was 161 ton ha⁻¹ yr⁻¹ for the treatments managed under irrigated conditions and 85 ton ha⁻¹ yr⁻¹ for rain fed conditions. Gel production represented 59 and 57% of the whole biomass weight for the irrigated and rain fed conditions respectively. Chemical analysis of the whole leaf indicated an exudated content of 0.28%, containing 12.85% of aloin. These values fulfill the international requirements for commercialization of raw aloe material. Due to its biomass production, chemical composition, and drought tolerance, aloe represents a new crop with potential for the semiarid zone of San Luis Potosi, Mexico.

ADVANCES IN QUINOA PRODUCTION IN COLORADO

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Quinoa, *Chenopodium quinoa* Willd., was developed and adapted to the highlands of the Andes prior to European invasion. The quinoa crop became one of the three most important crops to the Inca Empire along with maize and beans. Quinoa production over the past 4 centuries has largely been replaced with European crops of wheat and barley. In the early 1980s, however, quinoa became more available to a world market and the Bolivian type with large white seeds and low saponin became the standard for whole grain, edible use. Quinoas today have established themselves in most of the highland tropics and in the temperate regions of the world.

The adaptation of "A sealevel@ Chilean quinoas to the central Rocky Mountains has allowed quinoa production from Colorado to Canada; and Finland to Australia. Unfortunately, these quinoas are small grained, carry a strong saponin pericarp and are generally considered inferior to the Bolivian standard. They are, however, resistant to heat and disease and are rapid in maturity.

Cleaning the Chilean quinoas of the bitter pericarp results in significant losses in grain yield and equally high gains in a triterpene enriched waste product. Some triterpenes from this process are marketed in Japan but generally they are considered a waste product. Currently, Colorado State University is involved in seeking new industrial markets for the Chilean quinoas and their waste products from processing. The quinoas are being debranned to remove the pericarp. The cleaned grain are puffed to remove the protein rich embryo and the flour milled for evaluation in cosmetics and as a fine grain starch for food processing. The pericarp is rich in cellulosic materials and in triterpenes and is under evaluation as a binder in manufactured construction materials.

AGROFORESTAL PRODUCTION OF AGAPANDO (*Agapanthus* sp) IN ERODED SOIIS: AN AGRICULTURAL ALTERNATIVE SUSTAINABLE IN HUEXOTLA MEXICO

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The forest plantation carried out in the area of Texcoco deteriorated before having an economic value and was destroted for the rural local population. Research on *Agapanthus* sp and *Eucaliptus camaldulensis* was performed over six years in shallow soils (sandy loam) that were partially recovered from water erosion.

The feasibility of finding an alternative of agroforestral production that is economic, agronomic and sustainable was evaluated by themesuarement of changes in soil propeties. Bulbs were sown to reduce soil tillage and eventually tillage was completly eliminated. The only cultural practice carried out was weed removal and this was performed on two occassions, this was later determined to be unnecessary.

A plant density of 22,500 plants/ha gave the best results. The production of flowers with commercial value in the second cycle (1996) was 31,171. Effort to establish and maintain the cultivation in the first years was from 15 man-days/ha/year. It was not necessary fertilize or apply insecticide. The retail value of a dozem flowers ranged from \$0.50 to \$1.00 and the relationship of benefit/cost on the average for the six years were higher to the five. The effects in the soil were zero erosion, reduction of pH from 7.5 to 7.0; organic matter from 1.70% to 1.50%; bulk density from 1.52 t/m³ to 1.47 t/m³.

AGROFORESTAL PRODUCTION OF CEMPASUCHIL (*Taguetes erecta*) IN ERODED SOILS, IN HUEXOTLA STATE OF MEXICO, A SUSTAINABLE ALTERNATIVE

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National production of *Tagetes erecta* has grown since its industrialization in 1984, and its exportation as food complement in avian diets. From 1990 to 1995 cenpasuchil's production passed from 42,299 t to 72,000 t. It is growing on irrigated and rainfed areas. It can be cultivated in poor (sandy loam) and shallow soils. *Tagetes erecta* also has nematicide activity and is resistant to certain insect plagues.

With the objective of generating a sustainable agronomical forestal crop system, technically feasible for local peasants, economically suitable and environmentally appropriated.

The forestal component was 30 years old *Eucaliptus camaldulensis* plantation, with 50% of canopy and 3 × 4 m separation. The annual crop was established with local *Tagetes erectus* seeds at the level of 500 000 seeds /ha density. The crop was managed under a conservational tillage system. No fertilization, no insecticide or chemical weeds control were applied.

The average production in 6 years was 10,063 kg/ha (15% humidity). Flower diameters through annual selection passed from 4.6 cm to 6.4 cm. The benefit/cost ratio was 7 which is highly convenient. Soil erosion was eliminated and organic matter content in 6 years passed from 1.7% to 2.3%; pH from 7.5 to 5.9; Nt% from 0.1% to 0.17%; bulk density from 1.52 t/m³ to 1.43 t/m³.

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JOJOBA DIVISION

SIMMONDSIN AND JOJOBA PROTEIN ANALYSIS

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Simmondsin and its analogues have been extracted from meal with various solvents and their concentrations measured by a number of chromatographic procedures. The ability to completely extract simmondsins depends on the substrate to some degree, but the range of polarities of the simmondsin analogues makes solvent selection difficult. Water, acetone, methanol, 90/10 acetonitrile/water and other solvents have been recommended as the extraction solvent. Analytical high pressure liquid chromatography procedures have varied as well, leading to inconsistent results between laboratories. This presentation will discuss the limitations of some methods for extracting jojoba meal or water-soluble concentrate and measuring simmondsin analogue concentrations.

Jojoba proteins have been separated by gel electrophoresis to show a predominant protein at about 25 kilodaltons (kDa) molecular size and a smaller amount of protein at about 47 kDa. By scanning the gels with a densitometer and analyzing the densitometer scans in GRAMS 386, it was shown that the 25 kDa protein consists of at least 3 proteins which vary significantly in concentration. The function of these proteins is not known, but this method could be used to select plants high in one of the proteins to facilitate elucidation of their function in the plant and their functional properties for potential industrial use.

ANOREXIC EFFECTS OF SIMMONDSIN ANALOGUES IN RATS

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Jojoba meal, the coproduct of oil production from jojoba nuts (*Simmondsia chinensis*) has so far not been used for animal feed as it causes food intake reduction and emaciation in different animal species.

It is known that in rats and other mammals, the most important anorexigen in jojoba meal is simmondsin [2-(cyanomethylene)-3-hydroxy-4,5-dimethoxycyclohexyl-D-glycoside]. A linear dose dependent food intake reduction was described for simmondsin in rats.

It is also known that its analogue, simmondsin ferulate displays a food intake reducing effect, but no dose response curve has been constructed. Other analogues of simmondsin, like 5-demethyl simmondsin and 4,5-didemethylsimmondsin occur naturally in jojoba meal. It is not clear whether they have any anorexic activity. Simmondsin amide and 2-hydroxy-3-methoxyphenylacetoneitrile (HMPA) are possible metabolites of simmondsin formed in the gastrointestinal tract or in the blood. For both the three natural occurring simmondsin analogues and the above-mentioned possible metabolites of simmondsin we have measured the anorexic activity and constructed a dose response curve.

Our results indicate that demethyl and didemethyl simmondsin do not have any anorexic effect, nor do simmondsin amide and HMPA. Simmondsin ferulate displays a dose dependent anorexic effect that can be compared to that of simmondsin if taken into account the differences in molecular weight.

We can conclude that the cyclohexyl moiety with both the two methoxy groups and the cyanide group is essential for the anorexic effect of simmondsin, but that the glucose moiety can be changed without interfering in the anorexic activity.

TERATOLOGICAL STUDIES IN DEFATTED JOJOBA MEAL SUPPLEMENTED RATS

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Sixty adult female Wistar rats were allowed to mate. After mating they were divided in 3 groups of 20 rats each: (1) a first group received normal food during gestation (C), (2) a second group received normal food supplemented with 3% defatted jojoba meal (JJ), (3) the third group was pair-fed to JJ (PJJ). During gestation, food intake (FI) and body weight (BW) evolution of the dams were followed. FI of JJ was reduced to $\pm 70\%$ of C. Compared with C, BW increased less but similarly in JJ and PJJ.

Ten rats of each group were killed on gestation day 21. Reproductive performance parameters as the number of corpora lutea, living and dead foetuses, foetal length and BW and placental weight were recorded. Placental weight and foetal BW and length were similarly reduced in JJ and PJJ compared to C except for foetal weight which was slightly more reduced in JJ than in PJJ. No effect of the jojoba treatment was seen for the other reproductive performance parameters studied.

About half of the foetuses of these rats were observed for gross external and internal malformations and recording internal sex organs. No difference was observed between the 3 treatment groups for these parameters. The other

half was used for examination of the degree of skeletal ossification. Compared to C, the ossification of the limbs was somewhat retarded similarly in JJ and PJJ

The other 10 rats of each group were allowed to litter. Number of living and dead young were counted, BW and length were recorded on days 0, 7, 14, 21 and 7 days after weaning, as was the vitality index (VI) on day 7 and lactation index (LI) on day 21. Body length and BW were reduced in JJ and PJJ compared to C; this was slightly more expressed for BW in JJ than in PJJ. BW at days 7, 14, 21 and 28 remained lower in JJ and PJJ than in C but were mutually similar. No negative effects were observed for VI, LI or sex ratio.

The offspring of the second group of 10 C, JJ and PJJ rats was raised normally for 15 weeks. No malformations or illness were observed. Females of the 3 treatment groups had a similar body weight, males of JJ and PJJ were still less heavy than C. At 15 weeks, males and females were allowed to mate and reproductive performance parameters were recorded at day 21 of gestation. No negative effects of the jojoba treatment were observed in this offspring.

It was concluded that, except for a slightly more expressed BW reduction in JJ than in PJJ, no teratological effects were observed in the offspring of rats fed with jojoba containing food.

EFFECT OF JOJOBA SUPPLEMENTATION ON THE REPRODUCTIVE SYSTEM OF BROILER BREEDER FEMALES

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To investigate the possible use of defatted jojoba meal with its feed restricting characteristics as animal feed, it has been tested in growing broiler breeder pullets. The feed intake of broiler breeder pullets must be restricted from young age onwards in order to control body weight gain and hence to prevent leg disorders, high mortality rates, and excessive fattening. Concomitant with increases in the growth rate of broiler chickens, the ability of the meat-type parent stock to reproduce has been severely reduced. Feed restriction of the broiler breeders during rearing delays sexual maturity and improves egg production and fertility. Quantitative regulation offers the greatest degree of control; Skip-a day programs as well as every-day feed restriction can be applied. Nowadays, there is a growing concern about the welfare of broiler breeders, submitted to the severe physical feed restriction in typical commercial rearing programs. Qualitative, self-restricting feeding methods would save labor or investment costs and minimize stress. Until now, no satisfactory autonomous feed restriction methods for practical use, has been identified. In this study this has been tried by supplementing the diet with jojoba meal, resulting in an autonomous self-restriction by the birds when fed ad libitum during the rearing period. The purpose of the present study was to determine the effects of jojoba meal supplementation on reproductive parameters of these broiler breeders during the laying period. Results were compared with those of quantitative restricted broiler breeders.

Supplementation of feed with jojoba meal, as a mean for autonomous feed restriction, was successful in depressing feed intake and controlling body weight of broiler breeder pullets to the extent recommended by the breeder company. However, these broiler breeders never produced eggs. At the level of ovary, normal follicle development and maturation did occur. A considerable number of ovulations occurred which were not followed by oviposition. After ovulation, the ova could not be captured by the oviduct, because of the small size of the oviduct, resulting in 'internal laying'. The virtual absence of oviduct development can not be explained presently but it must be due to some yet unidentified factor(s) in jojoba meal which prevent(s) the normal development of the oviduct. These factors may be acting by abnormally increasing plasma P4 or T3 levels and/or directly by themselves to interfere with oviduct development. The nature of these factors requires further investigations.

COMPARISON OF JOJOBA CLONES PLANTED IN PERU AND ARGENTINA: SIMMONDSIN AND

ITS DERIVATIVES

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Jojoba (*Simmondsia chinensis* (Link) Schneider) is an evergreen bush native to the Sonoran Desert. Its great resistance to drought allows this plant to produce with a significantly lower quantity of water than is necessary for traditional crops. There are commercial plantations in Australia, Argentina, Israel, Mexico, Peru, and the U.S.A. Argentina and Peru currently are planting the most new fields.

Jojoba seed contains a unique wax ester oil, and with the main market being the cosmetic industry. However, new scientific studies have shown that simmondsin, a chemical compound present in jojoba meal has effect of regulating food intake in animals. This new use opens new potential markets for the crop.

Not one of the commercial jojoba plantations in the world were planted using clones selected for their simmondsin content. This project was undertaken to determine the simmondsin, oil content and the relationship in clones currently being planted in Peru and Argentina. Ten clones from Ica, Peru and Catamarca, Argentina, were selected according to seed yield, rooting capacity, wax quantity and wax quality. They were then analyzed for simmondsin content, with the best ones selected and then used to produce high simmondsin clones.

OXIDATIVE STABILITY OF JOJOBA AND OTHER BOTANICAL EMOLLIENTS

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The oxidative shelf life of cosmetic formulations is influenced by a number of factors including the particular combination of ingredients used, the inherent stability of those ingredients, the presence or absence of appropriate antioxidants, processing and packaging techniques and materials, and the distribution system utilized. Marketing priorities often require the combination of unusual ingredients. The trend toward use of biodegradable ingredients of botanical origin has been boosted by consumer environmental pressures, the "Mad Cow Disease" crisis in Europe and with the advent of full disclosure labeling in Europe and other world markets. These situations present a unique set of potential problems for formulators who are often asked to venture beyond experience and intuition when asked to create new ingredient combinations. Formulations containing chemical exfoliatives and skin whiteners are examples. Metal oxides in sunscreens and color cosmetics are thought to promote oxidation. This report examines the oxidative stability of a number of botanically derived emollients when they are used in combination with a- and b-hydroxy acids, several metal oxides and popular skin whiteners. The botanical emollients that were tested included almond oil, traditional sunflower oil, hybrid sunflower oil, macadamia oil, palm oil, sesame oil, and jojoba esters. The botanical emollients were tested for oxidative stability after additions of a group of "actives" including mixed natural tocopherols, titanium dioxide, zinc oxide, iron oxides, kojic acid, Arbutin, salicylic acid, malic acid, and magnesium ascorbyl phosphate. An oxidative stability index (OSI) was determined for the emollients containing the "actives" by using an Oxidative Stability Instrument.

DEVELOPMENT OF JOJOBA EQUIPMENT FOR ARGENTINA

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Equipment requirements for jojoba production are different in Argentina, than in the United States. To meet this need, a project began in Argentina in 1992 to develop commercially suitable equipment for jojoba production. The equipment developed, or still under development includes: a transplanter, an implement for in-row cultivation, a pruner, ground preparation implements, and a harvester.

The transplanter is based on a modified tobacco transplanter. The unit was simplified by removing the fingers used to set tobacco plants. The jojoba plants are manually set in the furrow opened by the machine, made possible by the greater in-row spacing used in jojoba. A horn sounds at a prescribed distance to inform the rider when each plant is to be set.

The tiller was developed from an implement used for tobacco weeding. The device was modified, with the most significant change being the addition of a hydraulic system that allows the operator to open the blades around the jojoba plants, rather than having to do this manually.

The pruner is mounted in the belly of the tractor, and is hydraulically adjustable as to elevation, knife angle, and distance from the tractor. The hydraulic powered lawn mower blade used for cutting rotates at approximately 1800 rpm.

The ground shaping equipment consists of a blade and roller arrangement which levels and compacts the soil. A blower is currently being developed to clean leaves and light trash from below the plants prior to harvesting.

The three point hitch harvester uses a pair of counter rotating circular brushes to move the jojoba seeds into a narrow path. A blade, conveying chain and elevator then lift the seed from the soil onto a trailer which is pulled behind the harvester. The cleaning and bagging components are mounted on the harvester.

DEVELOPMENT OF JOJOBA CLONES UNDER WATER AND SALINITY STRESS IN CHILE

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Selected jojoba clones established in field trials under severe salinity (Villa Frontera : E.C. 63.3 dSm⁻¹ in soil and 5.24 dSm⁻¹ in water; Quebrada de Camarones : E.C. 38 dSm⁻¹ in soil and 7.32 dSm⁻¹ in water) and water stress (Las Cardas: non-saline condition) were evaluated for seed yield at the 3rd and 4th year after plantation. Seed yield ranged from 0 to 468 g/pl in their 3rd year and from 0 to 1194.4 g/pl in their 4th year, for the clones established under saline conditions. At Las Cardas field trial, under severe water stress, seed yield ranged from 48.3 to 647 g/pl in their 3rd year and from 81.4 to 509.0 in their 4th year. The results indicate that at least 7 clones are highly resistant to extreme salinity and could be commercially established in a saline condition similar to Q. de Camarones. However, seed yield at Villa Frontera, with even higher salinity, was significantly lower and the plants showed leaf and flower bud necrosis from the 3rd year of development. The results obtained at Las Cardas, where the clones were drip irrigated with only 4L/week during their first four years after plantation, show that out of 27 clones 2 of them significantly increased their seed yield in the 4th year as compared to the 3rd. This could indicate some degree of tolerance to severe drought conditions, as most of the other clones either maintained the same yield or decreased it. Flowering timing and oil content were also evaluated. The economic study, which considered the average seed yield of the best clones at the 3rd and 4th year, indicates that commercial plantations with these selected jojoba clones can be a profitable alternative for arid and semi-arid regions in Chile.

ISOLATION AND IDENTIFICATION OF LOWER CARBOHYDRATES IN JOJOBA MEAL

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Deoiled jojoba meal contains about 30% of protein, dietary fiber and a greatly unknown mixture of lower carbohydrates. The present paper describes the isolation and identification of the lower carbohydrates. Those carbohydrates are isolated from jojoba meal by extraction with methanol. Part of the carbohydrates are precipitated from the methanol solution by the addition of acetone. The remaining methanol/acetone mixture was used for the isolation by means of column chromatography on silica gel, for the isolation of the different simmondsins along with a carbohydrate that was identified as pinitol by NMR spectroscopy. The precipitated fraction is also separated by column chromatography on silica gel, with a mixture of chloroform and methanol (50/50, v/v) as eluent. This procedure allowed to isolate the most important carbohydrate in jojoba meal, sucrose, and a fraction that was a mixture of different carbohydrates. This fraction was further separated by preparative TLC and HPLC. Two products could be identified as galactopinitol isomers by means of L SIMS and NMR spectroscopy.

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GUAYULE & NATURAL RUBBER DIVISION

PERFORMANCE OF TWO-YEAR OLD GUAYULE LINES

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Latex allergies in the United States have become a serious health problem in certain population groups, such as health care workers and patients who undergo multiple surgeries. Guayule (*Parthenium argentatum* Gray) is a source of hypoallergenic latex. Higher yielding, faster growing, and easier to establish germplasm lines are needed for guayule to be successful as a new crop. The objective of this study was to evaluate the survival rate and plant growth of 28 guayule lines. The lines were transplanted at the Maricopa Agricultural Center, Maricopa, Arizona, on 6 April 1995 in one meter rows with 36 cm between plants. Survival rate and plant height were determined at one and two years after transplanting. Plant width was measured two years after transplanting. Latex content was determined on seven selected lines two years after transplanting. One and two years after transplanting, G7-14, P10-4, G7-15, P3-11, N7-11, and 11591 had the highest survival rates. One year after transplanting G7-14 and G7-15 were significantly taller than the other lines. However, two years after transplanting 11591 was the tallest line, but not significantly taller than G7-14, N9-4, G7-15, or N7-2. The ten widest lines in descending order were N9-4, 11591, G7-14, N7-2, G7-11, G7-15, N565, O16-1, N13-1, and N9-3. The lines that increased in plant height the most the second year were 11591, N9-4, O16-1, N7-2, N9-3, N13-1, and N565. All lines had a plant height to width ratio greater than one at two years, except N565 which had a plant height to width ratio of 0.96. This was significantly lower than all the other lines. Preliminary data from latex analyses indicate significant differences among lines but not between plant age groups. Results from these studies indicate that the plant size, survival rate, and latex content of guayule can be increased by selection of improved lines.

GUAYULE YIELDS - A COMPARISON BETWEEN ARIZONA AND ARGENTINA

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This project, which is being sponsored by the USDA Foreign Agricultural Service, began in 1996. It is intended to speed up guayule commercialization by providing two crop seasons per year in which guayule can be analyzed and evaluated.

Seed yield and latex production in Arizona and Argentina are being compared under this project. Production will be compared between locations to determine which lines and climates are optimal for production of seed and latex.

Seed harvest in Argentina has proven difficult because of summer rains, even though harvesting is done manually on a daily basis. As a consequence yields have been minimal. In Arizona the mechanical harvester was used to harvest during the summer and fall of 1996, with harvests taking place every two weeks.

Results of the latex and rubber analyses conducted in Argentina have shown percentages of each material to vary with season, with the spring values being greater than summer values. Variations among lines also exist, with two of the old USDA lines N565 and 11591, proving consistently superior than G7-14. This follows the same general trends found in Arizona studies.

RESPONSE OF GUAYULE TO POSTEMERGENCE HERBICIDES

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Guayule seedlings grow slowly and offer little competition with weed species. Dacthal provides adequate preemergence weed control; however, postemergence herbicides that will control a broad spectrum of weed species with no injury to young direct seeded guayule plants have not been identified. The only successful postemergence treatments have occurred in older established stands where herbicides were applied during the dormant season, or applied as shielded, band sprays when the shrubs were at least one-year-old.

The objective of this study was to determine the toxicity of postemergence (over-the-top) herbicides to direct seeded guayule seedlings, and their efficacy for weed control. An experiment was initiated in June 1997 at the Texas A&M University Agricultural Experiment Station near Pecos, Texas. Conditioned guayule seed (selection AZ-RZ) was planted 1 cm deep on raised beds spaced 102 cm apart with a Gaspardo SV255 pneumatic planter. The seeding rate was 100 seeds/m using seed harvested and cleaned at the New Mexico State University Leyendecker Plant Science Research Center near Las Cruces, New Mexico.

Herbicide treatments consisted of four rows 9 m long, and were arranged in a randomized complete block design with four replications. The following postemergence herbicides were applied to guayule seedlings with 8-10 true leaves: AC 263-222 (36, 54, 72 g ai/ha), fluazifop (0.17, 0.22, 0.28 kg ai/ha), imazethapyr (0.4, 0.7, 1.1 kg ai/ha), and pyriithiobac (35, 70, 140 g ai/ha). Treatments were applied in a 0.5 m band on each bed by means of a CO₂ powered backpack sprayer with a four-nozzle boom that delivered 300 L/ha at 172 kPa. All treatments were applied with a nonionic surfactant (0.25% v/v). Guayule injury and weed control were rated visually from 0 to 100%, with 0 = no visible effects and 100 = complete kill. Ratings were made by comparing each treatment to the untreated check within the same replication.

COMPARISON BETWEEN THE RUBBER PRODUCTION IN GREENHOUSE AND FIELD GROWN GUAYULE SHRUBS

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The knowledge of guayule shrubs development is important to understand the bioprocesses involved in the rubber synthesis and eventually design agronomic practices. We have been monitoring the change in biomass, rubber and resin content in guayule shrubs, grown under environmental conditions and greenhouse. These data are compared looking for correlation between the two conditions; and, the effect of the environment on plant production is assessed.

Four high rubber yield varieties were studied, the seeds were planted in a greenhouse at the University in May 1992. When the plants were five months old, half of the seedlings (three varieties) were transplanted to a dryland field and the rest remained within the greenhouse. The parameters measured were biomass, stem diameter, rubber and resin content.

In previous results for the field grown plants, we found cycles of biomass accumulation that correlate well with the rubber and resin content changes. In this work, the greenhouse grown plants (GGP) had cycles like the field grown plants, but with higher biomass accumulation (approximately 50%). This would suggest higher rubber yields. However, the rubber content (4%) was around one-half that of the field grown plants (8%) at 30 months age. Surprisingly the average resin content (ca 8%) in GGP was almost equal to that in field plants (average around 9%). This indicates that rubber production is mainly a response of the plant to the environment, but not the resin. The rubber/resin ratio is a function of genetic characteristics as well as environmental conditions. Despite the fact that GGP plants were under isolated conditions, cycles related with the season were observed, although less pronounced than in the field. These results may be used to design better agronomic practices considering the existence of periods for rubber and biomass accumulation as a function of the season.

ENVIRONMENTAL INFLUENCES ON RUBBER, LATEX, RESIN, AND PLANT BIOMASS

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Environmental effects on guayule genotypes were investigated in this study. Estimates of environmental effects were determined by comparing plants generated from tissue culture with plants from the same line, generated from open-pollinated seed. Within the tissue cultured lines, all variation of measured plant traits was attributed to environmental influences since plants from the same line were assumed to be genetically identical. Differences within the seed generated lines gives a measure of the genetic variation within a line, when the environmental component is deleted. Three facultative apomictic and one sexual reproducing breeding lines were used for this study. A single plant of each of the four lines was cloned by tissue cultured to produce approximately 200 plants of each line. Simultaneously, seed from plants of the same lines were planted in the greenhouse. After establishment, tissue cultured and seed-grown plants were field transplanted in a randomized complete block design at the University of Arizona, Maricopa Agricultural Center, April 1995. Rows were one meter apart, with 36 cm between plants. The experimental lines in this study included G7-11, N7-11, P2-bulk, and 36-2-42. When plants were two years-old, plant heights, plant fresh and dry weight, rubber, resin, and latex contents were measured. Plants were harvested beginning on March 10 and completed on March 27, 1997. Tissue cultured lines had lower standard errors for plant heights than the seed grown plants. Higher variation was measured in latex content. This information provides an estimate of the heritability of the measured traits. This research helps to determine the amount of genetic improvement made through plant breeding.

OVERVIEW OF THE DEPARTMENT OF DEFENSE GUAYULE PROGRAM

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The Department of Defense has had a continuing interest in the development of guayule as a domestic source of natural rubber for many decades. In the late 1970's, the Navy began testing aircraft tires manufactured with guayule rubber. Because initial results showed that guayule tires performed as well as conventional Hevea tires, the effort was expanded to include testing by the Army and Air Force. To meet the requirements of this tri-service effort, a comprehensive program was initiated in 1982 that encompassed agronomics, genetic improvement, harvesting, processing, economics, coproduct development, tire production, and military tire testing. Tire test and evaluation was completed in 1996.

This presentation focuses on the tire test and evaluation phase of the program, and on current collaborative research projects between the Department of Defense and the Department of Agriculture to develop coproducts. Ground vehicle tires tested successfully and aircraft tire test results showed poor performance. Coproduct research includes an ongoing project with the Naval Research Laboratory, Washington, DC, and Harrison Experimental Forest, Gulfport Mississippi to evaluate the termite repellency of guayule resin in polyvinyl chloride formulations used in applications such as electrical insulation. Guayule resin is also included in a project conducted in collaboration with Mississippi State University at a Navy communications facility in Lualualei, Hawaii, to evaluate remedial treatments of termite-damaged transmission poles.

A third research project is being conducted at the Naval Research Laboratory to investigate the effects of intrinsic flaws on the mechanical properties of guayule rubber elastomers, and the potential of enhancing the barrier properties of latex films by tailoring the processing of guayule bulk rubber.

RAPID GUAYULE LATEX QUANTIFICATION

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Hypoallergenic latex extracted from the guayule plant (*Parthenium argentatum* Gray) for making medical products is generating great interest in the industrial and agricultural communities. No standard method is presently available for quantifying latex content that can be readily used in agronomic or processing research. Our objective was to develop a rapid analytical procedure for estimating latex content that can be used for screening purposes.

The extraction of guayule latex first involves the grinding of the plant in a water-based media containing an antioxidant, primarily Na₂SO₃, adjusted to a high pH (= 10) with NH₄OH. The mixture, which contains the latex, ground tissue, and soil, is filtered through a coarse filter and the homogenate centrifuged. The clear fraction is separated from the solid mass and the liquid fraction centrifuged again. Acetic acid is then added to coagulate the latex, which rises to the surface because its density is less than water. The coagulant is removed from the liquid, oven-dried, and used to estimate the "crude" latex content of the plant material. The latex does contain some resin and other plant material, but these appear to be minor. Corrections could be made to account for these constituents, but this would involve additional and lengthy organic liquid separation procedures.

In the development of the procedures, several types of variables were investigated including the (a) total quantity of shrub material, (b) ratio of solid to extracting solution, (c) period of grinding, (d) number of grinding and filtration combinations, (e) length and degree of centrifugation, (f) plant parts, i.e. stem to leaf ratios, and (g) stability of homogenate with time.

The entire procedure involves standard equipment available in most chemical laboratories and should be useable in most locations. Operational procedure takes about two hours, excluding sample preparation and drying. Several

samples can be run concurrently, and thus, analysis per unit time can be increased.

ANALYSIS OF RUBBER PARTICLE STRUCTURE USING SCANNING ELECTRON MICROSCOPY AND ELECTRON PARAMAGNETIC RESONANCE

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Natural rubber is compartmentalized in microscopic rubber particles located in the cytoplasm, either in parenchyma cells as is this case in *Parthenium argentatum*, or, more commonly, in laticifers. The particles contain rubber, protein and lipid, but their actual structure has been a matter of debate, particularly with respect to whether or not a true membrane exists at the particle surface. To address this issue, rubber particles isolated from different species were examined and compared using high resolution cryo scanning electron microscopy (cryoHRSEM) and conventional SEM. The purified rubber particles also were examined using electron paramagnetic resonance (EPR), in which comparisons were made between the behavior of stearic acid spin probes in pure rubber and in rubber particles.

Rubber particles, from all three species, were basically spherical in shape, although they varied in size. Fractures of frozen rubber particles observed using cryoHRSEM revealed that the interiors were entirely filled with uniform material, suggesting a homogeneous rubber core. Glutaraldehyde fixed, dehydrated and critical point dried rubber particles revealed empty spheres, where the contents had been extracted through broken or missing portions of the exterior membrane. The membrane itself appeared to be contiguous and quite uniform in all species examined. The rubber particle membrane probably ruptured along lines of relative weakness during sample preparation. The EPR spectra are consistent with the rubber particles being surrounded with an intact membrane. Isolated particles from *Hevea* and *Parthenium* seemed to be very elastic and deformed and fused readily upon manipulation. These results suggest that the surface components of *Hevea* and *Parthenium* particles are more fluid than those of the *Ficus* particles, and that the interior contents are also malleable to some degree. These observations agree with the EPR spectra in which the probes experienced a more rigid environment in *Ficus* and *Euphorbia* rubber particle membranes than in those of *Hevea* and *Parthenium* particles. The EPR spectra also provide direct evidence that the rubber particle membrane is actually a monolayer which serves as an interface between the aqueous cytosol and the hydrocarbon interior of the particles. In conclusion, rubber particles are shown to consist of a fluid, homogeneous rubber core surrounded by a distinct monolayer membrane containing a species-specific complement of lipids and proteins.

EVALUATION OF THE ANTITERMITIC EFFICACY OF GUAYULE RESIN CONTAINING LOW-MOLECULAR WEIGHT RUBBER

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Guayule resin containing 19.4% low-molecular weight rubber (the fractionator overheads from a simultaneous extraction process) was evaluated as a protectant against attack by subterranean termites. Wood disks impregnated with the resin-rubber mixture were exposed to termite attack at two rain forest sites at Chiva, Panama, and at a desert site at Green Valley, Arizona. After 67-71 months of exposure to *Heterotermes*, *Coptotermes*, and *Reticulitermes*, the treated wood was recovered, assessed for termite damage, and assayed for residual resin and rubber content. Acting as an antifeedant rather than a repellent, the resin-rubber mixture was an effective protectant in both environments. None of the disks showed termite damage, although there was a relatively greater stress to the physical integrity of the wood and to the retention of resin and rubber at the two rain forest sites.

EFFECTIVENESS OF FLOCCULATION AGENTS ON THE REDUCTION OF FINE SOLIDS IN GUAYULE SHRUB HOMOGENATE

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The production of guayule latex requires the homogenization of shrub in aqueous medium, to release the intact rubber particles from the parenchyma cells, followed by a series of purification steps to remove non-rubber particle components from the rubber particle suspension. The most difficult component to remove is the fraction of fine solids that approximate the rubber particles in size. These fine solids cannot be removed by filtration, which would also remove the rubber, and the centrifugation speeds required for clarification encourage coagulation of the rubber in the latex fraction.

We have examined the effectiveness of different flocculation agents in the removal of the fine solids fraction from guayule homogenates. Flocculation agents with different properties, alone and in mixtures, were tested over a concentration range of 0-3,000 ppm. Their effect on guayule homogenate (at pH 10) was observed initially, after a standard series of inversions, after centrifugation for 5 mins at $200 \times g$ and after 15 mins at $1,000 \times g$. These forces are too low to cause rubber coagulation under normal circumstances. Anionic agents and nonionic agents proved unsuitable since they had very little effect on the fine solids fraction and removed the latex fraction from the homogenate. However, cationic reagents of different chemical type showed considerable promise in the removal of solids with minimal effect on the rubber particle fraction.

In conclusion, optimization of the cationic polymer mixture as well as the molecular weight of polymers should greatly streamline the purification of guayule latex.

GUAYULE PLOIDY LEVELS IN A NATIVE POPULATION

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Mexico is considered the origin of guayule and rubber from this plant has been used commercially. It has potential for domestication in semi-arid regions of northern Mexico, southwestern United States and other similar climatic parts of the world. Natural populations of guayule contains plants with different levels of ploidy. This ploidy level has a profound influence on reproductive behavior such as sexual and apomictic modes of reproduction, self-incompatibility and expression of different agronomic traits like biomass, rubber and resin content. A collection of 195 accessions of guayule germplasm was made from 28 locations in the Coahuila province to determine ploidy levels and to locate their origin within the province. The inflorescences containing young floral buds were selected from the individual plants when the maximum number of cells were actively dividing.

Cytological examination revealed 4 diploids ($2n = 2x = 36$), 25 triploids ($2n = 3x = 54$), 153 tetraploids ($2n = 4x = 72$), 6 pentaploids ($2n = 5x = 90$), and 7 aneuploids. Aneuploidy plants possess an irregular number of chromosomes. The natural population had 2.1% diploids, 12.8% triploids, 78.5% tetraploids, 3.1% pentaploids and 3.6% aneuploids. Tetraploids were present in all 28 sites sampled, whereas diploids were found in three locations. In general, the diploid plants are associated with slow growth, low vigor, short stature and small top spread with resultant low biomass and rubber yield. Tetraploids are distributed throughout the Coahuila province. Tetraploids are vigorous, grow rapidly and produce more biomass and seed relative to the other polyploids. They produce seed by apomixis. The tetraploids and triploids are widely scatter among the different sites. An irregular number of chromosomes is distributed in aneuploids. At Palo Blanco, one plant had 45 chromosomes. Monosomes ($2n = 3x - 1 = 53$; $2n = 4x - 1 = 71$; and $2n = 5x - 1 = 89$) and trisomes ($2n = 3x + 1 = 55$; $2n = 4x + 1 = 73$ and $2n = 5x + 1 = 91$) were also observed the frequencies of monosomes and trisomes were more at the tetraploid level compared to the triploids or pentaploids. The monosomes and trisomes could be useful in identifying a gene or genes on a particular chromosome.

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OILSEEDS DIVISION

MOLECULAR SYSTEMATICS OF *LESQUERELLA* AND *PHYSARIA* SPECIES

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The systematics of the genus *Lesquerella* was largely deduced from morphological, physiological and cytological characters. We are reporting the progress in the first molecular systematic study of the genus. Fifty two species and accessions from the USDA-ARS Water Conservation Lab *Lesquerella* germplasm collection are included in the study. These samples represent species and populations distributed throughout the United-States. Also included are 29 species and populations of *Physaria*, and *Brassica nappus* as an outgroup. A novel DNA isolation was developed and employed in isolating DNA. Each Operational Taxonomic Unit (OUT) is represented by DNA pooled from ten randomly chosen individuals. We have applied DNA marker analyses of Random Amplified Polymorphic DNA (RAPD) and Amplified Fragment Length polymorphism (AFLP). A phenetic interpretation of the data addressing the limits of the genus, the systematic placement of *Physaria* and the division between western- eastern species will be presented.

COMPONENTS OF YIELD IN BREEDING *LESQUERELLA FENDLERI*

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This study examined the relationship of various plant growth traits to seed yields of *Lesquerella fendleri*. Seed yields are reduced at harvest when machine combines are unable to collect seeds of plants with prostrate growth habit. An upright plant growth habit would reduce the seed loss from combines. Plants were measured at the beginning of anthesis to find early predictors associated with upright growth habits and increased harvestable seed yield. Twenty-four breeding lines, with 50 plants each, were measured between January 31 and February 4, 1997. The plants were between 101 and 129 days-old. Plants were growing in the greenhouse and then transplanted into the field on February 6, 1997. Measurements included lengths of the terminal branch and five secondary branches, two perpendicular plant diameters, a rating of branch angle, leaf shape, and stem diameter. The ratio of the terminal branch length to five secondary branches was calculated, and standard errors of the means of the five secondary branches. Plant heights were measured before harvest and we again rated plants for growth habit. Seed yields of individual plants were determined at harvest along with number of pods per cm of branch. Correlations between the various growth measurements were calculated to detect which traits will be most important in selection and breeding for seed yield improvements.

FATTY ESTER DEVELOPMENT IN *LESQUERELLA FENDLERI*

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Acyl group composition was studied during seed maturity in *Lesquerella fendleri* seeds. Flowers of individual lesquerella plants were tagged while growing in the field at two Arizona locations. The age of the seeds in each pod was expressed as the number of days between opening of the flower and harvest of the pod (DAF). Seeds were harvested at 4-day intervals from 15 to 71 DAF. Seed samples were stored at -80°C following collection. After seed collections were completed, samples were arranged in three replications of a completely randomized design and analyzed on a gas chromatograph. Seed weight, lesquerolic hydroxy fatty acid, and other prevalent fatty acids were evaluated. The objective of this study was to relate the age of the seed to the optimum harvest date.

OIL CONTENT AND FATTY ACID COMPOSITION OF *LESQUERELLA FENDLERI* IN RESPONSE TO TIMING AND DURATION OF MOISTURE STRESS

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Lesquerella seed is a valuable source of hydroxy fatty acid. It contains 23% oil at maturity. Environmental stress during lesquerella seed filling can alter the chemical composition of the seed and reduce yield, viability and vigor. The effect of moisture stress on lesquerella seed oil content have not been reported. The objective of this study was to characterize the oil content and fatty acid composition of lesquerella seeds to moisture stress at different growth stages of the crop.

Two field and one greenhouse experiments were conducted at the New Mexico State University Plant Science Research Center during the 1993-94, 1994-95 and 1995-96 growing seasons. The experimental design was a randomized complete block with six replications for the field experiment and four replications for the greenhouse experiment respectively. The treatments consisted of (a) Continuous favorable soil moisture [irrigated at 50% available water content (AWC)], (b) moisture stress (irrigating at 25% AWC) from establishment to final harvest (c) moisture stress (irrigated at 25% AWC) from establishment to flowering with no stress afterwards (50% AWC), and (d) no stress imposed from establishment to flowering (50% AWC) followed by stress (25% AWC). The oil content and fatty acid composition was analyzed at the U.S. Water Conservation Laboratory, Phoenix, AZ.

Moisture stress did not show much variation in the seed oil content under field conditions compared to the greenhouse conditions. There was a significant difference among treatments with respect to the seed yield. Stress prior to flowering did not influence the oil content compared to control (50% AWC) under both the seasons in the field. Irrigating the crop at 25% AWC resulted in 12% (1994-95) and 8% (1995-96) reduction in the oil content compared to the control (26.03% in 1994-95 and 24.37% in 1995-96). Stress after flowering also reduced the oil yield and was not significant compared to irrigating the crop at 25% AWC.

Under greenhouse conditions stress prior to flowering resulted in 19% higher oil content compared to the control (22.08%). Irrigating the crop at 25% AWC and stress after flowering resulted in 9% reduction in oil yield compared to the control. The effect of stress on fatty acid composition will be discussed.

MODIFICATION OF *LESQUERELLA FENDLERI* SEED-SURFACE POLYSACCHARIDE

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Lesquerella fendleri is a promising new crop projected for commercialization in the next five years Its main

selling point at present is the industrially important unsaturated hydroxy fatty acid content of its oil that has many potential commercial applications. In addition to the oil, *L. fendleri* seed contains a seed- surface polysaccharide (SSP) The oil-extracted seed meal containing the SSP has market potential in industrially proprietary applications. The SSP has adhesive properties that could be exploited industrially. Consequently, much ongoing work on The seed-surface gum has been directed toward isolation techniques for obtaining gums of consistent quality and thus to determine the possible course for scale-up processes.

Preliminary structural study of these gums indicated presence of galacturonates which are cross-linked with divalent cations, resulting in only partial solubility of the gum. Our goal in this study was to chemically modify the gum component imparting industrially desirable properties in the SSP Such characteristics would enable the development of new value-added products from the gum component of the seed. The derivatization procedures explored include base catalyzed sulfation; etherification through glycidyl ring opening to form quaternary ammonium intermediates; base-catalyzed condensation of the polysaccharide alkoxide species with 2-chloroacetic acid to yield die carboxymethylated derivative; and thermochemical oxidation of gum via hydrogen peroxide/Cu(II)-Fe(II) reaction and NaIO₄ oxidation of the gum to the dialdehyde derivative.

USING A DIGITAL COLOR CAMERA TO ESTIMATE FLOWER NUMBER

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The number of flowers and the duration of flowering in a crop are important factors in determining the final yield of many crops. However, the time required to count flowers throughout a growing season makes it difficult to carry out studies in which flower counts are made regularly over an extended number of treatments. A study was undertaken using a true color digital camera to determine the feasibility of using images from the camera to automatically count flowers of several varieties of rape (*Brassica napus* and *B. rapas*) and of lesquerella (*Lesquerella fendleri*). The camera had a 1024 by 768 pixel resolution and twenty-four bit color resolution. Images of the rape were taken once per week and of the lesquerella two times each week during the flowering period. The first step in processing the images was to crop the image so that it showed only 1 m². Since both of the species of interest have yellow flowers, all pixels with yellow color were identified. A shape filter was applied to the image to reject pod and stems that had turned brown and resulted in false positives. Spots of yellow color were then counted and an overall index of yellow was calculated. Flower counts were made from the cropped images for verification on two dates. The results of the automated counts correlated well with the flower counts made by hand. With species tested where flowers are at the top of the canopy this technique can be used successfully to provide flowering data over the season.

LESQUERELLA SEED PRODUCTION: WATER REQUIREMENT AND MANAGEMENT

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Field experiments were conducted in 1991-92 and 1992-93 to determine the effects of irrigation management on evapotranspiration (ET) and yield of *Lesquerella fendleri* grown with surface irrigation on a sandy loam soil (Typic Haplargid) in central Arizona. ET was determined by water balance techniques using neutron probe soil water measurements made within a 1.7-m soil profile. Lesquerella was planted in 1.0-m spaced rows on 11 Oct., in 1991, and on 1 Oct. in 1992.

In 1991-92, five irrigation treatments were established in 8- by 25-m plots that resulted in an ET range from a

low to a high water stress condition. Treatments included a well-watered, control (7 irrigations made between late Feb. 1992, through early May); a limited irrigation treatment (4 irrigations, late Feb. through late Apr.); and three severely limited irrigation treatments, where one of the four irrigations given to the limited irrigation treatment was withheld to develop a greater water deficit during a particular growth stage. In each plot, 2.0-m² areas were established to sample yield. A hailstorm on 21 May, caused significant seed shattering and, consequently, the loss of total seed yield. However, the areas were hand-harvested on 16 June 1992, to determine total plant dry mass.

In 1992-93, eight irrigation treatments were established in 8- by 12.5-m plots with five replications. Treatments included a weekly irrigation treatment (12 irrigations, mid-Feb. through early May, 1993); a treatment nearly identical to the weekly, but given early irrigation on 3 Dec. 1992, and 4 Feb. 1993; a bi-weekly irrigation treatment (7 irrigations, mid-Feb. through early May); a treatment nearly identical to the bi-weekly, but given the two early irrigations; and four moderately limited irrigation treatments, in which one or two of the irrigations given to the bi-weekly treatment were withheld during certain periods during the growing season. On 6 June 1993, 2.0-m² areas were hand-harvested to determine seed yield and plant dry mass.

The measured ET for the control in the 1991-92 experiment was 626 mm, compared to 492 mm under a limited irrigation treatment and 452-461 mm for the severely limited treatments. Terminating irrigation in late Apr. resulted in large ET deficits in May for the limited and severely limited treatments in 1991-92. In 1992-93, the measured ET ranged from 707-764 mm for the weekly, 617-665 mm for the bi-weekly, and 532-595 for the moderately limited bi-weekly regimes. Treatment differences in plant dry weight and seed yield were than 17% or less. However, when no irrigation was withheld, seed yield was the same under both weekly and bi-weekly irrigation. Thus, an irrigation management of bi-weekly irrigation for lesquerella provided maximum yield production and resulted in the highest water-use efficiency for the crop.

CASTOR HARVEST: FROM HAND HARVEST TO MODERN MACHINES

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The traditional method of harvesting castor capsules has been by hand, with or without gloves. Stripping cups made of light gauge sheet metal and equipped with a handle on one side and a V-notch on the other are considered the most efficient aid to hand harvest. After capsules are harvested from the racemes, dehiscent or shattering type capsules can be spread on a threshing floor in sunlight for 5-6 days, and most of the seed will be shattered from the capsules. Winnowing then removes the hulls from the seed. Small hullers are necessary to remove seed from indehiscent capsules, and these may or may not be equipped with a fan to separate hulls from the seed. In West Africa, 200 man-days are required to hand-thresh 1,000 kilos of seed, where a portable huller can do the same in 3 hours.

Mechanized harvesting equipment has evolved since the 1940s. Early machines removed capsules from the standing plants before sutures had split, and the capsules were dried and hulled with a portable or stationary huller. A modification of the Kolos grain combine was used in former USSR, and the whole plant was cut with the sickle and moved through the machine, where the capsules were removed and seeds were hulled and deposited in the bin. Early harvester-hullers in the USA used vibrating or rotating beaters to shake capsules from two rows of mature plants, and the capsules were passed over a scalper before hulling by rubber-covered cylinders and concave surfaces. A coaxial huller was designed that used rubber-covered discs---the lower disc rotated and the open-center upper disc was fixed. The latest machines with increased capacity use two rubber-covered cylinders rotating at different speeds, with an adjusting mechanism to allow for different capsule and seed size. These new four-row machines, developed by Jean Browning and associates in Plainview, Texas, use rotating brush rolls to remove capsules from the racemes, and are more efficient than vibrating machines. Less repair is needed on the harvester-hullers with brush rolls, which speeds up harvest.

SILANE-MODIFIED LESQUERELLA OIL FOR COATINGS

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A lesquerella oil-modified polyester was reacted with vinyl trimethoxysilane (VTMS) to form a system which cures with HDI isocyanurate trimer at room temperature. Clearcoats showed outstanding solvent resistance (200-250 MEK double rubs) and exceptional impact resistance (160 ft. lb. reverse impact). Systems cured at 100 and 150°C for thirty minutes showed higher solvent resistance (500-800 MEK double rubs) while still maintaining the same impact resistance and pencil hardness. The 150°C-cure systems showed a slight yellow tint. The room temperature and the 100°C-cure systems were water-clear.

CANOLA YIELD TRIAL IN THE YAQUI VALLEY, SONORA, MEXICO

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The rapeseed *Brassica* sp. has been known in Mexico since ancient times. This industrial crop has an oil content of 60% erucic acid and has glucosinolates in the meal. In 1978 The Canadian rapeseed Industry adapted "canola" to identify the seed of *Brassica campestris* and *Brassica napus* that genetically have < 2% erucic acid and <30 mmol of glucosinolate in the meal. Since then canola has become the main oil crop in Canada. The oil with less content of saturated oil are of canola with 6% and sunflower oil with 12%. The most important fatty acids content in the canola oil are oleic acid 55%, linoleic 10%, palmitic 4%, stearic 2%, eicosenoic 2%, and a trace of erucic acid. In the South of Sonora, Mexico, specifically the plain coast of the Yaqui and Mayo Rivers, rapeseed is a wild plant considered as a weed in winter crops like wheat, chickpea, and safflower.

This yield trial was developed in the Yaqui Valley Experimental Station during autumn-winter 1993-1994. The materials evaluated were 18 canola and rapeseed experimental lines and varieties. The experimental design was a randomized square with three replications. The experimental plot was four rows 75 cm wide and 6 m long. The experiment was planted on December 14, 1993 in dry soil and in manual form. Some of the parameters evaluated: days to flowering, days to physiological maturity, plant height, lodging grade, specific grain weight, oil content, and yield grain.

The statistical analysis for yield of grain registered highly significant differences among varieties, but not among replications. The variability coefficient was of 12.15%. The MSD.05 proof detected that the best varieties were Canada 2 and Sel-W with 2077 and 1962 kg/ha respectively, and the oil content for the same varieties are 38.1% and 37.9% respectively.

BIODEGRADABLE VEGETABLE OIL BASED ENGINE LUBRICANTS

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Oil based lubricants from petroleum currently consume 9 billion liters of this mineral resource annually. Agro Management Group has developed and patented the first biodegradable engine oil derived from various *Brassica* sp. and from soybean (*Glycine max*) in combination with other natural esterified oils. The oils have been tested in over 4,000 hours of small, air cooled engine trials, over 6,000 km in air-cooled Volkswagen (40 hp) engines and over 6,000 km in a 5-L engine running in a 1970 Ford Mustang.

Small engine tests, the Volkswagen engines and the Mustang indicate the biolubricant runs at a significantly lower

temperature than petroleum, indicating better lubrication. Initial trials showed a significant viscosity change at 25 hours of operating under full load with the oil becoming fully polymerized at 42 hours. Alterations in the additive package have increased the useful life of the oil to the point where no significant viscosity change has been noted at 40 hours.

In addition, biodegradability using a U.S. ASTM modified Sturm test shows the oil to be biodegradable. The trials of biodegradability have led to additional developments as the potential for heavy metal residuals was considered. Currently, Agro Management is developing technology to remove heavy metals from the used oils with the potential for recycling the clarified oil or biodegradation.

MICROEMULSIFICATION OF OIL

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Membrane emulsification which can make a monodispersed emulsion in comparison with a conventional method is first reported by Nakashima et al. The emulsion droplet made by membrane emulsification process is so stable and its packing density is so high that the process is commercially used for production of low fat margarine in Japan.

Kikuchi et al. developed a microscope and video system and optically accessible microchannels formed in a single crystal silicon substrate. The microscope video system was used for diagnosing blood cell deformability by observing permeability through the silicon microchannel.

In this study, a novel emulsification method for making and observing monodispersed regular-size droplet is proposed using the microscope video system and silicon microchannel where the array of microchannels forms an effective microfiltration membrane, and emulsification properties are investigated in order to get O/W and W/O emulsions. The effect of the membrane emulsification process on the performance of bio-diesel fuel made of seed oil and alcohol will be also discussed.

CORIANDER (*Coriandrum oativum* L.) ESSENTIAL OIL YIELD: RELATIONSHIP WITH NITROGEN AVAILABILITY

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Coriander (*Coriandrum sativum* L.), an important aromatic crop in Argentina, is produced for its volatile oil used in perfumes, tobacco, alcoholic beverages and flavor food products. The leaf oil is mentioned to contain such a large amount of higher aliphatic aldehydes that it should also be considered as a commercial source.

The objective of this work was to study the effect of different levels of nitrogen on the production of volatile terpenes during the vegetative phase.

A greenhouse experiment was carried out at Buenos Aires (34° 35' 5" lat S, 58° 29' long W and 25 m over sea level). A completely randomized design with 7 replicates, in an Hidroponian system was used.

Two genotypes were used: on Argentine cultivar widely spread, characterized by a high mean grain weight (0.11 g) and low essential oil content (0.5%) and an European cultivar that has low mean grain weight (0.005 g) and high essential oil content (2%). Three plants per pot were sown and irrigated with Hoagland solution with four levels of nitrogen: 0 mM, 1.5 mM, 3 mM, 6 mM.

Between end blooming and first fructification, total above ground biomass and essential oil content were determined. Essential oil extraction was done by steam distillation using a Clavenger glass apparatus. After 2 hours, the essential oil was trapped in 1 mL of pure benzene to improve the recovery and were dried over anhydrous sodium sulfate.

Differences related to the nitrogen level ($p < 0.0001$) were found in biomass production, being maximum between 3 and 6 mM. No differences were found in biomass production between cultivars, and there was no cultivars-nitrogen interaction.

The essential oil content (mL) in the Argentine cultivar increases linearly between the explored N levels ($r^2 = 0.83$) and for the European cultivar it increases in a logistic form reaching a maximum at 3 mM of nitrogen.

SELECTION AND DEVELOPMENT OF CHIA CULTIVARS: INITIAL RESULTS

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Chia (*Salvia hispanica* L.), native to Central and North America, has oil containing a large amount of omega-3 fatty acid, and is being developed as a new industrial and edible oil seed crop. There has been a stable commercial production since 1993 in northwest of Argentina and in Central Colombia. However, no one improved cultivar is available for planting commercial fields.

In 1995, a study was undertaken to determine the protein quantity, oil quantity and fatty acid composition of selected lines of chia.

The results showed a significant difference ($P < 0.05$) among lines. Seed from lines AEV-A1 and AEV-B1 had the highest oil yield: 35.7% and 35.2% respectively. The average oil content of the commercial chia plantations in the Valle de Lerma, Salta, and Valle de Los Pericos, Jujuy, has been: 32.9% and 33.5%, respectively.

The main fatty acid found in all of the samples was α -linolenic, with lines AEV-A1 and AEV-B1 yielding a significantly ($P < 0.05$) higher content (64.4% and 64.9%, respectively) than the commercial ones (62.8%). Line AEV-B1 produced a significantly ($P < 0.05$) higher protein content (19.6%), than line AEV-A1 (18.4). Both lines showed significantly ($P < 0.05$) lower protein percentage than the best commercial plantation yield of 20.7%.

A significant correlation ($P < 0.01$) between α -linolenic fatty acid and palmitic, stearic, and oleic fatty acids was detected.

PRESENT DAY SITUATION OF CHÍA CROP (*Salvia hispanica* L.:LAMIACEAE) IN THE STATE OF MORELOS. MÉXICO

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The Chía (common name of *Salvia hispanica* L.: Lamiaceae) is a herbaceous plant which averages 1.60 m in height, Its seeds contain a high percentage of polyunsaturated fatty acids with medical and industrial properties, specially to obtain quality lacquer and oils.

In spite of its many advantages, the chía crop in the State of Morelos has been set aside in the agricultural context during the last forty years, risking the species conservation as a cultural element and as a genetic resource. In this

sense, the present work has been oriented towards determining the factors that have reduced the acreage of *Salvia hispanica* L. in the State of Morelos.

The parameters analyzed were the relationships between chia agroecosystems-social environment, through interviews applied in three society sectors: consumers, sellers and farmers. Likewise, the climatic and soil characteristics in producer localities were analyzed.

The study of the abiotic requirements, has shown the elements of climate: temperature and rain as restricting factors on the crop development. It was used as a point of reference to locate *S. hispanica* producer sites in the State of Morelos, complementing this activity with the ethnobotanical results obtained in the four cities with high mercantile flux in the State of Morelos.

The results show two kind of factors causing the crop margination: 1) The extremely low product request because of people ignorance and 2) The socioeconomic problems who face the farmers in the State of Morelos.

Complementary to this work, localization of producing sites of *S. hispanica* was determined as well as its importance within the commercialization web in the central region of the Mexican Republic.

AN OMEGA-3 FATTY ACID ENRICHED CHIA DIET: ITS INFLUENCE ON EGG FATTY ACID COMPOSITION, CHOLESTEROL AND OIL CONTENT

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In 1995, 15 million people died from coronary heart disease (CHD). Considering that cholesterol and triglycerides are two factors related to increased level of CHD risk, and their concentration in the body is influenced by the type of food consumed, it is evident that modifying the diet, the risk of CHD decreases.

Saturated fatty acids have been shown to increase the risk of CHD. There is a growing consensus among scientist that not only a reduction in calories from lipid sources to control CHD is important, but also omega-3 polyunsaturated fatty acids (PUFAs) such as -linolenic fatty acid play a key role in the process.

The objective of the project was to determine, through a feeding trial with laying hens, if the addition of chia (*Salvia hispanica* L.) to the diet influences egg production, egg fat, cholesterol content, egg fatty acid composition, or egg flavor. Twenty four Issa Brown laying hens were fed for four weeks to compare the results of a control diet and a diet containing thirty percent chia. No difference ($P < 0.05$) in the yolks fat content was found between treatments. Saturated palmitic fatty acid content of the yolks decreased significantly ($P < 0.05$) with the chia diet, and amounted to a 35 percent change by the end of the trial. Polyunsaturated, w-3-linolenic fatty acid was significantly ($P < 0.05$) larger in yolks from the chia diet, increasing from 0 to 14.7 percent by the end of the trial. Chia also resulted in an improved SFA:PUFA ratio, compared to the control diet eggs. No statistically significant differences ($P < 0.05$) in egg taste or intensity of off-flavor was found between treatments. On average, the chia-fed hens produced eggs with milder flavor than those of the control diet-fed hens.

EFFECT OF CLIMATIC AND GENETIC FACTORS ON THE GRAIN YIELDING AND OIL CONTENT IN SUNFLOWER (*Helianthus annuus* L.)

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Sunflower (*Helianthus annuus* L.) is a crop well adapted to arid and semiarid lands in Mexico mainly due to its root system that can obtain water from deep soils, besides Mexico imports about 85% of the oilseeds. These facts make sunflower an excellent option for the farmers in Mexican semiarid lands. There are no specific varieties for the region at this moment, but we are working in the development of genotypes. The present work aims to study

the influence of the environment on the biomass distribution in the plant, grain yielding, oil content and protein in six genotypes.

Two experiments were evaluated in the University experimental field, at two seeding dates during 1993 (May 18 and June 10). Thirty plants were selected from each experiment and sampled at different development stages (star, blooming start and end, physiologic maturity and harvest) for evaluation of the above mentioned parameters, the plant height and head diameter was also measured. A path coefficient analysis was used to evaluate the influence of several phenotypic variables on the grain and oil yield.

The results showed that in the first experiment the biomass, grain and oil content was higher than in the second. The temperature was the environmental factor that affected more evidently the biomass and grain yielding. We confirmed that yielding is a function of genotype, environmental factors and the interaction between them. Two university developed varieties (SAN-3C and SANE) and one Russian (Peredovik) varieties out stand from the six evaluated. The path analysis showed that phenotypic variables (head diameter plant height and thousand seeds weight) affect the grain yield.

GROWTH AND GRAIN YIELD SIMULATION IN SUNFLOWER

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Simulation is a well adapted tool for determining optimal strategies of crop management, including water management itself.

In order to simulate a succession of crops the model must be capable of simulating the growth and production of several sunflower crops, taking into account a variety of management practices such as tillage, fertilization, irrigation, and others. The EPIC model (Erosion, Productivity Impact Calculator) satisfies all these requirements.

This work has as an objective the evaluation of the EPIC model for simulating growth and yield of sunflower under different conditions of water management along a period of several years, in the southern region of the state of Coahuila, México.

In order to feed the model for simulating crop growth and grain yield along several years soil (texture, depth, available moisture), climatic (air temperature, relative humidity, light hours, wind speed) and crop management (seed time, fertilization, weeding) data were collected.

To collect field data from previous sunflower experiments on crop growth and grain yield from the years comprised in this simulation assay.

Comparison between simulated and observed data will allow a determination the model's reliability and its eventual future usage in the region.

PERFORMANCE OF SAFFLOWER IN DRYLANDS OF SYRIA

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This research was conducted at International Centre for Agril. Research in Dry Areas (ICARDA), Tel Hadya Aleppo Syria. The trial included 86 safflower varieties from 18 countries, of these 86 varieties 30 were under tests at ICARDA in 1992 and 1993. The remaining 56 varieties were selected from the 1701 world collection based on better performance in 1992-1993 in the screening nursery. Planting was done on 21 November 1993 at Tel Hadya ICARDA Aleppo Syria, in a RBD with three replications. Individual plots had 6 rows, 5 m long, spaced 30 cm apart. Fertilizer 20 kg N/ha, was applied before seeding with a row planter at a seed rate of 30 kg/ha. Intra row

weeding was done mechanically and inter row manually, trial was combine harvested with a wheat combine in the second week of July. The 20 varieties which ranked high in yields, 12 top varieties are from world collection. A USA variety '1498' yielded the highest (1.7 t/ha) followed by a line from Turkey '777' yielding 1.6 t/ha, variety standing third in yield was also from Turkey (1445) yielding 1.4 t/ha. '200 seed wt' ranged from small seed 5.3 g (1583-USA) to bold seed 9.1 g (1045-India). The number of plants /m² ranged 34-109 with an average of 58 plant/m², however only four varieties had plants more than 75 and 17 varieties had less than 50 plant/m². Plant height ranged from 93 to 137 cm with an average height of 118 cm. The conclusion is that world collection from Colorado Fort Collins has got varieties and lines which can be selected for immediate commercial use.

CHIA GORDA *Hyptis suaveolens* (L.) POIT. A CROP WITH INDUSTRIAL POTENTIAL FOR AGRICULTURE DIVERSIFICATION

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In Mexico, maize, beans, amaranth and chia were in pre-colombian times the four most important crops. "Chia gorda" *Hyptis suaveolens* (L.) POIT. can be found growing wild and also in small cultivated areas in the Mexican states of Nayarit, Jalisco, Oaxaca, Colima and Veracruz. For Indian tribes chia is appreciated as a source of health and strength. It is considered an oil plant with a content of 13 to 23 percent oil which is rich in menthol. In 1989 this plant was introduced to the state of Sonora in Northwest Mexico, the purpose was to determine chia's adaptation to this environment.

The first stage of research included the evaluation of several planting dates from April to October; soon after plant behavior was observed in different soil types. Other agronomic tests included: Planting methods, fertilization and irrigation practices, under experimental designs. Plant growth and phenological development was determined as well as grain yield.

Evaluations conducted on chia gorda indicate a good adaptation to this area for planting dates from April, May and June, grain yield obtained range from 1.4 to 2.8 t/ha. A better development was observed on clay sandy soils or clay soils slightly loamy with low nitrogen and organic matter content with a 7.5 pH level. Best planting method was furrows 75 to 92 cm apart and 20 cm of distance between plants grain yield obtained was 2.5 t/ha. Best response to fertilization was with 0 and 50 nitrogen units per hectare; as for water use three irrigations along with a 230 mm of precipitation were enough for adequate plant growth. Leaves have an adequate composition with essential oils suitable for medical purposes. Seed oil content of 20 to 30% of high quality oil makes them a good ingredient for concentrate feed elaboration. In view of all the characteristics mentioned above *H. suaveolens* (L.) POIT. is considered a profitable option for commercial development in Mexico.

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EPOXY OILSEEDS DIVISION

VERNONIA GALAMENSIS: FROM ETHIOPIA TO ZIMBABWE AND KENYA.

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A USDA oilseed screening program identified *Vernonia anthelmintica* as a source of a naturally epoxidized oil. Chemists conducted utilization research aimed at market development and agronomists tried to adapt the plant to

U.S. agriculture. Seed of the best selections contained 31% oil with 75% epoxy acid. This species was abandoned as a new crop because of poor seed retention; they shed when matured.

In December 1964 I was collecting plants for another screening program at the height of the dry season in a semi-arid area near Harar, Ethiopia and observed a vernonia with excellent seed retention. Plants were dry, brown and near leafless with dead-ripe seed that had not been shed. The sample I collected contained 41.9% oil with 72.6% epoxy acid.

This plant was initially identified as *V. pauciflora* Wild, in his revision of *Vernonia* in the Flora Zambesiaca Area, showed that the correct name is *Vernonia galamensis*.

In his monograph of this complex species, Michael Gilbert, Kew Herbarium, showed that *V. galamensis* includes six subspecies, one of which has four distinct taxonomic varieties. From the initial collection in Ethiopia, the one of greatest current interest, is *V. galamensis* subsp. *galamensis* var. *ethiopica*. The Gilbert study has permitted assembly of an excellent germplasm collection. All of the subspecies and varieties are represented in about 40 germplasm accessions.

The initial collection of *V. galamensis* was grown out in Georgia where it proved to be a short-day plant. Plants flowered late in the season but were killed by frost before seed maturation. There was no further U.S. interest, but seed were increased in a greenhouse in Glendale, MD and placed in storage.

Interest in *V. galamensis* was rekindled by successful plantings in Kenya and Puerto Rico which provided a new supply of oil for utilization research and was further stimulated by agronomic research in Zimbabwe where a yield of almost 2.5 metric tons of seed per hectare was obtained.

Another stimulus to vernonia development was the observation by S. K. Dirlikov, Coatings Research Institute, Eastern Michigan University, that vernonia oil, because of its natural epoxy and low viscosity, could be used to formulate reactive diluents for oil-base paint to reduce air pollution from paint solvents.

AGRONOMIC PRACTICES FOR *EUPHORBIA LAGASCAE* PRODUCTION

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Euphorbia lagascae seed contains high levels of vernolic acid, a C:18 epoxidized fatty acid of commercial interest by the paint and coatings industry. Much is unknown regarding agronomic practices needed for dependable crop production. We examined the effects of planting date, plant density, water stress, and pre-harvest practices on crop growth and seed yield, using "non-shattering" Spanish cultivars. We also studied *Euphorbia*'s tolerance to herbicides.

Euphorbia is a drought-tolerant plant that grows well in hot weather, and has typically been planted in May here, with harvest in September or October. However, observations of volunteer plants that germinated in November or February, persisted through the winter, and produced seeds the following June or July suggest that euphorbia may possibly be grown as a winter or early spring annual. Results from a more detailed planting date experiment will be discussed.

The "non-shattering" cultivars used exhibited very little shattering in 1994 and 1996 through harvest in early October. Significant shattering occurred in 1995 starting in late August, probably due to increased water stress in 1995. Due to euphorbia's very slow senescence, direct combining was not practical. Two pre-harvest crop treatments were tested in 1995. Yields from plots that were swathed followed by windrow combining were slightly higher than yields where herbicide desiccation was followed by direct combining for both the 51 and 76 cm row spacing, possibly due to reduced seed shatter. Seed yields were consistently greater in 51 cm rows than 76 cm for both preharvest treatments.

Weed control is important for the first eight weeks or so after emergence. Several pre-plant incorporated (PPI),

pre-emergence (PRE) and post-emergence (POST) herbicides were tested to measure tolerance by euphorbia. Tolerance to benefin, ethalfluralin, and trifluralin PPI was excellent, especially at 1.1 kg a.i./ha rate. Slight damage was observed for trifluralin at 2.2 kg a.i./ha. *Euphorbia* exhibited excellent tolerance to pendamethalin PRE at 1.1 kg a.i./ha, slight damage at 1.0 kg a.i./ha PPI and 2.0 kg a.i./ha PRE, and moderate damage at 2.0 kg a.i./ha PPI. In preliminary studies of POST herbicides, only clopyralid was tolerated well by euphorbia. Bentazon tolerance was moderate, chloridazon and 2,4-D were doubtful, and other results were inconclusive. Results of additional ongoing studies will be discussed.

HARVESTING, SEED HANDLING, AND GERMINATION METHODS FOR *EUPHORBIA LAGASCAE*

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Euphorbia lagascae seed contains high levels of vernolic acid, a C:18 epoxidized fatty acid of commercial interest by the paint and coatings industry. Many questions remain regarding seed processing and germination requirements needed for dependable crop production. This study examined how seed handling practices and environmental conditions affected euphorbia seed germination, using recently developed lines of “non-shattering” Spanish cultivars.

Euphorbia seeds are soft, with a seed coat that is easily damaged during threshing or processing. In these studies, an intact seed coat was essential for germination, even in cases where much of the seed damage was not visible without magnification. Seeds in this study were threshed with a Hege 125C plot combine, and successfully cleaned using various common “Clipper” seed cleaners. Threshing at the slowest possible cylinder speed (approx. 400 rpm) with the concave clearance set near its maximum decreased damage, increased subsequent germination, but also reduced the number of seeds threshed from the pods on the first pass.

Unthreshed pods were left in cool storage (7-15°C), or heated storage (either 40-44°C or 60-65°C). The number of seed pods shattering in storage increased with oven time and temperature, but subsequent germination decreased as oven time and temperature increased. Germination was highest (above 90%) for naturally split pods (shattered in cool storage), germinated in the dark at 18°C, at least 4 months after threshing. Germination in the light at similar temperatures was 20-30%. The inhibition of germination in light decreased as threshed seed aged more than 6 months. For one seed lot, germination 6 months after threshing was 67%, compared with 12% 2 months after threshing, suggesting a moderate seed dormancy. For another lot, warm stratification at 32°C did not increase subsequent germination, but cool stratification at 7°C increased germination by 18%. Pretreatment with bright light for up to three weeks slightly increased subsequent dark germination. Dark germination decreased from 84% to 44% as germination temperature increased from 26 to 32°C. Germination of unthreshed pods was less than 10%. When mixed with broken pods, seeds germinated normally, but began to grow abnormally and eventually tended to die if the radicle touched a pod, suggesting an herbicidal effect by some compound in the pod.

LAB-SCALE PROCESSING OF *EUPHORBIA LAGASCAE* SEED AND OIL

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Euphorbia lagascae (50% oil, ca. 60% vernolic acid) and *Vernonia galamensis* (40% oil, ca. 80% vernolic acid) are two rich sources of naturally epoxidized seed oils. Because of different natural origins and physiological and

agronomic characteristics, the two species are complementary at this point in their development as domestic sources of epoxy oils. Both oils have been shown to have significant potential in coatings and polymer applications. Both seeds require traditional and non-traditional processing techniques because of potentially active lipase systems and reactive oils. Limited processing studies have been conducted on each oil.

E. lagascae seed was produced by Oregon State University and made available to us to examine processing parameters and to produce refined oil for some novel new product evaluations. We arranged to conduct prepress/solvent extraction processing of the seed and oil refining at POS Pilot Plant facilities in Saskatoon, SK, Canada.

Ten kg of seeds were moisture (ca. 10%) and temperature (ca. 96°C) conditioned as needed prior to hot pressing using a Komet Single Spindle Press with a throughput capacity of 8 to 15 kg/h. A ring heater on the press head provided nearly constant (74-76°C) thermal control on the pressing operation. Two die orifices (5 and 8 mm) and three screw speeds (motor rheostat settings of 6, 8 or 10) provided pressing rates of 3.0 to 4.7 kg/h and residual oils in the extruded rope (press "cake") of 8.7 % (5mm die, spd 6) to 18.8% (8mm die, spd 10). Crude oil yield overall from the pressing experiments was ca.42%. Double pressing (5mm die, spd 8) resulted in press cake with 6.3% residual oil. Combined press cakes were extracted over night in a pilot plant soxhlet extractor to give defatted meal with 0.21% residual oil, 43.7% protein and 13.0% crude fiber. Crude oil was water degummed and four bleaching experiments were conducted using various combinations of bleaching agents: TrisylR, B80 standard clay, and Darco 60 charcoal. A combination of all three agents provided the lightest oil (13Y,2.3R). No loss in oxirane content (3.09) occurred during processing, and vernolic acid content of the refined oil was 60.0%.

DEVELOPMENT OF *Vernonia galamensis* SUBSP. *galamensis* VAR. *ethiopica* AS A NEW CROP IN NAYARIT STATE, MEXICO

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Vernonia was introduced to Nayarit State in 1993 when seed supplied by the U.S. Department of Agriculture were grown out for increase. No information was then available on management. Our objective has been to develop cultural information on this crop.

Experimental plots were planted in a clay loam, low in nitrogen and phosphorous but with adequate potassium, pH 5.1, at the Universidad Autonoma de Nayarit, Tepic, Latitude 21.31 N., Longitude 104.54 W., Elevation 915 m. The rainy season is June through October; average annual rainfall is 1349 mm.

Before planting the soil was prepared by plowing and discing. Seed were planted 2.5 cm deep, 20 cm apart, with 70 cm between rows to facilitate cultivation and harvest. Seed were planted July 27 at which time fertilizer was applied at the rate of 80-60-50 units per hectare. Fertilizers were urea (41.3 kg/ha), ammonium diphosphate (130 kg/ha) and potassium chloride (83 kg/ha). The insecticide Counter 15% G (7 kg/ha) was applied at planting time along with preemergent herbicides Prowl 400 (1 L/ha) and Dual 960 (1.5 L/ha).

The crop was cultivated 55 days after planting at which time 82.6 kg/ha of urea was applied. Plants were topped 60 days after planting. At this time plants were 25 cm tall and the upper 5 cm was removed to promote branching from the base of the plants.

The crop was harvested 200 days after planting when seed were dark brown. Plants were cut with a machete and dried in the sun for a week after which seed were shaken from the plants.

The harvest was screened to remove trash. The best yield was 1275.6 kg/ha.

SALINITY AND TEMPERATURE INTERACTION ON THE GERMINATION OF *VERNONIA*

GALAMENSISNaveen Puppala¹, James Fowler¹, Dave Dierig², and Gail Dahlquist²¹Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM - 88003, USA.²USDA Agricultural Research Service, U.S. Water Conservation Laboratory, Phoenix, AZ - 85040, USA

Vernonia galamensis is a new oil seed crop abundant in epoxy compounds. The seed contains naturally occurring epoxidized oil and the associated epoxy fatty acid, vernolic acid. There is no information concerning the response of vernonia germination to salinity. Salinity reduces seed germination, stand establishment, and yield. Scarcity of water, competition for fresh water and soil salinization have resulted in a need to increase salt tolerance especially in irrigated regions of the world.

A laboratory experiment was conducted to determine the salinity tolerance of vernonia during germination and salinity \times temperature interactions that may influence germination and stand establishment. Treatment solutions were prepared using NaCl and CaCl₂ in a 2:1 molar ratio. The experimental design consisted of six salinity levels (electrical conductivity of 0.03, 5.43, 10.13, 16.23, 21.60 and 26.35 dSm⁻¹); six temperatures (10, 15, 20, 25, 30 and 35°C) using five hybrid seed lines (12E OR1, 21J 7-13, 29E OR2, 49B OR2 and 66BK OR1) developed at U.S. Water Conservation Laboratory, Phoenix, AZ. Evaluation for salinity tolerance during germination was accomplished by placing 50 -seed samples in 90 \times 15 mm plastic petri dishes containing one blotter paper to which 5 mL of distilled water or various solutions of NaCl and CaCl₂ (2:1 molar ratio) were added. The covered petri dishes were arranged in an incubator in a randomized complete block experimental design with one block per shelf over four shelves. Germination response to salinity at six temperatures was evaluated by replicating the temperatures twice in the two incubators. Counts were made at three day intervals over a period of 12 days.

Germination declined with increasing salinity at each counting date. Salinity \times temperature interactions and salinity \times variety interactions were highly significant. An optimum germination temperature for all salinity levels fell in the 15 to 30°C range with the final cumulative germination percentage peaking at 25°C for all the treatments. Germination declined on either side (15 and 30°C) of the optimum. The line 66BK OR1 performed better at all temperature and salinity levels. The final cumulative germination of vernonia seeds in 0.03 dSm⁻¹ was 60%, 5.43 dSm⁻¹ was 37% and 10.13 dSm⁻¹ was 14% while germination at 16 dSm⁻¹ and above did not germinate. These results suggest that vernonia is very moderately tolerant to salinity stress during germination.

EPOXY FATTY ACID BIOSYNTHESIS IN DEVELOPING *Vernonia galamensis* SEEDS

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A number of plants are known which accumulate epoxy fatty acids in seed oil. The best examples of this are *Vernonia galamensis* and *Euphorbia lagascae* which accumulate an epoxy fatty acid known as vernolic acid (*E*-12,13-epoxyoctadeca-*E*-9-enoic acid). Some accessions of *V. galamensis* have as much as 40% oil which is comprised of 80% vernolic acid. Both *Vernonia* and *Euphorbia* only accumulate vernolic acid in seed triglyceride, not in any other lipid class or plant part. The biosynthesis of vernolic acid in *Euphorbia* has been partially characterized and reported by Bafor et al. (1993, Arch. Biochem. Biophys. 303:145). The precursor to vernolic acid is linoleic acid. The conversion of linoleic to vernolic acid is catalyzed by an epoxygenase. The substrate for the developing *Vernonia* seed epoxygenase appears to be linoleoyl-phosphatidylcholine (PC) as is the case for *Euphorbia*. The activity of this enzyme is localized to microsomes of developing *Vernonia* seeds. The *Vernonia* epoxygenase is inhibited by CO and cyanide. Either NADH or NADPH is necessary for activity and they support the activity similarly. The activity is not inhibited by anti-chrome P450 antibodies but is inhibited by anti-cytochrome b5 antibodies. The inhibition by CO and need of NADPH are consistent with the epoxygenase being a classical P450 monooxygenase, but the other characteristics are not. A likely pathway for the redox activity for the epoxygenase reaction is NAD(P)H @ cytochrome b5 reductase @ cytochrome b5 @ linoleoyl-PC

® vernoleoyl-PC ® ® triglyceride containing vernoleate.

DEVELOPMENT OF *VERNONIA GALAMENSIS* AS A NEW OIL SEED PLANT: THE NEED FOR IMPROVING AVAILABLE GERMPLASM

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Vernonia galamensis seed is a good source of epoxy oil with potential applications in the coating, and plastic industry. A limited number of accessions (less than 40) that belong to six subspecies have been collected in different habitats in Africa. The different accessions vary greatly in growth patterns, self incompatibility, flowering in response to day length, and other characteristics. The most promising accession belongs to ssp. *galamensis*, var. *ethiopica* (known as V 001); it is self fertile and has good seed retention. However, this plant does not flower in summer and it is susceptible to cold and frost in areas north and south of the tropical zone. Other varieties of ssp. *galamensis* and some other subspecies flower in summer but suffer from high seed shattering. For genetic improvement more germplasm is needed that has characteristics such as low seed shattering, flowering in response to long (or neutral) day, high yields, cold resistance and drought resistance. Collections of various populations of *vernonia* are being carried out by the regional gene banks and by researchers in Kenya and Ethiopia. A description of these collections will be presented. One of the most promising populations of *vernonia* is located in the Sidamo region of Ethiopia. These plants, which flower in summer, belong to the variety *ethiopica* accordingly to Gilbert (Kew Bulletin 41:19 35, 1986). However, in this region one can find plants of var. *petitiana* and plants that possess mixed characteristics of both varieties. This situation supports the suggestion of Gilbert himself about intergradation of these species in the Sidamo region. An intensive collection effort and systematic characterization of the important germplasm in the Sidamo region should take place.

Concomitant to the collection of more heterogeneous germplasm from the wild, hybridization should be instituted to produce improved plants suitable for cultivation in cold prone areas. Crossing can take advantage of the self sterility of some *vernonia* germplasm in an insect free environment. However, seed counts show that only a portion of the seeds obtained may be hybrid seeds. This portion varies greatly with the germplasm and even among individual plants. Crossing var. *ethiopica* of ssp. *galamensis* (male parent) with the varieties *petitiana* and *galamensis* of the same subspecies yielded hybrids that flower in the summer and exhibited mixed phenological characteristics of both parents. So far no hybrid has exhibited seed retention as good as that of var. *ethiopica*. Back crossing the hybrid between var. *petitiana* and *ethiopica* with var. *ethiopica* did not yield the desired offspring.

IMPROVEMENTS IN SEED YIELD AND SEED RETENTION IN *VERNONIA GALAMENSIS*

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Fifteen advanced *vernonia* lines were field planted in 1996 at Phoenix, Arizona to compare field germination, plant stands, plant growth, and seed yields between lines. Seed was sown on April 22, in four row plots, 4.5 meters long, one meter between rows, and three replications. Stand counts were taken at 43 days after planting (DAP). Plant heights were measured at 102 DAP, while plants were in full flower. Plants were harvested at 146 and 176 DAP for comparison of harvest dates. A plant pathogen was identified on stems of mature plants at mid-season. However, it was controlled using a soil drench fungicide.

The seed heads of *vernonia* contain petals called involucre that surround the seeds. As seeds mature, involucre dry and fold downward, allowing seed to disperse. Plants of one line displayed a new trait that allowed seed to remain on the plant for a longer period. Involucre dry in the same manner as normal plants but do not fold down.

As a result, seed is held on the seed head longer and harvestable seed yields are increased.

EPOXIDIZING PLANT OILS AND ESTERS BY LIPASE-CATALYZED PER HYDROLYSIS

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The epoxidation of unsaturated plant oils is industrially achieved using peroxy formic or peroxy acetic acid in situ. Various epoxidation methods (i.e. transition metal catalysts / hydrogen peroxide or hydroperoxides; dioxirane; co-oxidation with aldehydes) have been developed, but because of their particular drawbacks none has been applied commercially.

A new way to obtain epoxidized plant oils is the chemo-enzymatic "self-" epoxidation. Catalyzed by an immobilized lipase (Novozym 435 ®) triacylglycerols are converted with hydrogen peroxide (35 %) to peroxy fatty acids. These peroxy acids consecutively epoxidize C=C bonds in the plant oil. An addition of 5 mole% free fatty acids prevents the formation of mono- and diacylglycerols, that would be difficult to remove afterwards.

The reaction is very selective, even if high unsaturated plant oils like linseed oil are epoxidized. Linseed oil was epoxidized on a 400 g-scale with 98 % conversion and 98 % purity after NaHCO₃-washing. The quality of this product is superior to that of the commercial product made with peracetic acid.

Partly epoxidized plant oils were also produced by chemo-enzymatic "self-" epoxidation. Their properties (oxirane content, iodine value, viscosity) are similar to that of vernonia or euphorbia oils, but can also be "tailored". Although these products lack the isomeric homogeneity of the natural epoxy oils, they can be used for polymers in the same way.

The immobilized biocatalyst can be removed by filtration and recycled 15 times without losing most of its activity. Hence, enzymatic peracid generation on the lab-scale is already cheaper than buying preformed peracids.

Studies on the epoxidation of various unsaturated fat-based materials, reaction kinetics, and the construction of a fixed bed reactor for the chemo-enzymatic epoxidation are now in progress.

EPOXIDIZED SOYBEAN OIL FOR HIGHER SOLIDS ALKYD AND EPOXY COATINGS

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Epoxidized soybean oil has been used as a reactive diluent for alkyd coatings and epoxy coatings in order to meet environmental regulations. The advantages of the oil are that it is relatively low in viscosity, it can react into the coatings, and it is relatively inexpensive. The oil has been used in ambient cured alkyd coatings, ambient cured epoxy coatings and in UV cured coatings. The epoxidized soybean oil can usually replace 10-20% of the solvent in coatings. The UV cured systems were 100% solids with no solvent needed.

PRODUCTION OF NYLON 11 AND NYLON 12 MONOMERS FROM VERNONIA OIL

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12-Aminododecanoic acid and 11-aminoundecanoic acid, monomer precursors for nylon 12 and nylon 11 respectively, have been synthesized from vernolic (*cis*-12,13-epoxy-*cis*-9-octadecenoic) acid via a reaction sequence that includes the formation of 12-oxododecanoic acid oxime. The oxime was catalytically reduced to give 12-aminododecanoic acid with a yield greater than 85%.

On the other hand, 11-aminoundecanoic acid was prepared from the oxime via a three step reaction sequence that involved a Beckmann rearrangement, Hofmann degradation, and hydrolysis. Synthetic details, characterization, and commercial implications of these processes will be discussed.

CHROMATOGRAPHIC REFINING OF VERNONIA OIL

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A physical refining process has been used to deacidify crude vernonia oil To obtain refined vernonia oil that contains less than 0.25% free fatty acid (FFA). In the process, crude vernonia oil (containing greater than 2% FFA) was dissolved in a solvent such as 2-propanol and then passed through A column of activated alumina at room temperature. The process gives recovery of refined oil of 94 98% depending on the alumina/crude oil ratio. The spent alumina can be recovered by washing with dilute solution of sodium hydroxide.

VERNONIA GALAMENSIS: A RENEWABLE RESOURCE FOR REACTIVE MONOMERS AND THEIR CORRESPONDING POLYMERS

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There is increasing interest in using plants and plants derivatives for industrial purposes as substitutes for products currently produced from petroleum. We are focusing on *Vernonia galamensis*, which produces a natural epoxidized vegetable oil, as a candidate crop for arid and semiarid zones in both developing and developed countries.

Synthesis of novel products with potential industrial applications by exploiting the chemical tri-functionality of vernonia oil is the objective of our work. The current presentation describes new reactive acrylate and methacrylate monomers obtained by reacting the vegetable oil—the naturally epoxidized vernonia oil or epoxidized soybean oil (epoxol) —with unsaturated acids (acrylic or methacrylic).

The highest conversion of epoxy groups (85-98%) was obtained by performing the reaction with an excess of carboxylic groups at 100-120°C for about 10 h with and without catalysts. Acrylic acid was found to be more reactive than methacrylic acid. The new monomers obtained from vernonia oil and epoxol were characterized by IR and NMR spectroscopy.

The acrylates and methacrylates of vernonia oil and epoxol were thermally and photochemically polymerized. Thermal cross-linking, which was carried out in the presence of benzoyl peroxide, gave a white amorphous polymer. Photochemical cross-linking, which was carried out in the presence of benzophenone, produced transparent colorless films.

In addition, a commercial epoxy resin was modified with our reactive multifunctional monomers by in situ polymerization. The properties of the obtained materials will be discussed.

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HIGH ERUCIC CROPS DIVISION

INTEGRATING PRODUCTION, PROCESSING, AND MARKETING OF HEA OILS

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Commercialization of new crops has been a major objective among several USDA, State University, and private business partnerships over the last decade. Featured in the 1992 USDA Yearbook, New Crops, New Uses, New Markets, a common theme of these projects has been to, 1) commercialize diverse new crops which are compatible with existing crops with the goal of reducing pest problems through crop rotation, and, 2) to commercialize new crops which will not compete with existing crops, preferably targeted at markets which are currently imported or met with non renewable resources. One such project was the High Erucic Acid Development Effort (HEADE), a coalition of USDA and nine state universities which was organized between 1987 and 1994. The ultimate outcome of this project was the commercialization of crambe as a new domestic source of high erucic acid for the U.S.

Crambe was commercially grown in partnership with an existing oilseed processor from 1990 through 1994 in North Dakota. Relatively small volumes and limited niche markets discouraged further industry participation despite the willingness of the growers and the users of this oil. The oilseed processing industry in the Northern Plains, as has much of the developed world, has developed into a consolidation of facilities that are large and specialized for single or few crops. While such an infrastructure has proven efficient for commodity sunflower, canola, and soybean, it has been a barrier to support smaller volume, niche market oilseeds.

Smaller volume, niche oilseeds have different production, processing, and marketing needs than large scale commodities. Production must be balanced with demand, and processing must be carefully segregated to assure identify preservation and insure quality. Breeding and biotechnology seem destined to increase the number of 'designer' or market specific crops. In North Dakota alone in 1997, three modified fatty acid sunflower types, two different safflowers, and two different canolas are being commercially grown. While commodity crops, they all face the same infrastructure barrier as crambe, with specific production, processing, and marketing requirements.

An infrastructure has developed in North Dakota to complement the existing large scale processors, and hopefully better serve and encourage development of small volume, niche marketed oilseeds. The principal features of this infrastructure have been designed to meet the needs of these special oilseeds. They are 1) have the growers be the owners (or stake holders) helping insure the balance between supply and demand, 2) segregation of the special crops start and stays on the farm, rather than in central warehousing facilities, 3) delivery and processing in alternative facilities with flexibility, rather than specialization, being the primary design criteria, and 4) marketing vertically integrated with production and processing to insure open communication and keep profit as a motivator at the production level.

BREEDING ADVANCES WITH CRAMBE

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Crambe has been grown successfully on a larger scale in the 1990s than in the past. Further genetic improvement is required to insure future advancement and competitiveness with crops that produce similar end products. With this in mind, a vigorous crambe breeding effort is in progress at North Dakota State University.

Breeding programs at Purdue University, USDA/Beltsville, and New Mexico State University in the 1970s and 1980s culminated in the release of the varieties, Meyer, Indy, Prophet, BelAnn, and BelEnzian, the germplasms, C-22, C-29, and C-37, and numerous breeding lines in various stages of development. This material and 103 accessions available from the world collection maintained at the North Central Plant Introduction Station at Ames, Iowa provided the foundation for the breeding program here.

The objectives of the NDSU crambe breeding program include: (1) increase seed yield; (2) increase seed oil content to a level near that of rapeseed; (3) lower meal glucosinolate content to acceptable levels or eliminate them altogether; (4) increase erucic acid content of the oil to its maximum level; and (5) develop cultivars that are resistant/tolerant to potentially harmful diseases and insects. These objectives have been approached in two ways: (1) evaluation of existing germplasm; and (2) selection among and within breeding populations developed through hybridization among existing germplasms and subsequent selfing. A bulk-pedigree method is being used as inbred lines are originally derived from F₂ plants and seed is bulked in the succeeding generations.

Performance evaluations conducted at numerous locations in North Dakota in the years 1992-6 have indicated that many breeding lines have the potential to perform significantly better than the currently grown cultivar, Meyer. Inbred lines possessing nearly 40% oil and more than 60% erucic acid have been selected from breeding populations. However, no genotypes have been found to have the desired glucosinolate level. Breeding efforts continue in an attempt to combine all desired traits.

IMPROVEMENT OF HIGH ERUCIC ACID BRASSICACEAE BY TRANSFORMATION WITH A YEAST SN-2 ACYLTRANSFERASE GENE

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A putative yeast sn-2 acyltransferase gene (SLC1-1), reportedly a variant acyltransferase which suppresses a genetic defect in sphingolipid long chain base biosynthesis, has been expressed in a yeast SLC deletion strain. The SLC1-1 gene product was shown to encode an sn-2 acyltransferase, capable of acylating sn-1 oleoyl-lyso-phosphatidic acid, using a range of acyl-CoAs, including 18:1-, 22:1- and 24:0-CoAs, in vitro. The SLC1-1 gene under the control of a constitutive (tandem 35S) promoter, was introduced into the model crucifer *Arabidopsis thaliana* and high erucic acid cultivars of *Brassica napus* (cvs. Hero, and Reston), and *B. carinata* (breeding line C90-1163). The resulting transgenic plants showed substantial increases of 8 to 58% in seed oil content (expressed on the basis of seed dry weight), and increases in both overall proportions and amounts of very long-chain fatty acids (VLCFAs) in seed triacylglycerols (TAGs). Furthermore, the proportion of VLCFAs found at the sn-2 position of TAGs was increased, and homogenates prepared from developing seeds of transformed plants exhibited elevated lyso-phosphatidic acid acyltransferase (LPAT; EC 2.3.1.51) activity. Thus, the yeast sn-2 acyltransferase has been shown to encode a protein which can exhibit LPAT activity, and which can be utilized to change total fatty acid content and composition, as well as to alter the stereospecific acyl distribution of fatty acids in seed TAGs. The current findings suggest that the reaction catalyzed by the plant LPAT may be a regulatory step in the Kennedy pathway for TAG biosynthesis in developing oilseed embryos. Examples of modifications achieved by both constitutive and seed-specific SLC1-1 gene expression in the Brassicaceae, will be presented.

THE CRAMBE *Crambe abyssinica* HOCHST. EX. R.E. FRIES IN THE YAQUI VALLEY, SONORA, MEXICO

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Crambe abyssinica Hochst. Ex. R.E. Fries is a vegetable species that belongs to the cruciferae family, with its main use as oil in the rubber metallurgic and plastics industries. Crambe oil is highly resistant to temperature change, as a result it is used as lubricant in the mold industry. Crambe contains 60% erucic acid which makes the oil unacceptable in animal and human diets. Because of national interest and its good adaptation qualities crambe has good potential in the Yaqui Valley environment. This crop was evaluated for three years from 1992 to 1994 using 10 experiment lines from south United States.

Crambe yield trials were conducted in the Yaqui Valley Experimental Station, Sonora, Mexico, during 1992, 1993, and 1994. Ten experimental lines were evaluated under a randomized square design with four replications. The experimental plot was formed for four rows 75 centimeter wide, and 6 meters long. The followings parameters were measured: days to flowering, days to physiological maturity, plant height, lodging grade, specific weight of grain, oil content, and grain yield.

The highest yield was 3619 kg/ha obtained during the cycle 1991-1992 and corresponded to the line Sp.88 NM #2. The mean yield of this line through 1992-1994 was 2500 kg/ha. Considering the yield, agronomics characteristics, and the oil content obtained from this line, farmers will be able to plant this crop in the northwestern Mexico. However, research is still necessary to obtain information about fertilization, water management, pest management, weed control, disease management and harvesting in order to increase the yield and oil quality.

PRODUCTION OF CRAMBE IN EUROPE

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Starting with a demonstration project (300 ha annually) in 1991 in the Netherlands crambe has gradually expanded into Europe. In 1996 a demonstration project started in Germany and in 1997 commercial production in France.

In Europe industrial crops such as crambe are mainly grown on a set aside land. The total acreage is limited by the Blair House Agreement of 1993 at about 5 million hectare. Crambe is an erucic acid containing crop and in competition with HEAR. The market size for erucic acid containing oil in Europe is estimated at about 35.000 tons respectively 35.000 ha., relatively small in comparison with the very large acreage of 2.7 million ha of rape.

The profitability of the crop will depend on the industrial utilisation of each component of the seed. The hull contains mainly a cellulose which can be used in paper production. The meal, depending on the type of processing, can contain fibres from the hull but always glucosinolates. These glucosinolates limit the application of the meal as a feed component.

The production chain of crambe will be explained from breeding to the use of the endproduct erucamide, as an anti slipping agent in plastic foil. Economic and agronomic focus points will be discussed.

To promote the growing of crambe the meal resulting from the processing has to be a value added product, to achieve this end, the glucosinolates will have to be removed to facilitate the incorporation of crambe meal in special feeds for piglets and broilers. A recent developed detoxification process will be presented. In addition, a European wide conference on crambe was organized in Italy (May 15 and 16, 1997) and the results of this meeting will also be presented.

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