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2006 AAIC Annual Meeting: New Crops and New Uses: Creating Markets for Economic Development

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ABSTRACTS

Horticultural/Agronomic Crops Session I (Botanicals and Medicinals)

MEDICINAL AND AROMATIC PLANTS – FUTURE OPPORTUNITIES

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The first pharmacological use of plants for the treatment of ailments is lost to history, but most likely began at or near the time of the first afflictions. Those plants containing unique chemical profiles that offered relief from nausea, pain, and/or other signs of illness would soon be recognized and valued. Continued experimentation with various materials would undoubtedly lead early humans to associations between specific plants and "feeling better." These plants, now known as medicinal plants, along with various minerals, animal tissues, and fungi, would serve as the primary pharmacy for early civilizations. The objective of this report is to examine past and current trends as a guide

to the future for medicinal and aromatic plant production.

Although linked with humans from the earliest of recorded history, the acceptance and application of these materials has oscillated with the development of other medicinals and association of plants with negative myths and historical traditions. In the 20th century, the synthesis of sulfur drugs and the organics produced modern sources of medicine became the preferred method of treatment in some countries, especially in America. In the U.S., the 1910 Flexner Report and the American Medical Association indicated only trained physicians using allopathic pharmaceuticals should be allowed to practice medicine. While many countries continued to use plants as a primary pharmacological repository, America began to re-recognize the value of plants only in the late 1960s.

Current trends in plant medicine are primarily science-based and focused on producing high quality, uniform raw materials to produce effective medicines in a sustainable manner. As the use of herbal medicines becomes more prevalent in the Westernized nations, regulator authorities are seeking to ensure that the public will receive safe and effective remedies. Researchers and growers are concerned with developing and producing in the field and in more controlled environments clean materials high in bioactive constituents. Independent, non-government organizations are creating certifications for an equitable and sustainable production, to meet consumer demand for ethically produced products.

Future trends indicate a growing market for medicinal and aromatic plants. In addition to pharmaceuticals, market expansion has occurred in such areas as agrotourism, cosmeceuticals, and veterinary products. Demand is for organically grown herbs produced in a sustainable manner with fair-trade prices.

ELDERBERRY AS A MEDICINAL PLANT

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There is an increase demand to replace synthetic dyes used in food processing. Numerous fruit and vegetables provide excellent sources of natural pigments quite suitable for such use. In its search for a new food colorant, a Canadian company teamed up with Agriculture and Agri-food Canada to understand better the behavior of American elder (berry) (*Sambucus nigra* sbsp. *canadensis*)[SN] under cultivation. We report some of our findings about this interesting plant.

American elder is a close relative of black elder (*Sambucus nigra* sbsp. *nigra*)[SC]. While black elder has been used for centuries in Europe and some parts of Asia and the Middle East, the American elder has remained relatively unknown to North Americans until recently. The taxonomic closeness of these two subspecies is such that they share common medicinal properties. Of interest, the anthocyanins in SC are more stable to light, heat, and pH than in SN, which makes the SC fruit more suitable for transformation.

The elderberry fruit is an excellent source of anthocyanins, vitamins A and C, and a good source of calcium, iron, and vitamin B6. It also contains sterol, tannin, and essential oil. Its total antioxidant capacity is one of the highest of all the small fruits.

Mild symptoms of stomachache and vomiting have been reported after the consumption of the unripe fruit. However, these mild side effects are outweighed by the numerous medicinal uses for which they are known, some of which are well documented. Among the proposed medicinal properties of elderberry (flowers and fruit) are: diuretic, laxative, and diaphoretic. They have also been use to treat stomachache, constipation, diarrhea, sinus congestion, shore throat, cold, and rheumatism. Elderberry extract can increase insulin production, thus improving sugar absorption. Probably the most documented medicinal effect of elderberry is its capacity to reduce significantly the symptoms associated with the flu. Despite the many claims about the therapeutic value of elderberry, it is still used as a transformed food (juice, jam, jelly…) that it is known by North Americans.

Over the past three years, much of our work has been done on cultivation practices, cultivar evaluation, and selection. Yield and pigment vary among cultivars. Those with small fruits usually have higher pigment content. In response to an increased interest for healthy food from the public, we are focusing on the various medicinal properties of elderberry. Pigment content and antioxidant capacity are now been evaluated when analyzing cultivation practices and doing cultivar selection. We are also looking at clinical trials to validate some of the claims reported in the folklores of various countries.

GROWING AND MARKETING NATIVE WOODLAND BOTANICALS

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The market demand for woodland botanicals native to North America is rising. Because many of these herbs are harvested from wild populations, concerns for their conservation are also increasing. At the same time, a small but growing number of herb product manufacturers are requiring documentation that the raw material they purchase is certified organic, low in heavy metals, free of pesticide residues, contains a minimum specified level of bioactives, is traceable to its source, and has a voucher specimen. This provides a unique market opportunity for some farmers, particularly those with wooded acreages. With the exception of ginseng (*Panax quinquefolius*), however, little information exists on the commercial production and marketing of many of these plants. Markets are also unstable and the risks of producing these crops are great.

The objectives of a series of projects on woodland botanicals, including goldenseal (*Hydrastis canadensis*), black cohosh (*Actaea racemosa* or *Cimicifuga racemosa*), bloodroot (*Sanguinaria canadensis*), and false unicorn (*Chamaelirium luteum*) have been (1) to help farmers interested in growing native woodland botanicals by developing commercial production systems, enterprise budgets, and markets; (2) to train extension agents and agriculture students; (3) to build a network of growers and buyers; and (4) to create readily accessible reference materials.

This presentation will focus on the results and impacts of some of these projects, demonstrating that production of native woodland botanicals can be a viable enterprise for some farmers.

MEDICINAL CROPS FROM AFRICA

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Africa is a vast continent with over 50 countries, 800 languages, and 3,000 dialects, and with a diversely rich cultural heritage. Africa is recognized as a veritable treasure of genetic resources including medicinal plants, and these plants still play a significant role in the life, health, and culture of the people.

This invited presentation provides an overview to some of the leading African medicinal plants in sub-Sahara Africa that are in the international trade, plus an introduction to a number of lesser-known promising medicinal plants For each plant, the overview will include the plants' geographical range, whether cultivated and/or collected, their applications and use in health-care and medicine, and their natural products chemistry.

Some of the reviewed plants include: African potato *(Hypoxis hemerocallidea);* Aloe *(Aloe spp.),* Buchu *(Agathosma betulina);* Camphor tree *(Cinnamomum camphora);* Cancer Bush *(Sutherlandia frutescens);* Cryptolepis *(Cryptolepis sanguinolenta);* Devil's Claw *(Harpagophytum procumbens);* Wild Geranium *(Pelargonium sidoides);* White Ginger *(Mondia whitei);* Wild Ginger *(Siphonochilus aethiopicus);* Gota kola *(Centella asiatica);* Grains of Paradise *(Aframomum meleguetta);* Griffonia *(Griffonia simplicifolia);* Hoodia *(Hoodia spp.);* Pepper-Bark tree *(Warburiga salutaris);* Pygium *(Prunus africana);* Rooibos *(Aspalathus linearus);* Senna *(Senna italica);* Voacanga *(Voacanga africana);* Wild yam *(Dioscorea spp.);* and African Wormwood *(Artemisia afra).*

PRESERVATION OF MEDICINAL AND AROMATIC CROPS

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The National Plant Germplasm System (NPGS) is a cooperative effort by public (State and Federal) and private organizations to preserve the genetic diversity of plants by long-term storage of germplasm, primarily in the form of seeds.

The mission of NPGS includes: (1) the conservation of diverse crop germplasm through collection and acquisition; (2) conducting a variety of germplasm-related research; and (3) encouraging the use of the germplasm collections and associated information for research, crop improvement, and product development. Accession data is maintained via the Germplasm Resources Information Network's database (GRIN http://www.ars-grin.gov/npgs/). The accessions numbering 466,173 are represented in the NPGS as of 26 February 2006.

The presentation will summarize how medicinal plant researchers can utilize the NPGS both for acquisition and long-term preservation of research collections. The collections are suitable for a wide variety of research projects ranging from ornamental breeding studies to LC/GC analysis of metabolites of interest. Examples of current research projects will be discussed. The Echinacea collection will be used as a model example of a comprehensive collection that has been preserved via the NPGS and is currently available for research purposes. Illustrations of seed and control-pollinated cage propagation methods, and facilities utilized for seed cleaning, testing, and storage will also be included. In addition, methods for utilization of the GRIN database to view evaluation data, locate passport information, and acquire germplasm will be provided.

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Industrial Crops Session I (Meadowfoam)

RESPONSE OF CONIFER SEEDLINGS TO MEADOWFOAM (*LIMNANTHES ALBA* L.) SEED MEAL

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Meadowfoam (*Limnanthes alba* L.) is grown in Oregon because of its high quality seed oil used in cosmetics and lubricants. The seed meal (MSM) remaining after oil extraction has been shown to have plant growth-stimulating properties as well as glucosinolates that can release biocidal breakdown products. However, the commercial utility and rate of application of MSM to soilless media, and specifically the effect on conifer seedling growth has not been determined.

The objectives of this study were to determine the effects of different rates of MSM on seedlings of several conifer species grown in containers in soilless medium, and to determine the potential fertilizer savings on Douglas fir by using MSM amendment.

MSM was added to a peat-based potting medium (with minimal starter fertilizer) at 0 (control), 1, 2, 3, 4, and 5% by volume, and the mixtures seeded with five conifer species (Douglas fir, Eastern White Pine, Noble Fir, Western Hemlock, and Western Red Cedar). Seedlings were grown for 12 weeks under greenhouse conditions with no further fertilization, after which the dry biomass of roots and shoots was determined. In further experiments, fertilizer was applied at different frequencies to determine the equivalent to MSM amendment.

Growth stimulation was maximum for all species at 1% MSM amendment, with stimulation up to the 3% rate on some species. MSM was toxic at 4%, and seed germination was inhibited and mortality occurred with all species at the 5% rate. Growth of the unamended control seedlings was obviously retarded from nutrient deficiency. Tissue analysis revealed higher element concentration in MSM-treated than control seedlings. Transplants of Douglas fir into MSM-amended potting medium showed similar growth response as with seedlings started from seed in the mix. Further

experiments with Douglas fir indicated that 1% MSM amendment increased seedling biomass equivalent to bi-weekly fertilizer application over 12 weeks. This resulted in savings of at least six weekly fertilizer applications to achieve the same seedling biomass. Treatments with combinations of MSM and fertilizer applications are in progress.

The enhanced growth of conifer seedlings appears to be a hormonal effect that increases the fertilizer-use efficiency of treated seedlings. This effect is concentration dependent and the causal growth-stimulating component of the MSM is under investigation.

THE EFFECT OF MEADOWFOAM (*LIMNANTHES ALBA*) SEED MEAL EXTRACT IN POTATO PRODUCTION

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Meadowfoam (*Limnanthes alba*) seed meal (MFM) remaining after oil extraction contains fibers, proteins, and chemicals such as glucosinolates that may degrade to byproducts that inhibit weeds, insects, and soil-borne pathogen growth. A series of studies conducted at Oregon State University have shown that MFM when applied as soil amendment or foliar spray enhanced plant growth.

The objective of this study was to evaluate the effect of different concentrations of MFM water extract on potatoes (*Soloanum tuberosum* L.) in vitro and in greenhouse production systems. For this purpose, two varieties, Wallowa Russet and Mazama, were used. Nodal cuttings of both varieties from in vitro culture were allowed to root in the greenhouse and were transplanted into 18-cell plastic trays. A randomized complete block design with four replications was used to study the effect of MFM water extract at 0%, 5%, 10%, and 20% (W/V). The MFM extract was sprayed once a week on the foliage.

MFM water extract at 10% (W/V) promoted plant growth and increased tuber yield by 30 to 50% depending on the variety compared with the control. Another experiment was conducted in the laboratory to determine the effect of MFM water extract at concentrations of 0, 5, 10, and 100 mg/l (W/V) added into standard Murashige and Skoog media. A completely randomized design with four replications was used. MFM water extract at 5 mg/l produced plantlets with increased plant height, total number of nodes, and fresh and dry weights. Higher concentrations of MFM inhibited root formation in nodal cuttings and promoted microtuber production; however, lower concentrations promoted multiple shoot formation.

We have demonstrated that MFM extract can be successfully used as potato growth enhancer and have determined the optimum concentrations under both in vitro and greenhouse conditions. There is also great potential for MFM water extract to be used as a growth supplement in other crops both under greenhouse and field conditions.

MEADOWFOAM GAINING MOMENTUM

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OMG Meadowfoam Oilseed Growers Cooperative &
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The developing story of a new crop called "Meadowfoam" continues to achieve new levels of profitability and success. This wildflower native to southern Oregon and northern California was successfully bred into a commercially viable rotation crop for grass seed growers by Oregon State University. The unique oil removed from the seed is a broad-based functional ingredient for cosmetics that offers long-term stability. The potential environmental applications for this natural oil and the meal byproduct currently are being evaluated in several research studies.

Introducing and successful launching a new crop such as Meadowfoam require several important and complex steps. It is a time consuming process that takes individual champions, patience, money, agronomic research, product development, money, technical research, regulatory acceptance, market studies, interested buyers, money, challenges from freeloaders, legal expenses, and a certain degree of luck. Meadowfoam has experienced all of these phases and has recovered from many of the associated pitfalls in the process. Grower profitability and confidence in the crop is

are growing. as is, consumer awareness and demand.

I will review recent Meadowfoam accomplishments by the OMG Meadowfoam Growers Cooperative and their marketing company Natural Plant Products in my presentation. Successful new crop development requires a wide range of important steps that will present very unique challenges before a profitable result is achieved.

MEADOWFOAM YIELD AT FOUR LOCATIONS ON A LATITUDINAL TRANSECT

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Meadowfoam (*Limnanthes alba* Benth.) produces a very stable seed oil that has many unique properties. Meadowfoam is native to the Mediterranean climate region along the U.S. west coast from northern California to southern British Columbia. Because it is well adapted to poorly drained soils, cool, moist springs, and warm dry summers, research and commercialization efforts have occurred almost exclusively in Oregon's Willamette Valley. Little is known about how changes in day length, climate, and other factors affect the performance of newer meadowfoam varieties, but these effects must be known if expansion in production is to occur beyond the current limited area.

The objective of this study was to compare the seed and oil yield of two newer and one older variety at four locations along a north-south transect representing the range of meadowfoam's native habitat within the U.S. west coast Mediterranean climate region.

For two consecutive years, three meadowfoam varieties (Floral, Knowles, and OMF78) were planted on university research farms near Davis, CA, Medford, OR, Corvallis, OR, and Mt. Vernon, WA. Seeding rate was constant at all sites, but each site was managed by each cooperator using their best judgment and published guidelines regarding fertilizer, planting date, irrigation, and weed control. Bees were provided during pollination. As seeds reached maturity, all above-the ground material was cut, placed in fine mesh bags, and transported to the Corvallis site, where they were dried, threshed, and cleaned under uniform conditions.

In the first season, meadowfoam did not survive the winter at Mt Vernon, although it was not the coldest or wettest site. Seed yield, oil content, and oil yield were greatest at Corvallis, followed by Medford, then Davis. The number of seeds per acre was similar at Corvallis and Medford, but individual seed size was smaller at Medford. Knowles and Floral both had greater yield than OMF78 at Corvallis and Medford, but the reverse was true at Davis.

For the second season, seed and oil yields were significantly higher at Corvallis, followed by Medford, then by both Mt. Vernon and Davis. Oil content was more uniform across sites in the second season, with Davis slightly greater than the other three sites. Seed size was greatest at Corvallis, but unlike the first year, seed size at Medford was the smallest of the four sites. Knowles had the greatest yield at all locations except Davis, where OMF78 had the greatest yield.

Along a north-south transect representing the range of meadowfoam's native habitat, the environment in the Willamette Valley seems to be optimum for production of meadowfoam seed oil. Commercial production may be possible in other regions, but it appears climate strongly affects the yield and quality of meadowfoam seed.

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Industrial Crops Session II (Value-added Industry Processing)

BIOLUBRICANTS – HIGH MARGIN COMMERCIALIZATION OF OILSEED CROPS

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Oilseed producers have consistently struggled to generate acceptable returns for their crops. Commodity price scenarios play out constantly as the market surplus continues to be squeezed by the latest industry, biodiesel. Biodiesel manufacturers operate on thin margins and only become profitable due to scale. Efforts are always focused on reducing the feed stock costs, eliminating any possibility for agriculture producers to become profitable supplying this marketplace. Recent demand by the Federal government for biobased products became the focus of this project.

The objective of our market research and product development was to identify and develop new value-added oilseed markets, which operated on and allowed higher margins, thus creating premiums on the oilseed feed stock, creating more value for the producer.

Oilseeds and current technologies were researched to identify market channels in which competitive products could be produced and at a cost point acceptable to consumers. Research was undertaken in cooperation with Dr. Duane Johnson, Montana State University, Bozeman and the Biobased Institute to determine the suitability of various oilseeds in the lubricant markets, current demand, price points, product standards/certification, and manufacturability were all evaluated as well. Data provided indicated minimal success in the baser oil categories, with tough competition from low-priced petroleum products. Further research into advanced technology led to the discovery of USDA patented estolides, which converted the plant oils into a high performance lubricant base stock, competitive with current-day synthetics and manufacturability that was in line with the competitive pricing.

Development of the estolide formulas as a motor vehicle lubricant was undertaken to initially determine operating thresholds for the various compounds and to identify the most promising cost effective formulation. Additional work was undertaken in cooperation with USDA-NCAUR to identify promising new oilseed crops such as Lesquerella and Cuphea, which offer additional beneficial lubrication properties helping extend the operating environment for the motor oil. Lesquerella offers many of the same properties as Castor and will be commercially produced this fall. The initial bench test results of the motor oil formulations have proven the suitability as a replacement to petroleum-based motor oil and estimated large scale manufacture costs appear in line, allowing us to compete head to head with current offerings.

With the advent of the new Estolide technology in tandem with new oilseed crops such as Lesquerella and Cuphea, commercially viable, superior performing motor oils and other biobased lubricants will help reduce our foreign oil dependency and open new doors for agriculture.

ADDING THE VALUE IN VALUE-ADDED AGRICULTURE

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Farmers have been under increased strain to maintain profitability. Recently, the rapid rise in oil prices has affected the increase in costs associated with agricultural production. The prices of fertilizer, fuel, and transportation have caused producers to examine additional revenue sources still derived from the same land. This can be done by producers taking a greater role in value-added processing of the crops they grow through a business venture or a cooperative. The principles of a cooperative allow the farmer with limited risk capital to partner with others with the same vision.

The objective is to describe avenues of new revenue to existing farmers by both traditional practices and new innovative means. Also discussed will be the connective corridor throughout the state that provides relevant information, educational material, and professional guidance needed due to the diversity of agricultural production, size of the state, and costs associated with new ventures.

The Montana Cooperative Development Center and the Montana Agricultural Innovation Center both have as their mission statements to participate in the formation and direction of value-added agricultural ventures throughout Montana. The Cooperative Development Center utilizes a technical assistance network of eight people to assist in the formation of cooperatives. These cooperatives are formed in rural areas as defined by USDA-RD funding. The Montana Agricultural Innovation Center utilizes five resource centers in Montana to deliver services and beginning

capital specific to value-added agriculture.
The Montana Cooperative Development Center model has continued to be funded by both Federal and State dollars. The services and Technical Assistance Network continues to expand. We have presented the Center as a model in other states. The Montana Agricultural Innovation Center started with a one year expected funding allowance, yet has continued for three years due to the Resource Centers maximizing resources and the support of industry leaders. The results have two main evaluation points. The decision of funding and professional guidance is provided based on the merits of the project as it launches. The other evaluation point is at the time the self-sustainability. The projects vary in scope and complexities as well as their success.
Value-added agriculture has matured and diversified as the costs and flat markets conditions continue to make commodity production less profitable. The use of both Centers complement each other as well as provide a stable platform with many resources for the producer. Examples of new agribusiness ventures in Montana will be given.

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Bioproducts and Bioenergy, Session I

UNIVERSITY RESEARCH AND EDUCATION PROGRAMS ON RENEWABLE ENERGY: THE SUN GRANT INITIATIVE

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Americans are becoming increasingly aware of the need for national energy security. Consequently, state and federal agencies are stepping up efforts to develop renewable energy systems that are sustainable and minimize negative environmental impacts. Many people recognize that agriculture has a role in addressing the nation's projected energy problems. Increased involvement of agriculture in production of non-food products raises many issues that will expand research and education from agronomists and environmental scientists. A joint study by the U.S. Department of Energy and USDA estimates availability of 1.3 billion tons of lignocellulosic feedstocks annually for conversion to energy. Additionally, these resources will be used to produce biobased products such as composites, lubricants, and construction materials. Public research and education have an important role to play as a massive re-design of our energy system develops. One effort in this regard has been underway since early 2001: the Sun Grant Initiative.

The Sun Grant Initiative was authorized by Congress in January 2004 to broaden the role of land grant universities by implementing new programs on renewable energy and biobased industries. The missions of the Sun Grant Initiative are to (1) enhance national energy security through development, distribution and implementation of biobased energy technologies, (2) promote diversification and environmental sustainability of America's agriculture through land-grant based research, extension, and education programs in renewable energy and biobased products, and (3) promote opportunities for biobased economic diversification in rural communities.

Regional Sun Grant centers include Oregon State University, South Dakota State University, Oklahoma State University, the University of Tennessee, and Cornell University. The regions will emphasize integrated research and educational programs on ag-based renewable energy and biobased industries.
The Sun Grant Initiative has developed recently to a program with support and engagement with three federal agencies. Funding through USDA-CSREES has been the foundation for establishing awareness during the initial years. Support from the U.S. Department of Energy - EERE has resulted in research on feedstock production, conversion technologies, educational programs, and gathering information to support policy development. Lately, funding through the U.S. Department of Transportation will launch Sun Grant research and education programs in each region.

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Industrial Crops Session III (Oilseeds)

VEGETABLE OIL DERIVATIVES AS MONOMERS FOR EMULSION POLYMERIZATION

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Waterborne coatings employ coalescing solvents to facilitate polymer particles with high glass transition temperatures to coalesce effectively and form smooth non-tacky films. However, these solvents evaporate during the drying process and constitute volatile organic compounds (VOCs). The use of vegetable oil macromonomers (VOMMs) as co-monomers in emulsion polymerization enables good film formation without the use of coalescing solvents. Moreover, VOMMs are derived from renewable resources and offer the potential of post-application crosslinking via auto-oxidation.

To maximize the utility of renewable resources, it is imperative that VOMM incorporation into emulsions be at the highest levels possible. The inherent hydrophobicity of VOMMs poses challenges during emulsion polymerization, as the monomers do not migrate readily through the aqueous phase.

In this study, the copolymerization of hydrophilicized soybean oil-based VOMMs with conventional monomers and the properties of the resulting latexes are discussed. Latexes with VOMM content as high as 80% were successfully synthesized. Interestingly, the VOMM latexes displayed low minimum filming temperatures that were independent of the glass transition temperatures (T_g). Thus, high T_g latexes formed smooth, glossy films at ambient temperatures without aid from coalescing solvents. Data from latexes formulated into coatings, and tested for properties as per ASTM standards are discussed. While latexes with the highest VOMM levels exhibited certain performance limitations, other VOMM-based latexes performed competitively against commercial latexes.

ENGINEERING OILSEEDS FOR INDUSTRY

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World oilseed production for 2005/2006 exceeded 390 Million metric tons (MMT), yielding over 115 MMT of oil. The majority of this product was destined for use as edible oil and for food processing applications with only a small percentage entering the industrial market. The major non-food uses are currently for the production of soaps and detergents and conversion to biofuels.

Almost all plant oils are triacylglycerol (TAG) oils. Their chemical structure gives them great potential as petrochemical replacements in a wide variety of applications ranging from fuel and lubricants to the manufacture of polymers, foams, and surface coatings. Vegetable oil, therefore, represents a very much underutilized renewable resource for industry. A number of factors, however, may place constraints on the large-scale acceptance of plant oils as industrial feedstocks. These include the limited repertoire of fatty acids synthesized by the major oilseed crop species, and the presence of a mixture of different fatty acids in a typical seed oil.

Various approaches are currently being taken to improve the suitability of seed oil for industrial use. These include traditional plant breeding, accelerated by advances in genomics and high throughput analysis, and the genetic engineering of oilseeds to introduce novel traits. The challenges and opportunities in tailoring seed oil composition for particular purposes, and the development of new-engineered oilseed crops designed for industrial oil production will be discussed. Examples will include the manipulation of *Brassica* species to increase erucic acid content, and the production of unusual hydroxy fatty acids in oilseed crops.

THE ENZYMOLOGY OF CASTOR OIL BIOSYNTHESIS

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Castor oil is an important industrial oil used to produce greases, lubricants, coatings, detergents, monomers for plastic production, plasticizers, and cosmetics. It is derived from the castor plant, a Euphorb *Ricinus communis* L. The oil is unusual in that the fatty acid component is 90% ricinoleic acid, 12-hydroxy oleic acid. Because the castor seed also contains a protein toxin and a potent allergenic protein, there has been considerable interest in developing an alternate source of high ricinoleate oil. However, in attempts to generate transgenic plants producing ricinoleate, researchers have found that the amount of ricinoleate produced is limited, even though the introduced hydroxylase gene is expressed at a high level. We have postulated that the castor seed has enzymes that direct the production and incorporation of ricinoleate into triacylglycerols.

In an in vitro microsomal system, we have shown that ricinoleate is incorporated six-fold greater extent than oleate in the final step of oil biosynthesis, the acylation of diacylglycerol to triacylglycerol. There are several enzymes that can carry out this final acylation step. These are the acylCoA-dependent diacylglycerol acyltransferases (DGAT), types 1 and 2, and the phospholipid-diacylglycerol acyltransferase (PDAT). We have cloned genes for the two DGATs from developing castor seed and expressed them in yeast. In microsomes prepared from suitably transformed yeast, the DGAT type 1 shows a preference for acylating diacylglycerols containing ricinoleate. The DGAT type 2 shows very poor activity in the yeast expression system, similar to the finding of low activity for the *Arabidopsis thaliana* DGAT type 2 expressed in yeast. We have also cloned two genes from castor seed encoding acylCoA synthetases (ACS). One of these genes encodes an enzyme that shows preference for using oleate and other "hydrocarbon" fatty acids to acylate free CoASH, whereas the other ACS shows a threefold preference for using ricinoleate to acylate free CoASH. Taken together, the substrate preference of the DGAT type 1 and the ACS account for the sixfold preference we have observed for isolated castor microsomes incorporating ricinoleate into the triacylglycerol fraction.

BARRIERS TO COMMERCIALIZATION OF A CULTIVAR OF CASTOR (*RICINUS COMMUNIS* L.) WITH REDUCED CONCENTRATION OF RICIN

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Ricin is a protein toxin found only in mature castor (*Ricinus communis* L.) seed that enzymatically destroys the ribosomes of Eukaryotes. The presents of ricin in the high protein meal of castor has historically reduced its value as an animal feed. Because ricin has the potential to be used as a chemical warfare and bioterrorism agent, the production and processing of castor has undergone increased scrutiny by law enforcement and homeland security agents since the terrorist attacks of September 11, 2001. The production of castor cultivars with reduced levels of ricin would improve the economics of castor oil production, reduce the potential for accidental poisoning, and eliminate the potential of ricin being used by terrorist.

Since 1994, Texas Tech University has been developing castor with reduced levels of ricin. The dwarf-internode cultivar, ‘Hale’ developed by Texas A&M University in 1970 was crossed with two Plant Introductions from the Soviet Union PI 258368 and PI 257654 that had been previously selected for reduced levels of ricin. In subsequent segregating generations, individual plants were selected for dwarf-internode growth habit and reduced levels of ricin and RCA120 using a radial immunodiffusion assay. In 2003, 12 F_8 lines were intercrossed to develop a synthetic population, and in 2004 and 2005, this population was screened for semi-dwarf-internode growth habit and lack of shattering. This experimental cultivar is currently being tested in Mississippi and Texas to compare it with the parental cultivar ‘Hale’. Despite the growing demand for castor oil for both historical markets and as a feedstock for biodiesel, domestic production of this new cultivar has been delayed by the lack of oilseed processors willing to address the potential concerns of state and federal agencies with responsibilities to Homeland Security.

COSMETIC ATTRIBUTES OF CUPHEA OIL

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Trends in the cosmetic industry continue to lean heavily toward natural and naturally derived ingredients. Cuphea, grown in Minnesota and North Dakota, serves as the source of an oil with essentially no history of industrial use. The oil is rich in capric acid (65-75%) with smaller amounts of other short chain fatty acids. The oil also contains about 10% C18 unsaturated fatty acids.

Floratech is developing this unique-botanically derived oil for use as a commercial raw material for the cosmetic industry. Mechanical and physical property tests reveal that the oil has similar properties to some commonly used raw materials such as mineral oil and caprylic/capric triglyceride. We have evaluated the response of this oil to oxidation along with the effect of other cosmetic compounds (e.g., sunscreens) as it specifically relates to oxidative stability.

Cuphea oil has a medium to low spreading characteristic while having a low slip. These attributes are exactly what are needed for sunscreens that stay in place, providing requisite UV protection, yet providing desirable esthetic attributes of non-slippery or greasy upon application. Many low cost sunscreens already use mineral oil, and cuphea oil could be a suitable commercial substitute for this raw material. By coupling this information along with the fact that the oxidative stability of cuphea oil remains high in the presence of sunscreen actives, a strong fit for this ingredient in the highly visible cosmetic category is possible.

Studies are currently underway to evaluate cuphea oil derivatives and their potential role in other cosmetic categories (e.g., bath oil, lipsticks, and lotions/creams).

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Horticultural/Agronomic Crops Session II (Fruits, Nuts, & Vegetables)

NEW FRUIT CROPS WITH HIGH WATER USE EFFICIENCY

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With the aim to obtain new fruit crops that require minimum water, we started in 1984 to domesticate some species of cactus known in Latin America as pitayas. Four of these pitayas species are grown in Israel today as fruit crops, and the question that we currently ask ourselves is whether they really meet the expectation of having a water use efficiency (WUE) that is much higher than that of other fruit crops. We give the results of the only irrigation experiment of which we are aware that was conducted with the following vine cacti: *Hylocereus undatus* and *H. polyrhizus* known as red pitayas, and *Selenicereus megalanthus* known as yellow pitaya. For the fourth species, *Cereus peruvianus*, we give actual data on irrigation and yields based on the experience of farmers.

The aim of the project was to test the effect of three water regimes [including water shortage treatment(s)] on growth, fruit yield and quality of the three new vine cacti crops, the yellow pitaya and the two red pitayas. The experiments were conducted in the Negev desert of Israel (annual precipitation of 200 mm/year; winter only). Plants were grown under shade nets (40% for red pitaya and 60% for yellow pitaya) and irrigated with ~160 mm irrigation/year (treatment A - control), ~80 mm irrigation/year (treatment B), or ~45 mm irrigation/year (treatment C), keeping soil moisture above -2.2 MPa. In pot experiments, water was withheld for three weeks while stem elongation continued until soil water potential decreased to -3.5 MPa (about 7% volumetric soil moisture), demonstrating the capacity of these plants to absorb water from very dry soils. Yields of shoots and fruit, and fruit quality were assessed for three consecutive years.

Only treatment C showed significant reduction of yield and fruit size in the *Hylocereus* species, whereas in *S. megalanthus* the yield and fruit size were highest in treatment C. Absolute values of yield and fruit size for the yellow

pitaya are much lower than the red pitaya and are not related to the irrigation treatments. Root exposures showed a very shallow root system up to 40 cm deep. Yields of red pitaya fruit fluctuated between 35 to 40 ton/hectare/year for which 1600 tons of water were used, i.e., for the production of 1 ton of fruits, 40 to 45 tons of water are required. For citrus, avocado, and mango grown in the same area 340 to 500 tons of water are required for the production of 1 ton of fruit. In practice, WUE for a *C. peruvianus* orchard (grown outdoors) is about 60 tons of water for production of 1 ton of fruit.

In terms of horticultural production, fruit price per ton is also important. Taking into account that if accepted in the market, these new crops will acquire much higher prices than the common crops, hence their WUE is even higher in terms of income and profitability. We should realize, however, that the introduction of a new crop into the market remains a major problem.

UNCOMMON FRUITS WITH MARKET POTENTIAL

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The major fruit crops of temperate regions experiencing cold winters include the pome fruits and stone fruits as well as brambles, blueberries, strawberries, and grapes. The goal of the present research has been to identify a number of "uncommon fruits" that might expand this palate. Medlar (*Mespilus germanica*), cornelian cherry (*Cornus mas*), and alpine strawberry (*Fragaria vesca*) were once popular fruits that possess a number of qualities warranting their revival. Where climate is congenial and pest pressures low, juneberry (*Amerlanchier spp.*) and lingonberry (*Vaccinium vitis-idaea*) are worthy of commercial trials. Identification and development of suitable cultivars could bring American persimmon (*Diospyros virginiana*, perhaps as hybrids with Asian persimmons), gumi (*Elaeagnus multiflora*), maypop (*Passiflora incarnata*), and Nanking cherry (*Prunus tomentosa*) into the marketplace. *Ribes spp.* are popular in Europe and a century ago once increasing in popularity in the U.S.; new cultivars and increasing consumer awareness of the flavor and health properties of these fruits could make plantings again viable. And finally, pawpaw (*Asimina triloba*), hardy kiwifruit (*Actinidia arguta*, *A. kolomikta*), and shipova (X *Sorbopyrus auricularis*) are among those "uncommon fruits" adapted over wide regions and worthy of more extensive trial plantings today.

The market potential of these uncommon fruits derives from their high flavor, their uniqueness, and their relative freedom from pest problems. With these qualities, such fruits would fit well into the rapidly expanding "organic" marketplace as well as upscale and ethnic markets. Uncommon fruits that handle poorly, such as pawpaw, alpine strawberry, and American persimmon, are well suited to those regions having potentially strong local markets either because of tourist influx or because of proximity to large metropolitan areas. Because of their relative freedom from pest pressures, all the "uncommon" fruits mentioned would be ideal for regions where increased suburbanization creates local markets, but also causes conflicts because of pesticide spraying.

There is no perfect agricultural crop and research goals have been to highlight the strengths and the weaknesses, as well as research needs for each of the uncommon fruits with market potential.

PRODUCTION AND MARKETING OF HUITLACOCHE (*USTILAGO MAYDIS*)

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Ustilago maydis the causal organism of common corn smut can cause economic losses wherever maize (*Zea mays* L.) is grown. However, the galls formed by *U. maydis* are edible and can be a more profitable crop than the corn itself. Huitlacoche (cuitlacoche), the Hispanicized version of the Nahuatl name for the edible galls, has been consumed by the people of Mexico since pre-contact times. The popularity of huitlacoche is increasing rapidly in the U.S., due both to the increasing size of the Mexican-American community and interest in new foods and fusion cooking, especially in

high-end restaurants. The objective of this study was to determine the feasibility of adding huitlacoche to the product line of Troy Community Farm, an urban, non-profit CSA (community supported agriculture) farm.

Sporidial suspensions were injected down the silk channel of unpollinated ears of maize. Ears were harvested 14 to 20 days after inoculation. Huitlacoche was marketed fresh on the ear still enclosed in the husks or as frozen galls that had been cut from the cob. We looked at the consumer acceptance of the different products, the consumer price, and whether huitlacoche production fit the farmer's management system and business objectives.

The Pataky and Chandler inoculation method was highly effective and gave good yields of galls. For the average farmer, there is a limitation in obtaining and culturing the inoculum. It is not a difficult process, but it is not part of most farmers' standard techniques. When harvested at peak quality, as defined by flavor, the galls are highly perishable and delicate. At this stage, the galls are gray with a black interior and they split easily. The galls need to be consumed within a few days of harvest. Earlier harvest, when the galls are smaller with a grey interior, results in galls that can be removed from the ear either by plucking or cutting and freezing these galls. Freezing results in some loss of quality, but can be more attractive to chefs who have to plan menus in advance and require a dependable and consistent product. Pataky and Chandler estimated that based on an estimated price of $25 Kg-1, the value of huitlacoche harvested 15 to 17 d after inoculation ranged from $0.70 to $1.68 ear-1.

While there was a receptive market for huitlacoche in the Madison area, huitlacoche did not fit the system of the Troy Gardens Farmer. This was primarily due to questions on availability of resources for inoculation and the highly perishable nature of the product. Farmers in the U.S. can successfully produce and market huitlacoche to meet the increasing demand; however, the technical and marketing requirements may make huitlacoche a better crop for a farm devoted to highly specialized crops.

A POTENTIAL FOR NEW MELON MARKET TYPES

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Melon (*Cucumis melo* L.) is a complex group of horticultural types long intertwined with mankind for a variety of purposes. Different types are known around the world and often engendering faithful supporters for their local melon as the best. Africa is the center of origin, but centers of diversity may be found throughout Asia and the Iberian Peninsula. Germplasm from the centers of diversity, particularly India, have been found to possess numerous genes for resistance to disease and insect pests of melon.

Melons are known only as a fresh or lightly processed sweet salad or dessert fruit in many countries, but may be canned as fruit pieces or pressed juice, used for syrup, jam, or flavoring in baked goods. Dehydrated slices can be stored for short or moderate periods and reconstituted. Sour-sweet types are popular in the Middle East. Vegetable types dominate in regions of some countries, e.g., Rajasthan, India, but may be found in other countries such as Italy. Aromatic types, e.g., 'Queen Anne's Pocket Melon' was once popular in the U.S. The ornamental types may be found in other regions of the world. The seeds are useful for their oil and protein, and may be lightly roasted and eaten as nuts.

Formalized classification of the many melon types has been revised nine times since Naudin's scheme in 1859. The two most recent revisions reflect the two approaches; one proposed six cultivar-groups, the other, which included examination of melons from central Asia, proposed 16 varieties in two subspecies.

Molecular and phenotypic analyses of melon diversity indicate that remarkable genetic differences exist among geographic growing regions and cultivar-groups. Distinct differences exist between African melons and those from Spain, Central Europe, Mediterranean, U.S., and Asia, which are themselves dissimilar. These growing regions produce a delightful array of types differing in morphological characters. Numerous primary and secondary fruit skin colors and designs, shapes, interior textures and colors, flesh thickness, and sizes delight the eye, and form the genetic basis for the development of new market types. For instance, fruit flesh thickness ranges from nearly nothing to five or more centimeters, and occur with completely filled or large and empty seed cavities. Interior color can be uniformly orange, green, or white, or grading from one color to another. Moreover, the aroma ranges from nearly undetectable to highly aromatic and could be used to breed novel cultivars. The flesh can be bitter, tasteless, or highly sweet with a range of flavors from subtle to very pronounced.

There are opportunities for new market types in each of the many existing markets both from introduction of existing horticultural groups and through breeding of novel types. Existing markets, however, largely dictate the types of disease and pest resistant melons that breeders develop and seed companies produce for growers. Thus, the development of new melon market types will require integration of plant breeding and marketing to create market environments where consumers are attracted to novel products.

DOMESTICATION OF NEW VEGETABLES

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Domestication in all crops continues, but in vegetables at a different, sometimes slower, sometimes faster rate. Many plants that were domesticated as vegetables in ancient times have been lost or replaced by vegetables that have been introduced. Some vegetables are evolving very slowly, likely due to constraints imposed by the narrow expectations and market demands of growers, processors, marketers, and consumers.

Variation among cultivars is further constrained because many vegetables are introduced. Rather than developing variation among cultivars with adaptation to different growing environments, the trend has been to use cultural practices and choose locations to adapt the environment to the vegetable. Other vegetables are evolving more rapidly as other consumers are demanding and rewarding novelty in colors, shapes, sizes, and even flavors of traditional vegetables.

The development of new vegetables is also occurring through selection and utilization of new tissues, e.g., garlic scapes rather than garlic bulbs. The vegetables that are considered new or novel are being developed through selection within the same families as traditional vegetables.

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Horticultural/Agronomic Crops Session III (Botanicals and Medicinals)

ECONOMIC DEVELOPMENT OF ETHNIC CROPS FOR THE EAST COAST

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The general objective of this USDA-NRI study is to document the available opportunities for east coast farmers to grow ethnic crops from a market demand perspective. Economic opportunities have arisen in the last decade for specialty crop agriculture catering to the ethnically diverse consumers along the eastern coast of the United States. U.S. Census data for 2000 show significant increase in these ethnic populations ranging from 3% to 8%. The first generation ethnic composition of representative states like New Jersey, New York, Massachusetts, and Florida are 18%, 21%, 11%, and 17%, respectively. Individual state population percentages range from 20% to over 30% when including the second generation of ethnic citizens. Detailed community maps pinpointing concentrations of recent ethnic citizens showed that 75% of the consumers resides within a 10-mile radius from an ethnic grocery store.

A survey based on random sampling was prepared for four major selected ethnic groups namely, Chinese, Indian, Mexican, and Puerto Rican. Two hundred and seventy-one persons were interviewed from each selected ethnicity totaling 1,084 samples. Bilingual surveys of these ethnic consumers developed food crop preference and ranking from

a potential list of over 100 fruits and vegetables. Crop production experts from Florida to Massachusetts further refined this list from a production and climatic zone perspective. Chinese selections were edamame, pak choy, oriental spinach, snow peas, oriental eggplant, edible luffa, baby pak choy, napa cabbage, perilla, oriental mustard, holy basil, and malabar spinach. Asian-Indian selections were eggplant, amaranth, bottle gourd, cluster beans, fenugreek leaves, mint leaves, mustard leaves, ridge gourd, white pumpkin, and bitter gourd. Mexican selections were Anaheim pepper, calabaza, calabacita, tutuma, chili jalepeno, chili poblano, chili serrano, chili habanero, cilantro, and tomatillo. Puerto Rican selections were aji duice, fava beans, batata, calabaza, calabacita, chile caribe, cilantro, berenjena, pepinillo, and verdolaga. These specific lists of vegetable preferences and community maps were compiled to connect growers to these emerging marketplaces and to direct crop demonstration plots for university partners along the east coast of the United States.

The intended outcome of our USDA-NRI World Crops project is to generate and distribute science-based information about production, marketability, and utilization of selected ethnic crops and herbs. This initiative bridges the supply-demand gap, delivering practical solutions to economic problems faced by many vegetable growers while contributing to the nutritional and health needs of regional consumers.

DIRECT MARKETING OF U.S. GROWN CHINESE MEDICINAL BOTANICALS: FEASIBILITY AND MARKETING STRATEGIES

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In the 1990s, a boom followed by a decline due to market saturation in the herbal products industry resulted in losses to some U.S. farmers. To find more effective and profitable ways to market their herbs, grower associations in five different states formed a Medicinal Herb Consortium (MHC) to share information and develop strategies. In 2004-05, the MHC conducted a feasibility study and planning project for marketing domestically grown Chinese medicinal botanicals (CMB) directly to licensed practitioners of Acupuncture and Oriental Medicine (AOM) in the U.S. Project objectives were to combine existing and new market studies to assess the feasibility of direct marketing, to work with AOM practitioner groups to identify opinion leaders and develop direct marketing relationships, and to determine if herbs grown in different regions could provide an acceptable product mix for the AOM market.

To gather information and attract AOM practitioners, interviews and informal surveys were conducted, events were staged to show samples, articles were published in professional and trade journals, and presentations were made at practitioner conferences. The results can be summarized as follows:

1. A. A clearly defined market segment served by established educational institutions, product sources, and distribution channels could be identified. Practitioners graduated from accredited AOM colleges, which train herbal practitioners using whole plant parts imported from China, were able to differentiate sensory characteristics of imported and domestic herbs. Presented samples received the most favorable response of all project activities and indicated that direct marketing of fresh and fresh-dried herbs as a new product category was possible and could justify higher prices.
2. B. A well organized AOM profession exists as a cost-effective market. While imports can be expected to dominate the market as practitioners become familiar with the quality of domestic fresh herbs, increases in market share for domestic CMB depend on long term relationships established among farmers and AOM practitioners, including students and representatives of AOM organizations and educational institutions.
3. C. A conclusive preference for domestic herbs grown in different regions proved to be beyond the scope of this project. Regional variations were, however, an asset that could be used advantageously to stimulate comparisons of herb quality, attract practitioners, and encourage support of local production.

Future marketing by the MHC will feature a "pull" strategy designed to use educational activities to build demand for domestically grown CMB within the AOM profession. Evaluation of products by colleges, clinics, and individual practitioners will be supported by the sale of sample packs containing a collection of several herbs in small quantities.

THE NUTRITIONAL AND ECONOMIC IMPORTANCE OF THE KALAHARI DESERT TRUFFLE (Kalaharituber myces)

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The Basarwa (Bushmen) of Botswana collect and consume the Kalahari Desert truffle (*Kalaharituber myces*) annually at the end of the rainy season. As with other mushrooms, the truffles (fruiting bodies) are nutritious with relatively high amounts of proteins, fats, carbohydrates, minerals, crude fibre, and vitamins. The collected truffles are generally sold without consideration of the size (diameter), but weight is the preferred method of measurement of the crop.

This study was carried out to determine the sizes of the truffles that exist in the Kalahari, and also to establish the relationship between the size and nutritional content. Thus, the optimum truffle size could be established and pricing would eventually reflect the size of the crop. This would be particularly important where the crop is collected for export.

About one ton of truffles was collected from a geo-referenced site in the Kalahari Desert. These were sorted and replicated according to size and batches. Other parameters that were recorded include fresh and dry weight and the nutritional content of the truffles of the various group sizes.

There were five grades or sizes of truffles with the heaviest truffle weighing about 0.5 kg and the lightest weighing only 25 g. The macronutrient (Na, K, P, and N) concentration was not significantly different among the five different sizes or weight of the truffles. The micronutrients (Cu, Zn, and Mn) were also not significantly different in the five different groups of sizes, but iron (Fe) was significantly higher for the smaller-sized truffles up to the second small-sized ones.

On the whole, there appears to be very little differences in nutritional content parameters that were measured between the small- and the large-sized truffles. Therefore, it may not be necessary to export the large sized truffles because there is no real extra benefit that may be gained nutritionally.

The size of the truffles would presumably also have a bearing on the costs of packaging and shipping of the produce to far destinations.

CHARACTERISATION AND EVALUATION OF TWO POPULATIONS OF *GEUM QUELLYON* SWEE

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About 44.6% of the Chilean plant species are endemics, and therefore, they constitute a unique and exclusive genetic heritage in the world. Most of these are main components of indigenous herbolarium and their uses in popular medicine are presently recognized, and therefore, are in constant demand. One of these is *Geum quellyon* Swee used by Mapuche Amerindians herbolarium due to the supposed properties, among them, principally, as an aphrodisiac. Others confer the plant with antioxidant properties *in vitro*, although it still remains unknown in its *in vivo* potentiality. In Chile, information is unavailable about the behavior of *G. quellyon.* Thus, the anthropologic intervention and indiscriminate cultivation of endemic and native species represent a constant threat to its diversity and ecological

balance.

The objective of this work was to study seed germination, phenology, and chemical and molecular characterization in two populations from different altitudinal distribution (1200 and 200 m above sea level). The assays and evaluations were performed in two *G. quellyon* populations collected at the 8th Region, Chile, growing in greatly different hydric environments. Significant differences were observed in the maximum germination of seeds from both *G. quellyon* populations and could be an adaptive consequence of accessions. Optimum germination temperature was 23.3°C, and minimum and maximum temperature were 6.5 and 38.5°C, respectively. In relation to the phenology under crop condition and chemical characterization, both populations differ in phenological behavior. They also showed differences in total polyphenol concentration, expressed as Gallic Acid Equivalents. Both *G. quellyon* populations have 2n = 42 chromosomes, with size < 3 μm so that the populations from the 8th Region do not present difference in ploidy level. The DNA isolation and its amplification were performed. Fragments of approximately 400 bp were analyzed for genetic diversity.

There are differences in germination as in phenological behavior in *G. quellyon* growing at 1200 and 200 m asl. Moreover, there is evidence of accumulation of different concentrations in total polyphenol patterns, which justify evaluating responses to stress.

RETAILERS/WHOLESALERS OF AFRICAN NATURAL PRODUCTS: GHANA VERSUS RWANDA

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For most of the African countries, agriculture still remains the mainstay of the economies supplying both food and incomes via marketable surpluses. The continent's rich botanical heritage offers an excellent opportunity to diversify away from traditional exports. The natural products have a great appeal to consumers especially in Western and Asian countries. Thus, development of natural products as alternative or complementary to the current mix of tradable products could positively affect the economic lives of many people, especially those in the rural areas.

This paper has the objective of highlighting the marketing impediments facing the natural products market in the retail and wholesale portions of the value chain in Ghana and Rwanda. Specifically, this presentation will (i) profile the technical, financial, organizational, etc., constraints the traders face (domestically and externally); (ii) profile the natural products range and their functions; and (iii) suggest policy interventions using the West African country of Ghana with the East African country of Rwanda as case examples.

Rutgers University in concert with collaborating partners in five sub-Saharan African countries (Ghana, Rwanda, Senegal, South Africa, and Zambia) under a USAID-sponsored project, Partnership for Food Industry Development in Natural Products (PFID/NP) project prepared separate survey instruments (farmers and traders) to elicit information on production and marketing. The survey instruments were pre-tested for country specific production and marketing conditions, which in this study the focus is on traders. Data collected covered the market chain portions of production; wholesale and retail with additional information obtained on export trade as well. In addition, the survey collected information on traders' socio-economic data. A sample of 50 traders was selected from Ghana and Rwanda. The cities were selected as the sampling frame based on their cosmopolitan nature, and the fact that they account for the bulk of natural plant products trade such as exports, wholesaling, distribution, and retailing in the country. Trained personnel personally administered the interviews from the collaborators at the country office. The respondents were assured of confidentiality by letting them know that the respondents were to be identified by a survey number as an input to the summary results.

The preliminary results indicate that the majority of the natural product traders in both countries are retailers in business for less than four years, do not produce natural products on their farm, do not export any natural products out

of the country, and have not received any trade or finance or technical training in the natural products industry. The top five natural products traded in Ghana are *Khaya senegalensis, Alstonia boonei, Paullinia pinnata, Enantia polycarpa*, and *Kokrodoso*. The top five natural products traded in Rwanda are Akabanga (pepper), Simbambili (chili product), Moringa oil, Samona jelly, and Super pilipili (chili). When it comes to a variety of support received by the traders, only 12% received technical advice in Ghana compared with 64% in Rwanda; only 2% received processing and marketing support in Ghana compared with 55% in Rwanda; and 14% received information training in Ghana compared with 55% in Rwanda. Overall, 14% of the respondents received some sort of support in Ghana compared with 24% in Rwanda. The growth in the natural products sectors in both countries is increasing. Specific marketing and technical interventions plus public policy interventions can assist in accelerating this growth and ensure that benefits of increased trade reach rural farmers and communities.

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Industrial Crops Session IV (Oilseeds)

CAMELINA SATIVA, VALUE-ADDED FOOD AND FEED APPLICATIONS

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Camelina (*Camelina sativa*) is a plant containing valuable oil, fiber, and high quality protein with many potential uses in both nutritional and industrial applications. This crop can be economically produced throughout Montana providing a much-needed high-value crop with relatively low input costs for Montana producers. The oil can be used to produce biodiesel. The low input costs of camelina enable production of economic oil for biodiesel manufacture without sacrificing profitable farmgate. However, camelina oil is also a rich source of both omega-3-fatty acids (α-linolenic acid (~40%)) and the antioxidant gamma tocopherols. The oil can be used to produce high value foods and cosmetics. The meal can be fed to livestock for production of high omega-3 meats, eggs, and dairy products.

The objective of our camelina research was to evaluate the oil and meal as food and feed ingredients. Cold-extracted camelina meal has a residual oil content of 10 to 13% and contains >40% protein. This meal has been evaluated as a feed ingredient for the production of egg, goat milk, beef, turkey, dog, and fish. Beef, poultry, dog, and goat show normal weight. Feed rejection has not been observed. The fatty acid profiles of beef, egg, and goat milk were analyzed using GC-MS. In all cases, the camelina meal shows promise as being a high protein diet ingredient competitive with soy protein. Camelina- fed beef and milk from camelina-fed dairy goats contain increased levels of omega-3 fatty acid. The omega-3 content of egg is also increased in chicken fed camelina diets.

Future research is focused on optimizing camelina-feeds for maximizing omega-3 content in meat, eggs, and dairy. Initial trout feeding trials showed promise. However, in larger trials, fish rejected feeds that contained camelina meal, but did not reject feeds containing camelina oil. Camelina oil is being tested as cooking oil in baked products (bread), salad dressings, and spreads (peanut butter). The potential market for camelina-based food ingredients appears strong given the current interest in omega-3 foods.

CUPHEA SEED YIELD AND OIL CONTENT RESPONSE TO NITROGEN FERTILIZER

1 1 2 2

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Cuphea (*Cuphea viscosissima* Jacq. *x C. lanceolata* W.T. Aiton, PSR23) is a new oilseed crop being developed in North Dakota and Minnesota that has oil rich in medium chain fatty acids. Progress has been made on improving cuphea agronomically, but little is known about nitrogen fertility requirements for cuphea production.

The objective of this study was to determine the optimum nitrogen application rate for maximizing seed yield and oil content. The experiment was conducted at Casselton and Carrington, ND, and Glyndon and Morris, MN in 2005. The experimental design was a randomized complete block with four replicates. Treatments (soil + fertilizer N) were 0, 60, 80,100,150, and 200 kg N ha-1 at Casselton and Glyndon; 0, 50, 90, 150, 200, and 250 kg N ha-1 at Carrington; and 0, 40, 80, and 120 kg N ha-1 at Morris.

Measurements included plant nitrate content at three plant developmental stages [sampling date (1) 7/13 - 7/27, (2) 8/4 - 8/10, and (3) 8/31 - 9/12], seed and biomass yield, 1000-seed weight, oil content, and total plant and seed nitrogen content.

Plant nitrate content decreased from the first to the last sampling dates at all locations. Plant nitrate content at all sampling dates was significantly higher for the treatments with greater than 90 kg N ha-1 at Carrington. Plant nitrate content at Morris at the last two sampling dates was higher for nitrogen treatments of 80 and 120 kg N ha-1.

Seed yield was influenced by nitrogen treatments only at the Glyndon location where the highest yield (270 kg ha-1) was obtained with 100 kg N ha-1. Seed yield varied among locations with the highest yields at Morris ranging from 503 to 583 kg ha-1.

Biomass yield, 1000-seed weight, oil content, and plant total nitrogen content were not affected by the nitrogen treatments at any location.

Seed nitrogen content was affected by nitrogen treatments only at the Casselton location where higher seed nitrogen content (2.74 to 2.89%) was determined for nitrogen treatments from 80 to 200 kg N ha-1, compared with the check treatment that produced the lowest seed nitrogen content (2.65%). Cuphea total nitrogen absorption fluctuated between 69 and 83 kg N ha-1 at Carrington, 129 and 171 kg N ha-1 at Casselton, and 83 to 147 kg N ha-1 at Glyndon.

Accordingly, N fertility appears to have little influence on seed yield, and aboveground biomass, values of which were quite low for the former two variables, and relatively high for the latter. Consequently, the possibility arises that another soil nutrient may be limiting cuphea's ability to convert aboveground biomass to seed yield.

PHENOLOGY OF OILSEED CROPS FOR BIODIESEL IN THE HIGH PLAINS

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Oilseed crops are used mostly as a food staple and for industrial oils. With increased emphasis and demand for diesel substitution, acreage of brown mustard (*Brassica juncea*), canola (*B. napus*), and camelina (*Camelina sativa*) as biodiesel is anticipated to increase in the High Plains. The objective of this study is to elucidate the phenology of these crops in the western Nebraska and their adaptation to spring planting dates with the intention of developing a growth model for growers.

A field trial was conducted in 2005 on these crops to study their phenology after planting on 25 Feb, 22 Mar, 8 Apr, 26 Apr, and 6 May. Each was grown in replicated, randomized plots measuring 4.6 m long by four rows spaced 0.3 m apart. Phenology measurements of developmental stages were taken periodically. For brown mustard, canola, and camelina, the first date in late February had the longest emergence interval, and except for canola, the lowest stand. Canopy height was not affected. Flowering for these crops occurred earlier with the earliest date and occurred later as the planting date was delayed. However, the maturity date was the same regardless of planting except for camelina, which matured earlier with earlier planting. Bird damage occurred in brown mustard and was greatest with the earliest planting and least with the last planting. Yield was lowest with the first planting date. For brown mustard and canola,

yield was highest in the later planting dates, but for camelina yield was highest with the late March and earlier April dates that averaged over all three crops gave the best yields.

On 6 May, additional plots were seeded to obtain growth data from sampled plants. Four to six plants were removed after 4, 6, 9, and 12 weeks after planting (WAP), and their length as well as the weights of plant parts were taken. For all crops, canopy height and width peaked 8 WAP and 9 WAP, respectively. Stem length continued increasing to 12 WAP, just before harvest, reaching lengths of 169, 185, and 115 cm for brown mustard, canola and camelina, respectively. From 4 to 9 WAP, fresh weight accumulated 1.9, 4.5, and 0.8 g/wk for brown mustard, canola, and camelina, respectively. At 9 WAP, fresh and dry weights were shifting from vegetative to reproductive structures, and between 9 and 12 WAP, pods were increasing in dry matter, whereas stem dry matter was decreasing.

These trials were repeated in 2006 and the accumulated data will be used to develop a model to predict growth and development patterns of brown mustard, canola, and camelina for biofuel production in the High Plains. Related date-of-planting studies are being conducted in other states in this region.

SCALE-UP OF SICKLEPOD (*SENNA OBTUSIFOLIA* L) PROCESSING

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Sicklepod (*Senna obtusifolia* L) is an invasive weed species especially of soybean and other field crops in the southeastern United States. The seed contains a small amount (5-7%) of a highly colored fat as well as anthraquinones, proteins, and galactomannan polysaccharides. The character of sicklepod seed oil is such that a small amount of the weed seed present in a soybean crush lowers the quality of the soybean oil. Although cultivation of "Round-up-ready soybeans" mitigates infestation of the crop by sicklepod, the latter is so prolific that even volunteer stands yield >1000 lb of seed per acre. The right thing to do under this circumstance is to tap the potential of this weed as an alternative crop in the affected region.

In earlier laboratory-scale work, we have shown the feasibility of separating the different components of sicklepod seed. At the kilogram-level and higher processing quantities, however, exigencies have arisen leading to modification of the approach in order to separate effectively components of the defatted seed meal. In one version for cleanly separating the proteins, the dried petroleum ether defatted meal was extracted with 0.5 M NaCl solution to remove albumins and globulins; then with 80% ethanol, prolamins were extracted from the pellet from the salt extraction. Glutelins were removed from the residual solids with 0.1 N alkali leaving the polysaccharides. In a simpler (pilot-scale) version for the polysaccharides, several kilograms of the dried defatted meal were stirred into deionized (DI) water for 30 to 40 min, and then pumped into the centrifuge. The resulting centrifugate (supernatant) was removed and stored. The residual cake was resuspended in an equal volume of DI water as described and centrifuged again. The pooled supernatants were heated to 92°C (15-20 min), filtered, cooled to room temperature, and passed through a column of Amberlyte to obtain the polysaccharides after freeze-drying or spray-drying the eluate solution.

A WEED CONTROL PROGRAM FOR ESTABLISHING LESQUERELLA

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Several herbicides are registered under Special Local Needs (24c) [SLN] in Arizona and Texas for weed control in lesquerella. Trifluralin provides adequate preemergence control of annual grasses and broadleaf weeds, fluazifop controls annual and perennial grass weeds postemergence, and oxyfluorfen is used for postemergence control of annual broadleaf weeds. This program has worked well in establishing large blocks of lesquerella, but the postemergence control of broadleaf weeds is still a major concern. Treatments that offer a broader spectrum of control, and that are

more cost effective than oxyfluorfen are needed. The objective of this research was to determine the tolerance of lesquerella seedlings to alternative postemergence herbicides versus the SLN treatment: oxyfluorfen (0.6 kg ai/ha).

Our study was initiated 20 October 2005 at the University of Arizona Maricopa Agricultural Center, Maricopa, Arizona. Trifluralin (1.1 kg ai/ha) was applied preplant on an 8 ha block, and advanced generation lesquerella seed was planted on level basins with a Brillion seeder at 11 kg/ha and border irrigated. Herbicide treatments consisted of plots (6 m long and 3 m wide) arranged in a randomized complete block design with three replications. The following postemergence herbicide treatments were applied at 1/2x, 1x, and 2x rates on 5 December 2005 when the lesquerella seedlings were in the 4 to 6 true leaf stage: benoxacor (2.0, 3.0, 4.0 kg ai/ha); clopyralid (0.30, 0.60, 1.10 kg ai/ha); dicamba (0.07, 0.20, 0.30 kg ai/ha); oxyfluorfen (0.30, 0.60, 1.10 kg ai/ha); oxyfluorfen+clopyralid (0.20+0.20, 0.30+0.30, 0.60+0.60 kg ai/ha); and pyrithiobac (0.03, 0.07, 0.12 kg ai/ha). The treatments were applied using a CO^2-powered backpack sprayer with a four-nozzle boom (Teejet 8004 flat fan nozzles) delivering 225 L/ha at 187 kPa. Lesquerella seedling density was determined before spraying in each plot by counting the seedlings in a 0.25 m^2 quadrat. Counts were made weekly for 90 days and plant mortality was determined by the percentage change in seedling numbers. Seed production was measured in June 2006 by harvesting a 6 m by 2 m strip in each treatment with a Hege 180 combine.

Plant mortality was 100% in all pyrithiobac treatments. Mortality was only 3% in the 1x oxyfluorfen plots and 0% in the cloypralid and oxyfluorfen+clopyralid treatments, respectively. Seed production was greatest in the 1x treatments of oxyfluorfen (1,187 kg/ha), clopyralid (1,160 kg/ha), and oxyfluorfen+cloypyralid (1,195 kg/ha) treatments. The 1x oxyfluorfen treatment would cost $56/ha, versus $98 and $77/ha for the 1x clopyralid and oxyfluorfen+clopyralid treatments, respectively. Oxyfluorfen is still the leading postemergence treatment for weed control in lesquerella.

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Specialty Crop Initiative

SPECIALTY CROP OPPORTUNITIES IN THE NEXT FARM BILL

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As policy makers and agricultural leaders prepare for the next Farm Bill, many issues and topics are being debated. Given the sweeping nature of this reauthorization legislation that affect so many food and agriculture programs, one can identify a number of opportunities to improve the policy climate for specialty crops.

In the past, policy support for new crops or specialty crops has generally focused on research and education programs. While modest grant programs have been funded in this area, there remains a need to do more in this area, including the critical areas of plant breeding and utilization. The Specialty Crop Competitiveness Act of 2004 provided an authorization for USDA to provide block grants to states and other funding pools on specialty crops. The state block grants program has received appropriations, and support exists to expand the funding for this program.

In recent years, one debate surrounding new crops and specialty crops is the extent to which they should be included in farm subsidy programs. The last two Farm Bills have included a minor oilseeds program, giving crops such as sunflowers, canola, flax, and sesame equal footing with commodity crops in the farm payment programs. Discussions have frequently occurred about adding or allowing other crops to receive such subsidies. Opinions about adding horticultural specialty crops to the farm subsidy programs have been varied, with some growers wanting fair treatment and others concerned about a boost in fruit or vegetable acreage (causing potential oversupply and price suppression in those markets).

There are other areas of the Farm Bill where provisions could be added to improve support for specialty crops. These include conservation programs, food assistance programs, marketing and export programs, and risk management programs. The conservation area has seen significant boosts in funding and scope in the last four Farm Bills, including the enactment of the Conservation Security Program, which provides some support for crop diversification. The Risk Management Agency in recent years has supported a variety of programs for specialty crops, but demand exists for better crop insurance and risk management strategies pertaining to crops grown on modest acreages.

As the next Farm Bill is formulated, it will be important for all individuals and groups interested in specialty crops to work on getting a "seat at the table," so that economically important specialty crops and promising new crops are

given fair consideration for policy support.

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Panel Discussion: Building a National Strategy for New Crops

THE ROUTE TO MARKET FOR NEW INDUSTRIAL CROPS

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The route to market for a new crop or new crop product largely depends upon whether it is driven by a 'demand pull' or 'supply push' strategy. The demand-pull is led from the commercial end of the supply chain, and supply-push is led from the production end. There are commonalities between both of them, but there are also some significant differences. Generating sales is generally the target way to recoup investment made in new crops and is not always prioritized as a consideration.

This paper looks at certain new crop examples that have either reached full scale commercialization, are going through a process of market expansion and further roll out; or are at the proof of principal / scale up stage. The crops discussed include borage, lesquerella, camelina, and crambe as specialty oilseeds, and bog myrtle as a perennial shrub.

A demand pull strategy is based around a known or perceived market, where pricing, quantity, and quality are well defined and the challenge is production / process related. It assumes that the utility of the product has been addressed and now needs a well defined supply chain to be implemented and the identification of other stakeholders and their requirements, for example regulatory compliance.

A supply push strategy is based around a perceived market or utility for the product and often entails a greater deal of research and development to define the market and a marketing strategy to bring the proposition to reality.

From experience, whether the strategy is demand or supply driven, a collaborative approach between the organizations and individuals within the supply chain or 'primary stakeholders' is significantly more successful than when undertaken by any one primary stakeholder. This paper looks at the parties in the supply chain, from grower to consumer, or 'soil to oil'; the secondary stakeholders and the issues and considerations between where risk and reward are expected and accepted. It details various models that have been applied to the crops referenced, and looks at successes and failures.

Understanding the market and the route to follow are critical to the success of new crops. A detailed plan and in-depth understanding of the supply chain and business environment are required for commercialization, along with a robust collaboration of partners that meet the resource or skill set needs.

Specialty Crops: Some Examples for New Crop Development

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Industries associated with several U.S. specialty crops have mounted regional and national research and extension initiatives to help their industries become more viable and to solve complicated production problems. These efforts lead to the Specialty Crop Competitiveness Act of 2004. The legislation defines specialty crops as fruits, vegetables, tree nuts, dried fruits, and nursery crops, including floriculture. Title 1: State Assistance for Specialty Crops directs the Secretary of Agriculture to make FY 2005 through 2009 state grants to enhance specialty crop competitiveness.

These activities have galvanized the efforts on specialty crops. During the 52 farm bill forums held throughout the United States, many prominent individuals spoke strongly in favor of research and education programs to address specialty crops in the 2007 farm bill. Among the points made are that specialty crops provide some of the best opportunities for new, part-time, and socially disadvantaged farmers to enter successfully the business of farming, that

these enterprises contribute to maintenance of the entire agricultural infrastructure, and that they provide good teaching opportunities to reach the non-farm urban and suburban populations (Farm Bill Forums, News Release No. 0106.06).

There is much to be learned within the new crop community by observing the approach and progress made by these specialty crops advocates and how they have focused on common needs of the various crops. In particular, deliberations among the almond, berry, citrus, and tree fruit, walnut, and wine and grape industries revealed common research and extension needs. Representatives from these industries agreed that it would be possible to further their individual research goals by identifying common research priorities and communicating these priorities to USDA agencies and other research institutions. A white paper (Specialty Crops Research Team Position Paper 6-9-2006) outlined common research priorities as follows:

1. • Understanding and improving quality
2. • Understanding consumer perceptions of specialty crops, the role of nutrition in specialty crops, and the economic contribution of Specialty Crops to rural economies
3. • Enhancing processing and production efficiency
4. • Developing and promoting sustainable practices.

Groups for some specialty crops have joined efforts to secure greater research and extension funding. Current activities are being focused on broadening the base of interested specialty crop industries and communicating the nature of the effort and the advantages of working together to raise the profile of specialty crop research at USDA and throughout the land-grant system.

THE PUBLIC/PRIVATE PIPELINE FOR NEW CROP DEVELOPMENT

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Agriculture’s legacy includes the interdependency between people and nature. Throughout nearly 12,000 years of practice, the farmer as practitioner managed the process, and in contemporary terms ‘owned’ it on behalf of society. It took the profound advancement of science and other factors in the 20th century to shift agriculture’s ownership toward private interests as implement, seed, processing, and trade companies made investments and acquired rights to the tools and genetics fueling agriculture’s productivity. This balance of public and private investment is one of the largest drivers in the development of crop plants used today. It has also had the unexpected consequence of a reliance on relatively few plant species in agriculture.

Alignment of the research and development crop development ‘pipeline’ (the plant biology, breeding, utilization, and commercialization providers) used to be self-organizing in the U.S. Based on a network of federal, state, and local partnerships, all were largely contained in the public sector. The 20th century brought several break-through discoveries into the pipeline, beginning with the hybridization of crops such as corn, and ending with the incorporation of transgenics in crops such as soybean. These breakthroughs brought unprecedented productivity gains and were made possible largely through private investment.

It is estimated that sometime in the late 1980s, private investment in U.S. plant breeding exceeded public expenditures within the overall total spending on agricultural research. And, the majority of the private expenditures are focused on few crops; namely corn, soybean, wheat, alfalfa, cotton, and some vegetables. With a couple of exceptions, all other crops such as most oilseeds, small grains, grain legumes, and forages are dependant upon the shrinking resources available for crop development by the public sector, and hence less optimism for new crops.

The most recent trends suggest the possibility of a new alignment of public and private resources in crop development. As molecular breeding techniques are further developed, the private sector is increasingly out-sourcing the most basic research (such as gene mapping and discovery) on the major crops to the public sector. These discoveries are then licensed and combined to develop new crop varieties and products. These and other re-alignments of public/private partnerships in crop research hold promise to further improve established crops, but also hold promise to develop new crops as well.

A research and development pipeline focused on new crops could be encouraged through a public/private allocation of financial risk/reward, developing a stronger market pull strategy to identify new crop opportunities, and progressive

policies aimed at intellectual property management. Increasing the number of new crops is now dependant upon the alignment and coordination of public and private resources as never before.

STRATEGIES FOR NARROWING THE GAP BETWEEN R&D AND COMMERCIALIZATION OF NEW CROPS

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An important aspect of National Program Leadership at ARS is looking ahead, trying to anticipate the problems of U.S. agriculture, especially those involving the commodities we represent. The challenge is to develop research programs that address those needs and solve them in a timely manner; and work with stakeholders to enhance economic opportunities for producers. The process for building a successful research Initiative is similar for New Crops or any other commodity, regardless of the issue. The strongest framework always is based on strategic plans developed with stakeholder input, and implemented as an integrated research approach, where scientists with different expertise and ability are asked to work together and meld their individual contributions to achieve a common goal. This system enables realization of desired outputs of the work much faster, but as with the development of any new technology, the most difficult accomplishment of all is moving that technology to market. A lot good research never gets used because there is no easy way to bridge the gap between R&D and commercialization.
Various mechanisms have been proposed to catalyze the transfer of research technology to consumers. One example is QUALISOY, a business platform that enables appropriate players in the soybean value-chain to lessen the risk, perceived or otherwise, of marketing innovations that improve the quality of soybeans and soybean products.

One of QUALISOY's primary objectives is to facilitate industry-wide cooperation, and to encourage a spirit of collaboration to find effective solutions to important market issues, such as the promotion of low-linolenic and mid-oleic soybean oils to help reduce dietary levels of TRANS ISOMERS, a human health issue. As a result, Monsanto has introduced the Vistive™ brand, DuPont/Pioneer/Bunge have Nutrium™, and Kelloggs is the first food company to switch to these new products.

QUALISOY also works with other commodity partners to fund critical research that will benefit the entire market by helping remove impediments to the development or use of a new technology. Current examples include efforts to establish a Quantitative Swine Model for evaluating the digestibility of food and feed ingredients; and the development of a North American Swine Energy System to make best use of feed rations with improved protein digestibility and nutrient uptake. These enabling technologies will help reduce the environmental impact of livestock production.

Finally, let me reaffirm that QUALISOY is charting a strategic roadmap for future innovations in soybean traits that offer value and is striving to accelerate the acceptance of those traits. Short-term goals are market driven, whereas Long-term goals are influenced by market need, such as improvements in meal quality. This roadmap can be used as a model for New Crops for commodity or niche applications. Establishing an intermediary organization to foster research interaction with an industrial value chain will help support the development and marketing of enhanced the technology. Such a system helps bridge the gap between R&D and commercial interests, and would be an important step in establishing a strong competitive position in both domestic and global markets for New Crops and New Crop products.

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Horticultural/Agronomic Crops Session IV (Ornamentals)

EXPLORATION, DEVELOPMENT, AND INTRODUCTION OF NEW CALIFORNIA NATIVE PLANTS FOR GARDEN AND LANDSCAPE USE

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With over 6,300 native taxa, California has the most diverse state flora in North America north of Mexico. The State's flora has been horticulturally exploited since the late 1700s when the first species native to California (*Abronia umbellata*) flowered in Europe. Beginning in 1837, over 6,000 cultivars of taxa native to California have been named and introduced.

Due to greater use of California native plants for the purposes of restoration, water conservation, habitat gardening, and sustainability–beyond their inherent aesthetic and sensory appeal–there has been a marked increase in the general public's awareness and interest in growing these plants. Additionally, state, federal, and a variety of local laws, statutes, ordinances, and guidelines often mandate the use of native (frequently of local origin) plants.

Numerous attempts to integrate successfully these plants into landscapes and gardens have often failed for any one or combination of the following: lack of understanding of the plant's characteristics (growth rate, dormancy, mature size, life expectancy) or horticultural requirements (propagation, nursery production, planting, establishment, and garden care and maintenance). These issues continue to be addressed by a growing body of California specific literature.

In this presentation, I will provide an overview of three aspects of the current state of California native plants in horticulture: (1) exploration of the state, (2) breeding and introduction programs, and (3) the most significant California native plant species and cultivars of the past decade and a preview of several promising selections on the horizon.

OLD AND NEW TRENDS INFLUENCING THE INTRODUCTION OF NEW NURSERY CROPS

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At the First National New Crops Symposium in 1988, I reported on four trends that were influencing the introduction of new landscape plants. These were increased interest in, and use of, low-input plantings, edible landscaping, *in vitro* propagation methods, and ways to overcome limitations caused by urban conditions. The environment in which nursery producers and retailers operate continues to evolve, and the trends that affect them and their consumers continue to come and go. Thus, the objective of this presentation is to examine how past trends have fared and to describe the trends that are now supplanting them or are likely to become more important tomorrow.

Of the four trends identified in 1988, two remain relevant to the introduction of new cultivars: low-input plantings and ways to overcome site limitations caused by urban conditions. In contrast, interest in edible landscaping has generally declined, reducing its overall importance. And, *in vitro* propagation methods have become integrated with a suite of other commercial propagation methods and do not seem to be a major driving force in cultivar release.

Current trends, based on personal experience and a review of recent trade and popular gardening literature, include the rise of branding and the protection of intellectual property rights, increasing awareness of invasive species, and interest in native (and perhaps also sterile) plants, extending the season of garden interest, and challenges caused by emerging pests and diseases.

Within this environment, increasing numbers of new introductions are being marketed, but efforts to collect and share objective evaluation information on the long-term performance of these new cultivars under a wide range of garden conditions are insufficient to keep pace. This creates special challenges for growers, retailers, and consumers, and may give advantages to those organizations introducing new cultivars with well-understood branding that are supported by careful evaluation data.

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Industrial Crops Session V (General Crops)

PRODUCTION VARIABLES AFFECTING POD AND BIOMASS DEVELOPMENT IN COMMON MILKWEED

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With the reduced profitability of commodity crops, growers are looking for ways to diversify and supplement their businesses. An attractive option for these growers involves the introduction of new crops to their farming practices. One crop of particular interest is common milkweed (*Asclepias syriaca*) for the production of industrial fibers, oils, latex, and a potent nematicide.

The primary objective of this study was to examine numerous production variables affecting follicle and biomass development in common milkweed production fields. Experiments from 2001 addressed the effects of intra-row plant spacing on follicle formation and the effects of coal dust on plant establishment. The 2002 studies focused on planting dates, inter-row spacing, nitrogen requirements, and pruning.

Milkweed transplants were planted in replicated 2.5 m by 2.5 m plots in late May in both years. Data on follicle production and stalk biomass were collected on individual plants each year for three to four years. Processed follicle data was also collected each year for row spacing and planting date treatments.

Follicle weight and total number of follicles per plant increased with row spacing. The dry stalk biomass per plant increased with row spacing, whereas the total dry biomass per hectare decreased. Coal dust applications, nitrogen, and pruning do not appear to have any significant effect on either follicle or stalk biomass. Planting dates of transplants had a significant effect on follicle production. The second year of production on 30 cm rows produced an estimated 3,800 kg of dry follicles per hectare. Processing of these follicles produced 1,010 kg seed, 835 kg floss, and 1,340 kg hull matter. Production yields have decreased over subsequent years.

Common milkweed is a perennial crop with several market opportunities offering a tremendous advantage for farmers looking to expand their production with minimal costs.

AGRONOMIC AND CLIMATIC EFFECTS ON TEFF GROWN FOR FORAGE

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Teff *Eragrostis tef* Zucc. is a C4 annual grass. Teff is the traditional grain crop in Ethiopia, where it was first domesticated from 4000 to 1000 BC. Its flour is used to make enjera bread, a major Ethiopian food staple. Worldwide, teff is grown for livestock forage on a very limited basis. In the U.S., it has been grown on a limited basis for grain production to supply ethnic Ethiopian restaurants. Because of its rapid growth during warm weather, fine stems and leaves, and reports of good palatability, it was grown for forage on a preliminary basis for two years in Klamath Falls, Oregon, with promising results.

Based on these results, a more detailed study was conducted in 2005. The objective of this study was to evaluate teff yield and quality under different levels of moisture stress and nitrogen (N) management under varying climate conditions at three locations in Oregon.

We used teff seed available from commercial seed sources. The teff was seeded at three OSU agricultural research stations near Klamath Falls, Medford, and Ontario, OR. Because of teff's reported intolerance to frost, seeding dates at each location were chosen to avoid late spring frost. Seeding rates ranged from about 3 to 11 kg/ha. Irrigation rate by N rate treatments were applied at each location. Typical N rates were 0, 90, and 180 kg/ha N, with one-half applied at planting and one-half after first cutting. Irrigation treatments were adjusted at each location to cover the range from almost none to about 1.2 times the calculated Kimberly-Penman potential evapotranspiration rate (PEt). All plots were cut twice and analyzed for yield and forage quality factors.

The responses to irrigation and N rates varied somewhat at the different locations and also varied between the first and second cuttings, but there were several consistent results. The lowest rate of irrigation and lack of added fertilizer N clearly reduced yields. However, the highest rate of irrigation and N fertilizer often did not improve yield or quality compared with a moderate rate of both N and irrigation. Under these conditions, it appeared that applying about 90 to 100 kg/ha N total during the growing season resulted in optimum yield and quality. Similarly, optimal yield and quality were achieved when irrigation rate equaled about 0.5 to 0.6 of the calculated PEt, but did not improve with additional irrigation. It also appeared that if teff is planted to a well-prepared seedbed, and adequate moisture is present after

planting, that a 3 lb/acre seeding rate may be sufficient to result in a good stand and optimal yield, although it also appeared that teff might be more sensitive to nonideal conditions as the seeding rate decreased from about 7 to 3 kg/ha seed.

Teff grew well and produced good yields and forage quality at all three locations representing different climates within Oregon. It appears that moderate levels of N and irrigation will result in good yields of good quality, and that additional N and irrigation do not necessarily increase yield or quality.

LIGNOCELLULOSES FOR POTENTIAL BIOENERGY AND BIOPRODUCTS

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Lignocelluloses constitute an enormous global resource for bioenergy and bioproducts. Aromatics within lignocelluloses limit bioconversion of carbohydrates to ethanol and other useful products. Information on the nature of the aromatic-carbohydrate complex and its location could identify specific barriers to utilize and identify environmentally friendly strategies to improve bioconversion.

Diverse types of plants, including dicots and monocots, were characterized by chemical and microscopic means and their responses to specific enzymes and microorganisms. Characteristics of lignin and aromatic constituents were identified and quantified where possible and ranked as to their influence on bioconversion. A brief review is presented on environmentally friendly pretreatments to improve utilization of different types of plants.

Aromatic components exist as polymerized phenylpropanoid units, e.g., lignin, or as ester-linked phenolic acids to hemicelluloses in plant cell walls. Conifieryl and syringyl lignins are prevalent in wood, dicotyledons, and monocotyledons (e.g., grasses). The most recalcitrant materials are those with coniferyl-type lignin, such as xylem cells in vascular tissues. The grasses, which include energy crops such as corn, switchgrass, and wheat straw, also have high levels of phenolic acids, e.g., p-coumaric and ferulic, ester-linked to hemicellulosic sugars. The presence of these esters is notable in grasses, even in non-lignified cell walls, and often they constitute a major barrier to cell wall biodegradation. Strategies to overcome the barriers to biodegradation in lignocellulose involve removal, modification, or separation of aromatics that limit availability of carbohydrates. Bast plants, such as flax and kenaf, both provide industrial fiber, but differ widely in the location of lignin and its influence on fiber separation and biodegradation. In flax, specific enzyme formulations have been employed to separate effectively cellulosic bast fibers from lignified materials, which could be used in a variety of applications. The presence of esterified phenolic acids within grasses may offer a particular advantage for bioconversion and bioproducts. Breeding programs to reduce aromatics have produced huge gains in bioconversion, with emphasis on forage use but application to bioenergy. Selective, lignin-degrading white rot fungi remove aromatics and make available cellulose for other applications. Recent laboratory studies involving commercially available ferulic acid esterase and bioenergy grasses, such as corn stover, showed improved bioconversion of lignocellulose, release of p-coumaric and ferulic acids, and increased availability of glucose and xylose over cellulase-treatment alone.

Aromatics significantly influence the bioconversion of plant cell walls. Separation and removal of the aromatic components from lignocelluloses improve the availability of carbohydrates for subsequent use and offers the possibility of coproducts. Notably, the release of ferulic acid from grass lignocellulose may provide a value-added coproduct in conjunction with increased release of sugars for fermentation to improve the economics of bioconversion.

AGRONOMIC RESPONSE OF CANOLA LINES IN THE ENVIRONMENTAL CONDITIONS OF THE UTAH VALLEY

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Canola, *Brassica napus,* and other closely related cruciferous crops are widely cultivated throughout the world as vegetable crops for human consumption and as fodder crops for livestock feeding. However, the largest cultivation of these crops is for the production of edible vegetable oil. Most of the land area used for this crop is located in Europe and China, where it is sown to produce rape winter oilseed. As latitude or altitude increases, the winter variety of *B. napus* is supplanted by the summer variety. It is possible that the summer form of the plant could also be grown in the Utah Valley. In Canada, cultivation consists of approximately equal amounts of the summer types of this species. The fall conditions of Northern Utah, USA are appropriate for growing canola due to the altitude, temperature, and day length of the season. The objective of this study was to evaluate and characterize 10 genotypes of canola under the fall environmental conditions of the Utah Valley.

The research work was conducted in Provo, Utah during the spring and summer seasons of 2006. Ten canola genotypes were studied, including the well-known check IMC 204. The randomized complete blocks design was used with three replications. The genetic material were obtained from Australia and included: (1) IMC 204, (2) H1432, (3) H 1480, (4) H1750, (5) H4481, (6) H4592, (7) H4722, (8) H4815, (9) H4816, and (10) Y3000. Planting was made on 22 April 2006. Germination vigor, bloom, pods size, maturity, diseases reaction, insects damage, lodging, plants height, grain size, grain density, oil content, fatty acids profile, and grain yield were measured.

The experimental canola genotypes planted in the Utah Valley showed acceptable results. The plants developed earlier than those grown in the Yaqui Valley, Sonora, Mexico. The variety IMC 204 matured at 115 days in Mexico, whereas it matured at 100 days in Utah. The plant height was acceptable for both locations and ranged from 120 cm for the IMC 204, to 90 cm for the H4815. However, the IMC 204 was taller at 160 cm in the Yaqui Valley conditions. It can be concluded that day length, temperature, and soil type influence the genotypes' response. Disease and insect problems were low.

The canola oilseed crop will be able to adapt to the Utah Valley's environmental conditions. Additional studies with different soil types and canola varieties are recommended to measure the crop potentials.

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Horticultural/Agronomic Crops Session V (Edible Oilseeds and Grains)

SESAME: THE CHALLENGES OF INTRODUCING A NEW FIELD CROP TO THE UNITED STATES

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In 2003, the Jefferson Institute held a workshop and produced a white paper: *Strategies for Commercializing New Crops*. Because the paper covered many crops and several strategies, the paper had to have many generalizations. This paper looks at one specific crop – sesame.

Sesaco Corporation has been working on establishing sesame as a crop in the U.S. since 1978. The initial and continuing concept is that sesame is a healthy food with 25% protein and 50% oil with excellent antioxidants. It is a drought tolerant crop that can serve as way of stretching the declining amount of water in the West, and there is an existing world market negating the need to develop a market. Therefore, there is a place for sesame in American agriculture. A feasibility study was conducted the first three years to find a suitable starting point.

In 1981, a model was developed for the entire sesame industry from plant breeding through the consumer to include importing and exporting. The model identified the companies involved in the different parts of the models, defined market requirements, and hurdles to be overcome. A basic decision was made to develop sesame through private enterprise and not to obtain financial aid from the government – state or federal.

The paper describes the challenges in terms of changing the plant to allow for full mechanization; interfacing with farmers; interfacing with the farming infrastructure; contracting, receiving, cleaning, and distributing the crop; developing standards; understanding processing requirements, etc. Three basic lessons have been learned:
(1) Baseline decisions need to change because farming patterns and processing requirements change. It takes about five years from a cross to initial farming testing, and by that time, the requirement can change negating the necessity for the cross.
(2) As the research shifts from the land grant colleges to private industry and as very large agricultural companies get larger, the research is following the money, which is in the large field crops, vegetables, and fruits. There is less

research done on alternative field crops.
(3) It was a mistake not involving the government from the first day. Although many talk of the importance of developing alternative crops, government policy favors the existing crops. The government controls the Farm Bills, approval of herbicides and pesticides, and providing crop insurance. There is no such thing as a level playing field.

Introducing a new field crop to the United States is a very challenging goal, but through perseverance, sesame has made inroads and barriers are being overcome.

OPPORTUNITIES FOR MILLET GRAIN AND FORAGE

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Small seeded grains have been grouped as millets by many crop scientists, but the grouping is artificial beyond the seed size with most coming from separate genera and some from separate subfamilies of the grass family. By referring to them all as millets leads to a great deal of confusion among producers, government officials, and policy makers across the country.

The U.S. literature is heavy on pearl millet and the plethora of opportunities that it provides for producers; however, virtually no commercial production of grain type pearl millets occurs in the U.S. Pearl millet forage types make up only a small portion of the warm season, summer annual grass market. Some pearl millets have entered the ornamental grass market. Quantum improvements in grain yield may make it competitive as a U.S. feed grain, but at this point these have not occurred. Some pearl millets are produced in India and Africa, but they are primarily grown as a subsistence grain in these areas rather than as a cash crop for trade. Over the past 25 years, there have been an average of more than three U.S. scientist-years devoted to pearl millet research annually.

Foxtail millet has been grown in small quantities for the birdseed market for many years, and occasionally with oversupply, part of this surplus is used as livestock feed. However, its primary use is as a low input hay crop with limited yield potential due to short season or limited water. Foxtail millet is a major crop in Northern China where it is double cropped with wheat. The grain is used as porridge for human food and there is a commercial market for foxtail grain. Over the past 25 years, there has been less than one-half scientist-year devoted to foxtail millet research each year in the U.S.

Proso millet is grown for grain on about 250,000 ha annually in the U.S. Most are used for the birdseed market, but have also entered the trade for poultry, hog, and cattle rations. It is the primary millet that enters the human food market in the U.S., where it is frequently labeled as hulled millet or white millet. Over the past 25 years, there has been an average of less than one U.S. scientist-year devoted to proso research each year.

Specialists in new/alternative crops must work cooperatively and supportively on any effort to enhance alternative crops. However, U.S. investment in pearl millet is disproportionate at the expense of investment in the millet that we actually grow, trade, and export becomes immediately obvious. Proso has tremendous potential for crop production in the U.S. High Plains or Central Great Plains. Almost any advisory group of producers will identify it as one of the crops that works in rotation with wheat in this region. It is a low water user with a short growing season that can provide a profit opportunity with relatively low inputs. It appears that expanding the market opportunity for proso, and improving its yield potential and consistency would be of greater value than to attempt to develop a less competitive alternative for the same market.

HIGH DRAMA IN VEGETABLE OILS

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The North American vegetable oil market is going through the most significant change in the history of this market that comprises all of the various edible vegetable oils. The first major change was the Food and Drug Administration’s label requirement for trans fatty acids beginning in 2006. Trans fats are the byproduct of partial hydrogenation (PH), a

process wherein vegetable oils are hardened for stability. Historically, huge quantities of inexpensive PH soybean oil, a byproduct of the protein demand, were available to the North American market in surplus volumes at cheap prices. The market is now in the process of finding non-PH stable alternatives. The U.S. sunflower industry changed the fatty acid structure of sunflower oil in the late 1990s in anticipation of trans fatty acids becoming a health issue. The vast majority of the U.S. sunflower acres are now NuSun® or high oleic, both provide excellent stability without partial hydrogenation. Other oilseeds such as canola and soybean have completed or are in the process of developing naturally stable oils. Demand for naturally stable oils is placing price pressure on the topside of the market.

The other part of the drama is biodiesel. With the advent of high petroleum prices and government incentives, vegetable oil is finding significant market growth as a partial replacement of diesel. Numerous biodiesel facilities are either in the construction or planning stage. Biodiesel demand has become a factor in the vegetable oil market. The Chicago soybean oil futures contract often moves in sympathy with world petroleum prices. This demand is placing pressure on the bottom side of the market.

Vegetable oil prices have moved higher and are likely to remain higher with specific demand on the bottom and the topside of the market. In July of 2006, soybean oil represented 44% of the value of a bushel of soybeans. Traditional values are in the low 30s. This bottom-side demand has moved the entire oil complex price higher.

Historically, food companies have been able to buy inexpensive vegetable oil for most of their needs. This is no longer the case. Because of the dramatic changes taking place, vegetable oil users must be longer-term planners in order to lock in supplies. All of this makes for a dynamic scenario for oilseeds, especially high oil content oilseeds.

BIOLOGICAL AND ECONOMIC FEASIBILITY OF PEARL MILLET AS A FEEDSTOCK FOR ETHANOL PRODUCTION

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Development of the ethanol industry in the southeastern U.S. is limited by the amount of corn produced in the region. Additional feedstocks are needed to supplement locally-grown corn for an ethanol plant to be viable. These studies were conducted to evaluate the biological and economic feasibility of using pearl millet as a supplemental feedstock in a dry-grind ethanol production process.

For ethanol production, pearl millet grain was subjected to different grinding processes. The rate of the fermentation process for the pearl millet treatments and a corn control were measured, and the resulting composition of the distiller's dry grains with solubles (DDGS) was determined.

A process and cost analysis was used to assess the economic feasibility of using pearl millet as a feedstock. Expected yield of ethanol and DDGS was calculated based upon grain composition. Other variables in the model include the cost of feedstock, sizing of equipment, utility consumption, operating costs, capital costs, and revenues from products and coproducts.

Fermentation studies demonstrated that pearl millet could be converted to fuel ethanol using a conventional corn-to-ethanol process without significant modifications. Final fermentation efficiency was approximately 4% less than corn, but pearl millet fermented more quickly and reached 85% fermentation approximately 12 h earlier than the corn treatment. The DDGS from pearl millet was higher in protein and fat, and lower in fiber than corn DDGS.

The process and cost analysis indicated that the higher protein content of pearl millet would result in a 13% greater DDGS coproduct income than corn. Within the limitations of this preliminary analysis, results suggest that even with a 10% premium on the cost of pearl millet, the net cost of ethanol production is $0.06 per gallon less than production using corn.

PROGRESS IN GRAIN PEARL MILLET RESEARCH AND MARKET DEVELOPMENT

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Pearl millet (*Pennisetum glaucum* [L.] R. Br.) has historically been grown only for forage and hay in the southern United States. However, recent research and technology transfer activities are resulting in continued improvements in grain hybrids adapted to the southeast and the emergence of new markets for the crop. With increasing global market competition for major commodity crops, farmers have been actively seeking alternative crops to remain profitable. Pearl millet provides an opportunity for production on sandy and acidic soils of the southeast without irrigation because of its deep root system and the ability to withstand drought and extract nutrients from poor soils.

The current and future demands for pearl millet grain are coming from diverse markets. The agri-tourism and recreational wildlife industries are finding superior results from using pearl millet in rations for bobwhite quail production, and for supplemental feeding. It also seems to be an excellent food for other birds, including dove, turkey, and songbirds. Pearl millet is equal to or better than typical corn-soybean poultry diet for broiler production and can be fed without grinding, thus eliminating processing costs. New evidence indicates superior results when used in pre-starter and starter rations for poultry.

Pearl millet can be a useful supplemental feedstock for ethanol production. Research suggests that ethanol facilities processing pearl millet could yield a 60% greater gross return over traditional feedstocks.

Immigrants from Africa and the Indian subcontinent where pearl millet is widely grown for food are in the habit of eating this grain in various preparations. The large immigrant population from these two regions ensures a steady demand in the foreseeable future. Because it is gluten-free, marketing opportunities for this grain also exists in the health-food outlets.

'Tifgrain 102', a pearl millet hybrid cultivar released jointly by USDA-ARS and the University of Georgia, possesses resistance to diverse nematodes, rust, and pyricularia leaf spot. Research is currently in progress to identify molecular markers for disease and pest resistance in 'Tifgrain 102'. This effort will lead to broad-spectrum resistance against multiple diseases and pests in future hybrids.

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Industrial Crops Session VI (Latex, Rubber, and Resin)

TRANSFORMING SUNFLOWER INTO A RUBBER-PRODUCING CROP

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Natural rubber is an irreplaceable raw material and constitutes about 45% of the total amount of both natural and synthetic rubber used. Currently, nearly all commercial natural rubber comes from a single species, the Brazilian rubber tree (*Hevea brasiliensis*) and the United States is almost completely dependent on imports from developing countries. Leaves of sunflower **(***Helianthus annuus*) produce rubber and researchers have postulated there is genetic potential for increasing the rubber content of cultivated *H. annuus*. Sunflower is a good candidate as a potential source of rubber because: (1) it already makes rubber that means it can compartmentalize this secondary product; (2) it is adapted for agronomic production; (3) it produces high biomass per acre; and (4) sunflower agronomy is well understood and would need only minor adjustment as a rubber crop.

The objectives of our research were to: (1) develop a reliable method for regenerating transformed sunflower tissue;

(2) insert genes into sunflower to increase rubber biosynthesis; (3) evaluate the phenotype of transformed sunflower; and (4) develop a protocol for determining rubber content using the Dionex Accelerated Solvent Extractor (ASE) 200.

Agrobacterium-mediated transformations were used to insert genes into sunflower. An herbicide-resistant selectable marker was used initially to verify and fine tune protocols, and ultimately kanamycin-resistant selection was used in a series of vectors containing the target genes. Transformed meristem tissue from mature seed was regenerated using a sequence of semisolid agar medium in Petri dishes for shoot production followed by rooting on a sterilized peat pellet in a liquid medium in ventilated Magenta boxes. Plantlets were grown in a tissue culture growth chamber, and when well rooted, were transferred into pots with soil and moved into a BL2-P+ greenhouse. PCR testing confirmed several positive transformations of sunflower and included incorporation of genes that are part of the rubber biosynthesis pathway. A study is currently underway to evaluate transgenic sunflowers to determine if they produce more rubber than non-transformed controls.

A rubber extraction and quantification protocol has been developed using acetone, methanol, and hexane, each with unique extraction temperatures, times, and number of extractions. Extractions using the ASE 200 were sequential using first acetone, followed by methanol, and last with hexane. The optimized protocol will be used to evaluate transgenic sunflowers.

INTERSPECIFIC COMPARISONS FOR ALTERNATIVE RUBBER CROPS

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Over 2500 species of plants have been reported to produce some form of natural rubber, varying in molecular weight and microstructure. High molecular weight cis-1,4-polyisoprene, biosynthesized by *Hevea brasiliensis* remains the largest single volume elastomer in commerce because of its high performance properties. Despite significant investment and innovation, natural rubber has not been duplicated by synthetically produced polymers. Almost all natural rubber used in the United States is imported from tropical countries and comes from *H. brasiliensis*. Natural rubber latex prices have increased more than 80% since the beginning of 2005. The shortage is real, driven by Asian growth, and influenced by petroleum supply and price. The shortage is expected to worsen over the next 10 to 15 years. Alternatives to *Hevea brasiliensis*, such as guayule, *Parthenium argentatum*, have the potential to provide another source of natural rubber, especially in critical medical applications as a solution to Type I IgE-mediated *Hevea* latex allergy.

Successful commercialization of new rubber-producing crops requires efficient production and recovery of high molecular weight, high cis-1,4 microstructure polyisoprene. Various reports in the literature show rubber from *Hevea* and guayule to be unimodal, bimodal, or even multimodal in molecular weight distribution. Our study was designed to compare carefully rubber from various candidate crops to provide a clear baseline for development strategies. We have measured the molecular and other characteristics of rubber from alternative natural rubber candidate species, to those of natural rubber from *H. brasiliensis* and synthetic polyisoprene. Methods employed include SEC-MALLS, modified Lowry Protein Assay, ASTM D1076, and dynamic mechanical spectroscopy by APA2000. Rubber from *F. elastica* (ficus) and *H. annuus* (sunflower) had significantly lower molecular weight than *P. argentatum* (guayule) and *Taraxum kok-saghyz* (Russian dandelion) both of which are similar to *H. brasiliensis*. The weight-average molecular weight, M_w, of all species is strongly influenced by the fraction of the lower molecular weight polymer present. Guayule rubber, obtained from mature plants that were processed in a commercial facility, had high cis 1,4 content, showed consistently high molecular weight, and low total protein content in the latex.

INFLUENCE OF FLOWERING ON GROWTH AND SECONDARY COMPOUND PRODUCTION IN GUAYULE

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In previous work, we found that the flower structures (peduncles, pedicles, and flower heads) of cultivated guayule can account for up to 9% of the total biomass. We hypothesized that by removing the flower structures the photosynthate that would have been used in flower development would be shunted to other structures and/or biochemical pathways, perhaps even affecting rubber and latex production.

Six germplasm lines (11591, AZ-2, AZ-3, AZ-5, AZ-101, and N565) were transplanted into a field at the Maricopa Agricultural Research Center on 15 April 2003. The plants were irrigated weekly until they were established, then every two weeks during the active growing season (March through November) and approximately monthly while the plants were dormant. Flowers and flower buds were removed weekly during the active growth using a battery operated hedge trimmer. Plants were harvested in March 2004 and 2005 (13 and 25 months of age, respectively), and April 2006 (38 months of age). At the time of harvest, plants were measured for height, width, and fresh weight, and then analyzed for dry weight, and rubber, resin and guayulin A and B contents all three years. Latex content was measured only in 2005 and 2006.

Plants increased in height, width, and dry weight each year of growth, and there were differences among lines, with AZ-2, AZ-3, and AZ-101 always the largest plants. Removing the flower heads had no effect upon height, width or dry weight. There were differences in rubber, resin, and latex contents over years and among lines. Interestingly, rubber, resin, and latex contents were higher in the plants in which the flower buds had been removed. Rubber and resin yields were different over years and lines, reflecting differences in dry weights. Latex yield was not different over years, but there were differences among lines. There were significant increases in rubber, resin, and latex yields in the plants from which the flower heads had been removed over the uncut treatments.

Removing flower structures over three years of growth increased rubber and latex yields. This is a result of the increased percentage of rubber and latex in the plants from which the flower structures had been removed. Although mechanical flower removal is impractical on a commercial scale, it does suggest that breeding programs might include decreased or synchronous flower production as goals. There may be chemical treatments that would alter flower production, and might be used as a cultural technique to increase yields; however, these would have to be tested for both efficiency and cost.

DISTRIBUTION OF MARKER MOLECULES IN GUAYULE

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Guayule (*Parthenium argentatum* Gray) is a source of high-quality hypoallergenic natural rubber. Whether isolated as latex or bulk solids, the byproducts of rubber extraction contain varying quantities of guayulins A-D, a family of sesquiterpene esters. Guayulins A and B are derivatives of partheniol, and can be readily found in the resin, the non-rubber acetone extracts. Guayulins C and D are rarely present in fresh extracts and may be artifacts of the degradation of guayulins A and B. While guayulin B has not been shown to cause any reaction, guayulin A is a strong elicitor of contact dermatitis in sensitized test animals, and both have been recovered in dipped latex films.

Current small-scale harvest methods focus on reducing the time between removal of the shrub from the field to minimize latex degradation. The penalty for this handling speed may be samples that are not mixed completely, which leads to heterogeneity of subsamples and a potential source of error in estimating secondary compound concentrations.

Our objective was to determine whether there are differences in the concentrations guayulins A and B among plant parts, and whether they are influenced by age or time of harvest.

Two plants each of lines 11591, AZ-1, and AZ-3, and two ages (1- and 2-year-old) were harvested in October 2003 and April 2004 for a total of 24 plants. Plants were cut up into eight parts: brown leaves, green leaves, stem tips (the apical meristem), stems less than 5 mm in diameter, stems 5-10 mm, stems greater than 10 mm, green stems (which represent the current year's growth), and flower parts. After drying and grinding, samples were analyzed for resin and rubber, and the resin fraction was analyzed by HPLC for the presence of guayulins A and B.

The majority of the shrub biomass was contained in the stems; however, the brown and green leaves contribute a surprising 13.5 to 20.1 percent of the total. This fact, coupled with a wide range of guayulin A and B concentrations found in the leaves, suggest that these parts may contribute the most to the variation observed.

The concentration of rubber nearly doubles from fall to spring, with most of it localized in the woody tissue (stems). This is most likely due to the increase in size of the rubber particles in the vacuoles of the parenchyma cells, where rubber deposition occurs. Surprisingly, the amount of rubber in brown leaves, which are traditionally discarded or physically removed before processing, ranged from 2.4% in the spring to 13.6% in the fall.

Thorough mixing of the chipped shrub is vital to ensure that a representative sub sample is obtained for analysis.

GUAYULE: PATH COEFFICIENT ANALYSES FOR RUBBER AND RESIN YIELD IN A WILD POPULATION IN MEXICO

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Mexico has more than 50% arid and semiarid zones where the guayule region is located in six states in the northern part of the country. The native guayule population has shrubs with outstanding rubber and resin contents. It is important to know the factors that influenced direct or indirectly rubber and resin yields. The path coefficient analyses have been a successful tool to develop selection criterion in different crops. In guayule, information is scarce on the use of this technique in rubber yield and none on resin yield. This information is required in order to support the hypoallergenic natural rubber latex process as well as for the resin to help guayule commercialization.

The objectives of the present work were to evaluate the interrelation among different components in the rubber and resin yields and to develop selection criteria for an efficient management to improve wild populations.

For path coefficient analyses, two-year-old plants were collected from a wild stand in Gomez Farias, Mexico, located at 1900 m asl. The data taken in shrubs were main stem diameter, plant height, dry weight, rubber and resin contents, and yields. The phenotypic correlations between the evaluated characteristics were carried out as well as path coefficient analyses.

The results showed that the main stem diameter has a higher direct effect (0.707) than plant height (0.286) These are in relation to the total dry weight, and for that reason, can infer the influence of this characteristic on dry weight. For rubber yield, the dry weight has a higher direct effect on rubber yield (0.855) than on rubber content (0.295), and for this variable, the indirect effect (0.283) was similar to the direct effect. For resin yield, the total dry weight had the highest direct effect (0.916) on this variable, whereas for resin content, the indirect effect (0.284) was higher than the direct effect (0.199).

The path coefficient analyses determined the different interrelation among the evaluated characteristics for rubber and resin yields.

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Banquet Presentation

ART AS A SOURCE OF INFORMATION ON GENETIC DIVERSITY

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Works of art from antiquity to the present constitute an alternate source of information on horticultural technology providing significant information on subjects such as the history of technology, crop evolution, lost traits, and crop dispersal. Sources include ancient mosaics, sculptures, illustrations of medieval manuscripts, Renaissance paintings, and illustrations from illuminated and printed herbals.

The uses of art as a source of horticultural technology will be illustrated using examples of ancient Roman mosaics, an illustrated prayer book (Grandes Heures d'Anne de Bretagne, 1505-1508) painted by Jean Bourdichon; the ceiling in the Loggia of Cupid and Psyche of the Villa Farnesina in Rome (1515-1518) painted by Giovanni da Udina of the workshop of Raphael Sanzio; and paintings of Michelangelo Merisi (1571-1610) known as Caravaggio.
The systematic collection of crop iconography from the artistic record would be an invaluable resource to crop researchers and a project (Crop Image) is being organized to assemble a searchable database of crop images.

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Bioproducts and Bioenergy Session II

HAVE WE UNDERESTIMATED THE POTENTIAL OF PLANT BIOMASS IN ACHIEVING A RENEWABLE FUTURE? *MISCANTHUS X GIGANTEUS* IN THE MIDWEST

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Energy production as envisaged in the proposal to replace 30% of U.S. gasoline use with bioethanol by 2030 must increasingly rely on dedicated bioenergy crops that will be used for the production of cellulosic ethanol. The successful crop(s) must have a positive energy balance; i.e., must be able to convert solar energy to biomass with minimal energy inputs. Equally, the yield per hectare will be critical in determining economic viability. Herbaceous bioenergy crop research has focused on switchgrass (*Panicum virgatum*) in the U.S. and Miscanthus (*Miscanthus x giganteus*) in Europe. Both grasses have a perennial root system and produce an annual crop of stems. During the Fall nutrients are translocated from the dying stems to the root system, making these crops highly nutrient use efficient. The stems are typically harvested during the winter when atmospheric humidity is low to avoid drying costs. To date, side-by-side comparisons of mature stands of these two crops have not been reported. Our quantitative review of the peer-reviewed literature indicated an average Miscanthus yield of 22 t/ha (97 observations mainly from Europe) compared with 10 t/ha for switchgrass (77 observations mainly from the U.S.).

The objective of this study, by using side-by-side trials across Illinois, was to determine whether this suggested yield advantage of Miscanthus over switchgrass was realized in practice.

We established the first side-by-side trials of Miscanthus and switchgrass in the U.S. on agricultural land at three Illinois locations in June 2002. Sites spanned 5º of latitude and a range of soil types. Each trial of 0.2 ha (0.5 ac) included four plots of Miscanthus and four of switchgrass in a fully randomized design. Biomass was sampled five times across each annual crop cycle.

Overall, Miscanthus produced more than twice the biomass of switchgrass at all sample locations in all years ($P<0.001$). Peak biomass occurred in the August to October period in both crops. Mature stands of Miscanthus averaged 48.3±2.3 TDM/ha over the three locations in 2004, whereas switchgrass produced 15.3±2.8 TDM/ha. In 2005, yields were moderated by low rainfall across the state and were 33.3±2.3 TDM/ha and 7.9±2.3 TDM/ha for Miscanthus and switchgrass, respectively. The average efficiency of conversion of visible solar radiation into biomass by Miscanthus was 3.1%. Illinois is the eighth largest consumer of gasoline in the U.S. combusting 1.34 EJ in 2002 equal to 0.4% of visible solar energy receipt in the state. Miscanthus, at the average efficiency of 3.1% could, therefore, replace 30% of petroleum using 7.7% of Illinois land, assuming that 50% of biomass energy is lost in conversion to ethanol. This area appears viable than the more than 20% of the state that would be required to achieve the same with switchgrass.

BIODIESEL: FUELING THE FUTURE

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National survey results indicate that as of December 2005, 41% of U.S. consumers surveyed have heard of biodiesel. This is a 6% increase from the previous year. The increased focus on the energy security of the nation, the attention given to renewable fuels in Congress and the continued rise in fuel prices have increased Americans' awareness of biodiesel and its role in the nation's fuel plan.

The biodiesel industry growth more than tripled from 2004 to 2005 with annual volumes reaching approximately 189.3 M liter (90 M gal) per year. With a favorable economic environment in 2006, growth continues to be significant, with production on track to exceed 567.8 M liter (150 M gal) per year. Evidence of this growth can also be seen by the increased number of retail pumps offering various blends—more than 850, more than 65 production facilities, an almost equal number of facilities under construction, and approximately 1,800 distributors offering the renewable fuel. Automakers and engine manufacturers such as John Deere, Chrysler, General Motors, and Cummins have also made major public announcements supporting biodiesel.

Much of the recent growth can be attributed to passage of the American JOBS Creation Act of 2004 on 22 October 2004 that included the first federal biodiesel tax incentive. The Energy Policy Act of 2005 extended these provisions and also passed a national renewable fuel standard. This presentation is designed to provide an overview of the legislative and regulatory environment for biodiesel, an update of industry current and planned capacity, raw material issues, and factors influencing investment and growth.

UTILIZING LOCALLY-PRODUCED CANOLA TO MANUFACTURE BIODIESEL

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Even though efforts to produce canola (*Brassica napus* L.) in the United States are beginning to bear fruit, most of the canola oil used in the United States is still imported from Canada. A lack of crushing facilities in most areas where canola has been shown to be highly adaptable, such as Virginia and the mid-Atlantic region of the United States, has been a major block in the domestic production of canola. This presentation would detail an avenue for establishment of canola in many parts of the United States.

It is proposed that a small-scale crushing and a small-scale biodiesel manufacturing unit be established at a farm to provide biodiesel to an individual or a group of farmers. The plan includes production of canola, on-farm crushing with a small crusher (approximate cost $5,000), and conversion of canola oil into biodiesel with a self-contained unit (approximate cost $500 to $4,000). Canola yields up to 3363 kg/ha (3,000 lb/Ac) have been obtained in Virginia. Canola seed contain an average of 40% oil equaling approximately 544 kg (1200 lb) of oil that should result in approximately 570 L (150 gal) of biodiesel. This biodiesel can be used to operate farm machinery at this farm.

In order to demonstrate this technology, several farmers will be contracted to grow canola at their personal farms. Upon maturity of this crop, the whole process will be demonstrated to the farmers around one farm that grew canola. These demonstrations will consist of canola harvesting with a combine already available at this farm, crushing of the canola seed for oil extraction, and manufacturing of biodiesel from this canola oil. The biodiesel, thus manufactured, will be used to operate a small tractor along with a tractor operating on conventional biodiesel. This technology could be utilized by an individual farmer or a group of farmers to produce biodiesel locally on their farms. Additional details of this technology will be presented and discussed.

THE FUTURE OF BIOREFINING FOR FUELS AND CHEMICALS PRODUCTION

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The successful emergence of advanced biorefineries will be influenced by many factors including the extent of biomass availability, the kinds of products that can be produced, the nature of the conversion processes employed, the ability to efficiently utilize the energy content of biomass, and the size of the facilities to be built. This presentation provides an overview of these issues and describes the prospects for advanced biorefineries.

The amount of biomass that could be produced in the United States depends not only upon biomass yields, but a variety of social, political, economic, and environmental factors influencing decisions about placing land into biomass production. A recent study by the U.S. Department of Agriculture concludes that over 1.2 billion tons of dry biomass could be produced in a sustainable manner. This is equivalent to 21 billion GJ of energy and represents 21% of the U.S. energy consumption.

Although biofuels will probably dominate the output of biorefineries, other potential products include commodity chemicals, natural fibers, and electricity. At present, commercially available biobased products include adhesives, cleaning compounds, detergents, dielectric fluids, dyes, hydraulic fluids, inks, lubricants, packaging materials, paints and coatings, paper and boxboards, plastic fillers, polymers, solvents, and sorbents although most of these are not produced in the context of biorefineries.

Biorefineries can be based on either the sugar platform or the thermochemical platform. The sugar platform fractionates fibrous (lignocellulosic) biomass into hexose, pentose, and lignin. The carbohydrate fractions are fermented to ethanol and other products while the lignin serves as boiler fuel for generation of process heat. The thermochemical platform breaks down plant material into carbon monoxide (CO) and hydrogen (H_2). This so-called syngas can be catalytically reacted to produce alcohols, carboxylic acids, and hydrocarbons. Hybrids of these two processes can also be envisioned.

Giant refineries characterize the petroleum-based motor fuels industry because plant operating costs per unit of production decrease as the facilities get larger, whereas feedstock transportation cost per unit of production remain relatively constant. The case is more complicated for biomass feedstock because it does not come from a single mine-head located a fixed distance from the plant, but is dispersed over a large area surrounding the plant. Delivery cost for a unit of biofuel increases as the capacity of the plant increases because the biomass must be transported over increasingly greater distances. Thus, an optimal plant size is expected that achieves the lowest unit cost of renewable fuel. This optimal size may be very different for biorefineries based on sugar and thermochemical platforms.

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Tools for Efficient Crop Development

IDENTITY PRESERVATION IN NEW OILSEEDS: U.S. AND EU BIOBASED PRODUCTS COLLABORATION

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In 1990, the European Commission and the U.S. White House, Office of Science and Technology formed a task force to promote information exchange and coordinate biotechnology research programs funded by the EC and US government. Out of that task force, a biobased products working group was established in 2004 to develop sustainable sources of energy and raw materials for industry. A portion of this working group is devoted to biobased materials from plant oils working towards the production of non-food oils for industrial applications.

In this presentation, the considerations and efforts of this working group to produce industrial oils in crops will be described. In addition to describing proposed industrial targets, issues surrounding identity preservation of these "industrial seeds" will be discussed. Furthermore, the use of non-food crops as platforms for the production of industrial oils will be explored.

USER-FRIENDLY GIS: HELPFUL TOOLS FOR CROP DEVELOPMENT

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Geographic Information System (GIS) applications provide a wide range of tools that can increase the efficiency for developing new crops. Thanks to the growth of applications that are user-friendly and relatively inexpensive, scientists developing new crops can capitalize on the technology without needing to be GIS specialists. The objective of this paper is to highlight user-friendly GIS tools that can help scientists identify, evaluate, and develop new crop species and new uses for existing crops.

Several applications have been developed that allow scientists to model the geographic distribution of species or assess habitat suitability for species. FLORAMAP has user-friendly software that uses occurrence and climate data to create maps showing the most likely distribution of the targeted species. These types of maps are useful for planning seed collection trips. BIOMAPPER builds habitat suitability models using Ecological Niche Factor. DESKTOP GARP can also be used to model species distribution. WHYWHERE allows users to use latitude and longitudes to not only generate a predictive map, but also provide an explanation for the distribution of the points. WEBGRMS, a recent web-based prototype, illustrates a practical approach that allows users to identify germplasm accessions collected in climates similar to the environment targeted. DIVA GIS is freely available, general purpose GIS software that allows users to plot where plant species were observed, map the distribution of biological diversity (e.g., species richness; Shannon index), identify areas that have complementary levels of diversity, extract climate data for accession points and assign and verify map coordinates based on locality data. HORTIVAR, developed by the Food and Agriculture Organization (FAO), allows users to identify horticultural cultivars and cropping practices adapted to their specific requirements and environment.

The GIS tools mentioned are available freely or at low cost and are relatively straightforward to use. Depending on objectives, scientists developing new crops may find these tools and others useful in their work.

HARNESSING INFORMATION TECHNOLGIES FOR MORE EFFICIENT CROP DEVELOPMENT

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Candidate new crops must survive a gauntlet of scrutiny by researchers, producers, processors, marketing specialists, and others. Increasingly in this process, quantitative data are displacing anecdotal information and personal judgments. Information technologies (IT), including databases, geographic information systems (GIS), automated instruments, and the Internet are keys to the move to decision-making supported by quantitative data. IT has already greatly assisted crop development. However, IT can further benefit crop development through greater integration of data across disciplines and software. Stakeholders must move from individual, isolated software tools and data sets to a realm where information flows smoothly from field and laboratory studies to diverse types of software capable of linking crop-specific data to information on climate, soils, production regions, markets, or other topics relevant to decisions of stakeholders. This paper examines benefits from data integration, with examples from data management, simulation modeling, and geographic information systems (GIS).

The International Crop Information System (ICIS) is a software system for managing agricultural research data and includes tools for tracking pedigrees and selections, preparing fieldbooks, and describing individual experiments. Developed through collaboration among international centers, universities and the private sector, ICIS has recently been used to consolidate data on Lesquerella, and Vernonia to facilitate breeding and promotion efforts.

Agricultural research often involves data analyses to describe crop response to genotypes, environments, and management. Simulation models, which integrate knowledge on physiology, genetics, soil chemistry, and climatology, can predict both crop performance and effects of the crop on the environment, such as water and nutrient requirements

and impacts on soil organic matter. Model outputs are no better than data used to calibrate and run the simulations, so work is underway to link crop databases to modeling efforts. This effort also seeks to establish data-interchange standards that will have applications far beyond modeling *per se*.
Stakeholders often seek to understand where a promising crop can best be produced, considering both biological potential and access to processing facilities or markets. GIS can provide this geographic context, but again, it is more efficient when reliable, spatially explicit data on crop performance, climate, soils, and location of markets or other facilities are readily available in standard formats.

While information technology already contributes tremendously in the development and promotion of new crops, component technologies such as databases, simulation modeling, and GIS offer even greater potential when they are fully integrated. Groups seeking to develop new crops should emphasize sound data management with a goal of achieving full integration across disciplines and software tools.

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POSTER PRESENTATIONS (Herbs, Botanicals, Medicinals, Fruits, and Vegetables)

IMPROVING STRESS TOLERANCE AND QUALITY IN SPEARMINT THROUGH IN VITRO SELECTION

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Conventional breeding programs designed to improve medicinal and aromatic plants are frequently time and labor consuming due to their tiny flowers and erratic blossoming schedules. The use of tissue culture in the selection process enables a relatively rapid differentiation among types for desirable traits. Those selections with modified traits can be grown into full-sized plants for field and greenhouse evaluation. In this study, tissue culture was used to select for drought resistance and enhanced oil production in spearmint.

Clonal lines of spearmint were started from seed germinated on MSBAP media in 3 percent Phytagel™. Roots were induced by transferring the developing shoots to ½-MSHF medium (3 % Phytagel™) for root development. Rooted seedlings were subsequently acclimated by growing them in sterilized vermiculite for two weeks and then transferring them into a standard greenhouse mix in 13 cm diameter pots for 30 days. Plant growth and development were monitored by measurements of fresh and dry weight and chlorophyll content. Total phenolics and proline content were extracted and then measured spectrophotometrically. Resistance to drought stress was initially measured by exposure of the seedlings on Phytagel™ to the proline analog L-azetidine-2-carboxylic acid (A2C).
From among the 22 clonal lines isolated, 10 exhibited elevated resistance to A2C and salt stress. Clonal lines with tolerance to A2C had increased levels of proline and phenolic content. Total phenolic concentrations ranged from 2.75 mg/g to 6.82 mg/g fresh weight. Total phenolic concentration ranged from 9.57 mg/g to 14.91 mg/g fresh weight at the highest concentration of A2C (200 µM) tested. Free proline concentration ranged from 22.73 to 52.81 µmol/g fresh weight.

The use of tissue culture enabled the rapid development and screening of spearmint types exhibiting rapid growth, a relatively high level of secondary metabolites, and resistance to environmental stress. Use of the clonal lines may prove beneficial in the development of other medicinal and aromatic plant lines.

ECHIUM (*Echium plantagineum*): A SOURCE OF STEARIDONIC ACID ADAPTED TO THE NORTHERN GREAT PLAINS

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Echium plantagineum is a new crop grown commercially in the UK primarily for the cosmetic industry. Echium's oil composition, of stearidonic and gamma-linolenic fatty acids and a unique omega-3/omega-6 ratio, promotes anti-wrinkling properties in skin care lotions. The objective of this study was to evaluate echium's adaptation, seed yield potential, and oil composition at different global locations, and also to evaluate seeding date effects on crop performance in North Dakota.

A preliminary evaluation of echium's adaptation was performed at Carrington, Minot, and Prosper, North Dakota from 2002 to 2004 with subsequent evaluation of seeding date effects in 2005 and 2006. Measurements were recorded for days to emergence, days to flowering, plant height, biological and seed yields, harvest index, and oil content and composition.

Sixteen wild populations of echium seed were collected in southern Chile between 35º to 41º S latitude in December 2002. These populations were evaluated in Chillán, Chile in the 2003 to 2004 and 2004 to-2005 seasons, and at Prosper, North Dakota in 2005. The experimental design was a randomized complete block design with two replicates. Evaluations were days to flowering, plant height, oil content, gamma-linolenic acid (GLA), and stearidonic acid (SA) content.

At the North Dakota locations, biological and seed yield, ranged from 3.3 to 11.5 t ha-1, and 63 to 425 kg ha-1 , respectively. Reduced yield was indicated with delayed seeding in 2005. Oil content was 272 and 298 g kg-1 at Prosper in 2003 and 2004, respectively. The GLA and SA contents were, respectively, 11.3 and 11.6 % (2003), and 13.5 and 15.2% (2004) at Prosper.

In Chile, seed oil content ranged from 270 to 395 g kg-1 and seed yield was between 115, 617 kg ha-1 in 2003 to 2004, and 191, and 517 kg ha-1 in 2004 to 2005 for the wild echium populations. Among wild populations, differences were not observed for alpha linolenic acid and SA, which averaged 38% and 12%, respectively, of the seed oil. Differences among wild populations were observed for GLA content with the greatest amounts at 9.9% of the seed oil.

Two of the wild echium populations collected in Chile that were grown in North Dakota failed to flower and several others flowered late in the season and produced few mature seeds. The highest GLA and SA contents were 11.9 % and 13.5%, respectively, for those populations producing sufficient seed for analysis.

Echium has good production potential for eastern North Dakota. The crop can be produced with conventional equipment presently used for planting and harvesting making this crop a potential alternative for the region.

Genetic diversity identified among the wild Chilean echium populations is a valuable germplasm source for the development of improved commercial echium cultivars.

NEW CROP OPPORTUNITIES FOR KENTUCKY

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The New Crop Opportunities Center at the University of Kentucky was established in July 2000 to provide Kentucky farmers with production and marketing information on crops that are potential alternatives to tobacco. Horticultural crops and specialty grains, two traditionally underfunded research areas, were chosen as the focus of the Center, which is funded by the United States Department of Agriculture through a Special Grant.

To aid in determining which crops to focus on, the Center solicits ideas from growers, Extension agents, and industry leaders, as well as an advisory committee. Funded research projects are generally conducted on at least one of four university research farms. Grower demonstration plots are often part of the New Crop Opportunities research program. The Departments of Horticulture, Plant and Soil Science, Agricultural Economics, Entomology, Plant Pathology, Biosystems and Agricultural Engineering, and Food Sciences are involved in new crops research. Current research includes projects on strawberries, organic production systems, blueberries, burning bush, woody cut stems, edamame, soft red winter wheat, and corn for ethanol production, chia, flax, hulless barley, and pot-in-pot nursery production.

Cooperative Extension Service agents, as well as farmers, compose the primary audience for new crop information, which is offered through the Center's Web site. In addition to production information about crops that are the focus of

the Center's research, the Web site offers information about a number of additional crops that have potential for Kentucky. The Crop Profiles page includes 90 fact sheets with introductory information on fruit, vegetables, grains, herbs, and mushrooms, as well as topics such as agritourism, beekeeping, and honey production, starting a nursery business, and the organic certification process. These profiles are designed to help farmers choose the alternative crops that are right for them. The Web site also offers a series of marketing profiles to help farmers determine what marketing avenues best suit their enterprises and personalities. The Center also participates in training programs for Extension agents as well as workshops for growers.

New Crop Opportunities Center research and information dissemination is helping Kentucky growers acquire profits from growing markets. For instance, the floriculture/ornamental industry in Kentucky saw an increase of $8 million, or 10% in cash receipts in 2005. Meanwhile, more than 1,800 vendors sold in farmers markets in Kentucky in 2005, and the number increases each year. Farmers markets account for about one-fourth of all Kentucky farm produce sales. The state has seen an increase of 53% in the number of vegetable acres planted since 1997, the second highest increase in the United States.

For more information about the New Crop Opportunities Center, visit the Web site at http://www.uky.edu/ag/newcrops .

DEVELOPMENT OF LATE BOLTING CULTIVARS OF ARUGULA

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Arugula is a fast growing, cool-season crop of the Brassicaceae that is increasingly popular as a salad green in Europe, especially Italy, and is gaining popularity in the United States. There are two forms: cultivated arugula (*Eruca sativa*) and wild arugula (*Diplotaxis tenuifolia*) The cultivated arugula, also known as *rocket* (English*), roquette* (French), *rucola* or *rughetta* (Italian) is a low-growing annual with dull-green, deeply-cut leaves. It contains glucosides, such as allyl sulphonocyanate, which give this vegetable a distinct spicy-pungent flavor. During the vegetative stage, the leaves of arugula are large and arranged in a rosette.

The plant sends up a seed stalk (bolts) in response to vernalization, high temperature, and long days. Greenhouse selection for late bolting arugula is possible through selection of germplasm subject to long days followed by recurrent selection. In the greenhouse. A late bolting cultivated arugula named 'Adagio' has been selected from Italian germplasm. 'Adagio' is very late bolting when nonvernalized, but is later bolting than traditional cultivars even under vernalized conditions.

Selection for the late blooming is underway in *Diplotaxis tenuifolia*. Selection for the late bolting wild arugula is also underway.

THE PRODUCTION OF NATIVE AND EXOTIC HERBS, MEDICINAL, AND AROMATIC PLANTS IN ARGENTINA

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Herbs, medicinal, and aromatic plants (HMAPs) are a diverse group of plants with potential to contribute to

economic development. Argentina has a long history of using and producing HMAPs where more than 60 species are commonly used (either collected from the wild or cultivated) to produce different types of raw and finished products such as fresh, dried or ground flowers, leaves, and roots, and their extractable essential oils and oleoresins. This presentation will provide an overview of the HMAPs, both exotic and native, that are produced in different regions of Argentina.

The HMAPs are largely produced in seven different regions. The main herbs that are cultivated include chamomile, oregano, lemon verbena, mints, common hops, and boldo (*Peumus boldus*). The main seed spices that are cultivated include coriander, *Capsicum* species, thyme, nutmeg, and others. The native flora also offers important species that are used commercially and are still collected from the wild with the main ones including "poleo" (*Lippia turbinata*), "incayuyo" (*L. integrifolia*), and "carqueja" (*Baccharis sp*).

Although the statistics are difficult to confirm, about 80 to 90% of the producers of HMAPs is estimated to be small-scale farmers cultivating less than 1 ha. The potential of commercially growing and marketing HMAPs in Argentina by both large and small-scale farmers has generated significant interest during this recent time period where the local currency exchange rates would be favorable for growers to produce and process both native and exotic HMAP for the export market. Argentina does have a significant private sector involved in this agricultural subsector as well as a strong and supportive public sector that is working on developing HMAP as a national industry.

QUALITY ATTRIBUTES OF ESSENTIAL OILS FROM MADAGASCAR

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The commercial potential of essential oils remains of interest to developing countries around the world. With over 28,200 tons of essential oils produced worldwide every year at an estimated value of $18 billion, of which China contributes about 16,600 tons, African countries contribute collectively less than 1% of global production. One of the major factors limiting increased trade and market penetration of African essential oils has been the lack of quality standards and in the challenge of meeting product specifications of the international marketplace. The present study describes the quality attributes of Malagasy essential oils and strategies to enhance their competitiveness.

The organoleptic, physical and chemical properties were determined in selected Malagasy essential oils including different fresh ginger chemotypes (*Zingiber officinale*), cinnamon bark (*Cinnamomum zeylanicum*), clove bud, and black pepper essential oil (*Piper nigrum*). These Malagasy essential oils were compared with the same essential oil products coming from competing countries. Other lesser-known essential oils were also included in this study such as Niaoli (*Melaleuca sp.*), ravintsara (*Cinnamomum camphora*), and ravensara (*Ravensara aromatica*).

The essential oil of ginger was found to have a unique aroma (rose notes) and chemical profile (rich in geraniol and geranyl acetate) that could present novel new essential oils for international markets. While the essential oils of cinnamon bark were found to contain low levels cinnamic aldehyde, and some new applications may prefer such lower levels of international standards still need to recognize that such levels are typical of Madagascan cinnamon and from younger trees. The quality of black pepper essential oils and the clove oil, as expected, was very high and resembles those found in international markets, and Madagascar remains a major global supplier of these and other oils.

Several lesser-known Malagasy essential oils included in this study are unique products that have promising potential in international trade. The implementation of a science-driven model coupled with well-defined standards will assist in the commercialization of these Malagasy essential oils by highlighting their chemical and quality attributes.

SCREENING THE GENE POOL FOR SPECIAL USES IN CORIANDER

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Coriander (*Coriandrum sativum* L.) is a member of the Apiaceae family with a wide diversity of uses. Its rapid life cycle allows it to fit into different growing seasons, making it possible to grow the crop under a wide range of conditions. Three subspecies and 10 botanical varieties have been proposed at the infraspecific level in coriander. However, molecular evidence does not support classifications based on phenotypic and/or biochemical characteristics.

The objective of this study was to reveal phenotypic and biochemical characteristics of coriander populations suitable for different uses and to use amplified fragment length polymorphism (AFLP) to clarify patterns of genetic diversity among these populations.

In 2002 and 2003, two field trials were conducted for phenotypic characterization of 60 coriander accessions from the North Central Regional Plant Introduction Station in Ames, IA. In 2004 and 2005, biochemical and molecular analyses were carried out, measuring essential-oil and fatty-acid content, and yields of linalool and petroselenic acid on a per plant basis. Accessions were grouped by suitability of use: as spices and vegetables, for high essential-oil and fatty acid contents, and for high linalool and petroselenic-acid yields.

Eight accessions were considered to be suitable for use of their fruits as a spice, and they are characterized by their high 1000-fruit weight. They all exhibited a short life cycle and originated from Canada, India, Mexico, Netherlands, and Oman. Morphologically, they conform to the subspecies *sativum* and *indicum*. Two accessions with longer life cycles and many basal leaves were considered to be suitable for use as vegetables. They originated in the Russian Federation and Syria, and can be considered morphologically intermediate between subspecies *indicum* and *microcarpum*. Two accessions, representing subspecies *microcarpum* displayed high overall essential oil contents. They were intermediate in life cycle and came from Tajikistan and Uzbekistan. These same two accessions presented the highest linalool yields per plant. Five morphologically diverse accessions with high fatty acid content were intermediate to late in cycle. They came from the Republic of Georgia, Mexico, Pakistan, Tajikistan, and Turkey. The highest petroselenic acid yields were obtained from five accessions with intermediate life cycles, from Mexico, United States of America, and Tajikistan. Subspecies *sativum* and *microcarpum* are represented in this group. In spite of clear differences in phenotypic and biochemical characteristics among these groups, an Analysis of Molecular Variance based on AFLP data provided no clear molecular support for these groups.

KOREAN VEGETABLES, GREENS AND HERBS: NEW FRESH PRODUCE FOR EMERGING ETHNIC MARKETS

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Rapid urbanization, coupled with increasing land values and rapidly changing demographics (> 32% ethnic population in 2000) provide a compelling case for high-value crops in New Jersey. New Jersey now has the most diverse ethnic population of any state in the U.S. The introduction of fruits and vegetables, long known to those ethnic communities, but largely unknown to most American farmers, creates a potential opportunity in the search for new market-driven fresh produce.

A multidisciplinary research and extension team in concert with New Jersey agricultural leaders, growers, and

marketers came together to examine the production and market potential of Hispanic/Latino, Asian, West African, European, and Russian crops. Our preliminary results were favorable in evaluating the production potential of Korean vegetables in New Jersey.

Seeds of Korean vegetables were obtained from our South Korean partners and from Korean and American commercial seed companies. Ten species of 13 varieties of Korean vegetables were evaluated in numerous field trials conducted from 2001 to 2006 at three agricultural research farms in New Jersey representing three distinct climatic growth zones. Each trial analyzed plant performance, yield, and quality.

The Korean vegetables screened in this applied research included: (a) Korean cabbage, *Brassica campestris*; (b) Korean lettuce, *Lactuca sativa* L.; (c) CheongKyungChe, *Brassica campestris*; (d) Korean radish, *Raphanus sativus*; (e) Chicory, *Cichorium intybus* L., (f) (edible) Chrysanthemum, *Chrysanthemum coronarium*; (g) Cucumber, *Cucumis sativas* L., (h) Korean wild chives, *Allium thunbergii*; (i) Korean chives, *Allium tuberosum*; (j) Balloon flower, *Platycodon grandiflorum;* and (k) Perilla (*Perilla frutescens*).

From these studies, we conclude that:

(1) New Jersey climate and soil are suitable for the production of many Korean vegetables;

(2) The production of locally grown Korean vegetables can provide the Korean and Asian populations in New Jersey with products that they are familiar with and other consumers with new specialty products;

(3) These emerging markets can provide additional income and opportunities to New Jersey and other American farmers.

BREEDING SWEET BASIL (*OCIMUM BASILICUM* L.) FOR CHILLING TOLERANCE

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Sweet basil (*Ocimum basilicum* L.) is a tropical species native to East Africa known to be very sensitive to chilling injury. Sweet basil can be damaged in the field by chilling temperatures both in the spring and fall, and can be injured when stored and transported to the market under cold temperatures used to transport other fresh culinary herbs and vegetables. Temperatures below 5EC lead to significant leaf necrosis. In basil, chilling causes brown discoloration of the interveinal leaf areas, increase of leaf blade thickening, decrease of plant growth, reduction of the post harvest shelf life, and deterioration of product quality and marketability

Tolerance to cold environments has long been a target for plant breeders for a wide range of crops. Chilling tolerance has been well studied from a wide range of disciplines including genetics and physiology in the quest to both understand the underlying mechanisms of chilling injury for the plant species and identify the protective mechanisms that could be used in plant improvement. However, few studies have detailed how cold tolerance is inherited, and fewer still have examined this for annual plants and herbs of tropical origin. The expression of certain kinds of cold tolerance from primary crosses has relied on examining the inheritance of the progeny from crosses between cold tolerant and sensitive parents. This project identified and developed chilling tolerant genetic materials in basil to better understand the nature of the chilling damage while developing chilling tolerance through screening, selection, evaluation, and physiological adjustment under low temperature.

Since 2001, thousands of plants were screened for chilling tolerance. Initial screenings subjected basil plants to chilling temperatures by comparing the growth of 720 plants every week, for 8 weeks, in a cold chamber at 4ºC, for 48 h to 96 h. By following the screening of thousands of plants, 70 genotypes that exhibited little to no chilling injury as visually determined were selected, seed collected and their chilling tolerance reconfirmed. Sensitive lines were also identified, reconfirmed, and maintained for comparative physiological studies. After further screening, two chill tolerant and two chill sensitive genotypes were selected for a heritability study. These four genotypes were both crossed and self-pollinated and have been followed for several generations. Results show that the chill tolerant trait is inheritable. We now have over 20 advanced lines with chilling tolerance. Parallel physiological studies show a strong association between foliage chilling injury, leaf water content membrane leakage, and stomatal conductance (prior to the chilling stress). Several non-breeding approaches to mitigate against chilling injury in sensitive or traditional sweet basil by altering post-harvest handling practices also have been identified that appear promising.

EVALUATION OF EDAMAME VARIETIES IN THE MID-ATLANTIC

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The edible soybean (*Glycine max* (L.) Merr.) or Edamame is increasing in popularity as a niche vegetable crop. Asians consume fresh or salted edamame much as Americans consume peas and peanuts. The increase of soy products in the news, touting their health benefits, has increased the public's awareness of this traditionally Asian vegetable. To develop production information for growers of this new crop, organic variety trials were conducted in New Jersey and Maryland (2002 - 2005) to determine its suitability in the Mid-Atlantic region.

In New Jersey, 16 edamame cultivars were established in replicated trials to evaluate seasonality, marketable yields, and pod/bean quality. Five, long vine type cultivars were found to achieve maturity too late in the season for commercialization and two varieties lodged excessively. Shorter season varieties of approximately 80 to 90 days were best for production in crop growth zones 6 and 7. Highest marketable yields were found with varieties Emerald, Green Legend, Giant Black Seed, and Taiwame. Yields ranged from 148.0 to 389.6 g/plant.

In Maryland, three weed suppressing treatments were evaluated to assess the economic feasibility of these varieties when organically grown. Vegetable soybean cvs. BeSweet 292, BeSweet 2020S, Dixie, 414F, and Moooncake were grown with straw, compost, and clover (as a living mulch) to suppress weeds. Compost and straw were both applied at a depth of 10.2 cm and clover was applied at a rate of 39.2 kg/ha. Overall, the weed suppression methods did not have an effect on plant population. However, compost resulted in the highest yield and pod number per plant (7,530 kg/ha and 33.8 pods/plant, respectively). Variable environmental and cultural conditions (rainfall, seed size differences) resulted in inconsistent yields. However, the Dixie cultivar had the highest yield (8,137 kg/ha) and plant population (34,323 plants/ha).

Phytochemical comparisons were made between some of these edamame trials and concurrent trials with tofu soybean varieties. New analytical methods were developed to determine the major isoflavones among these Asian legumes that are used as human food. The major isoflavones identified were daidzein, glycitein, and genistein. There was both a difference in isoflavone content among the mature tofu soybean varieties that all had significantly higher yields of these isoflavones than the immature edamame varieties. This new method utilizing High Performance Liquid Chromatography in conjunction with the Electrospray Mass Spectrometer proved to be practical, rapid, and reliable to quantify simultaneously the three major isoflavones as well as the minor ones.

CATMINT (*NEPETA* SPP.): A SOURCE OF ESSENTIAL OILS

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Catmint (*Nepeta* spp., Family Lamiaceae) contains about 150 species and is considered in the horticultural trade as

an ornamental. Catnip (N. *cataria*) a short-lived perennial herbaceous plant is perhaps its best-known species long recognized as the plant that induces a state of euphoria and stupor in domesticated cats. Research has shown that the essential oil of catnip is largely responsible for the plants biological activities including its application as a cat attractant, insect pheromone, and insect repellent activity.

Limited commercial acreage of catnip has been centered in the Western U.S. and Canada with most of that acreage dedicated to the production of essential oils or for seed production, whereas smaller farms have focused on the production of dry leaves for catnip toys and herbal uses. Despite the increased interest in this plant as a natural source of insect repellent activity, few studies have documented the horticultural attributes and yield potential. As a source of essential oil, the production of catnip on a large-scale is challenging because the available varieties are relatively low biomass producers that do not accumulate high amounts of essential oils.

We report on studies that were conducted to evaluate the yield potential of catnip under a variety of geographical locations and the impact on the available sources or lines of catnip relative to their growth and essential oil yields. We also report on our ongoing selection program that was initiated in 2001 to identify new novel types of catnip and higher yielding lines rich in nepetalactones.

SUSTAINABLE DEVELOPMENT OF AFRICAN NATURAL PLANT PRODUCTS

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The development of sustainable agricultural businesses in high-value niche sectors could stimulate agricultural growth that will not only improve the livelihoods of rural Africa, but also have a multiplier effect on the rest of the economy. The natural plant product (NP) industry is one of such industries that can offer higher income and niche markets for resource limited farmers in developing countries compared with many traditional agronomic crops. However, the NP industry is beset with a number of challenges hindering the realization of its full contribution to economic development and poverty reduction. Among these challenges are: (1) limited appropriate germplasm for cultivation; (2) lack of quality control and quality assurance systems for production and processing; (3) lack of knowledge and understanding of international markets and markets channels; (4) limited processing infrastructure that effectively constrains value-added opportunities; and (5) weak enterprises with low technical and managerial skills to meet the requirements of buyers.

In 1999, we began to develop models for the sustainable commercialization of NP in sub-Sahara Africa using a market-first and scientific-driven approach. This program is implemented under the Agri-Business in Sustainable Natural African Plant Products (ASNAPP) program (see www.asnapp.org.gh) and funded through a variety of programs and agencies and multitude of public and private sector partnerships including but not limited to the USAID. This partnership has developed a sustainable development model for the diversification of valuable agricultural commodities and marketing channels including a proactive from bush to final product quality assurance (QA) and quality control (QC) system for collection and/or cultivation through harvesting of raw botanical materials to help obtain reproducible high quality natural products. This evolving model consists of a multi step value-addition process

through the production chain that provides local, regional, or international consumers with safe and high quality NP products. Our NP programs are now in Ghana, Rwanda, Senegal, South Africa, and Zambia with newer pilot programs in Angola, Malawi, and Mozambique.

ARTEMISIA ANNUA: PRODUCTION IN SUB-SAHARAN AFRICA

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Malaria continues to be a major infectious disease affecting those living in tropical regions of the world. WHO estimates an annual infection of nearly a billion/year and they now recommend the use of artemisinin-combination treatments (ACT) as the first line treatment for multi-drug resistant falciparum malaria. Pharmaceutical companies manufacture ACTs using derivatives of artemisinin, a natural product from Artemisia annua but artemisinin supplies are in short supply while demand is very high. The major commercial production regions include China, Vietnam, and East Africa (Tanzania/Kenya). Several challenges face the commercial production of artemisinin including lack of available high quality and affordable seed, low artemisinin yields, and limited number of commercial processors handling the raw dried herbal materials from producers.

Due to the short supply and the emerging demand for artemisinin-derived anti-malarials, many other countries are exploring the feasibility of large-scale production. As part of our international development work (see: www.asnapp.org) and history of working on the biology of the plant, and in developing high yielding lines, we established trials in several sub-Saharan African countries to ascertain the adaptability and commercial production potential. This paper will review the highlights of several trials conducted in Ghana, Madagascar, Rwanda, Senegal, South Africa and in the USA at Rutgers University, where several of the same selections were comparatively evaluated.

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POSTER PRESENTATIONS (Industrial Crops: General Crops)

OIL PUMPKINS: A NICHE CROP FOR QUALITY ORGANICALLY GROWN PRODUCTS

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Consumer’s demands, especially in developed countries, are for healthy food with high nutritional value. It might be a new challenge for small-scale and part-time farmers to develop a new market niche, assuming that farmers are convinced of the food benefits and have knowledge about organic crop management. In the case of limited knowledge

about organic production of oil (seed) pumpkins (*Cucurbita pepo* L. group Pepo) and potential use of their healthy and nutritional products, the aim of this contribution is to present arguments and possibilities about how to increase their production, use, and marketing.

Based on research, case studies, personal experience in organic farming, professional and scientific literature, we want to provide farmers, advisers, and teachers an extensive overview of the production system and the main characteristics of the products, as a base for successful decision and eventual development of this target niche for marketing.

To take into consideration growth conditions for the family *Cucurbitaceae*, there are little important differences between the conventional and organic production of oilseed pumpkins, except for weed and disease suppression. Weed suppression under organic production system should be based on good crop rotation, and mechanical and manual weeding. An alternative to avoid diseases is to use organically grown seedlings instead of traditional sowing. Appropriate plant population and available nitrogen in the soil have an important influence on the quantity and quality of fruits and seeds. Additional quality of organically grown certified seeds, oil, and other products is in their use in traditional (seeds are fumigate for the stomach and therapy for prostate gland, …) and official medicine (due to its antioxidative compounds, which help improve the life quality of patients suffering from benign prostate hyperplasia, patients with HIV/AIDS, influence on hormone regulation, etc.)

Nutritional value of the oil is also very high. Depending on the process of pressing, the oil could be cold pressed or pressed after thermal procedure, which affects the oil's special taste and color. The preceding facts, clear inputs of production, selling prices, and consumer requests have to be taken into account by producers for further decisions. As a support for decision about production of oil pumpkins and additional marketing, a multi-criteria model for decision on organic farms developed at the University of Maribor should be helpful.

The discussions presented about the oil from the seed of pumpkin and the possibilities for its organic production and benefits of their products with healthy and rich nutritional compounds might be a new niche crop for farmers.

POTENTIALS OF ANNUAL CEREAL CROPS SERVE AS FUEL ETHANOL FEEDSTOCK AND LIVESTOCK FEED

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Corn grain is currently the major feedstock for fuel ethanol production in the United States. However, little corn grain is produced in Montana due to its cool climate and short growing season. An alternative feedstock, therefore, must be explored for potential fuel ethanol production. There is an abundant, but underutilized supply of agricultural residues and herbaceous grasses available in Montana. In this project, we plan to (1) develop production systems to maximize biomass yield, and (2) evaluate annual cereal hay and straw as well as warm season grasses for potential fuel ethanol feedstock and livestock feed.

A double-cropping system was developed, where winter triticale was planted in the fall and harvested in mid-June for hay or silage followed by sweet sorghum or sweet stem pearl millet planted immediately into the field for a second harvest in late September. Enzymatic hydrolysis and fermentation were conducted for chemical pretreated and ensiled wheat, barley, and triticale straws, and barley, triticale, pearl millet, and sweet sorghum hays. The qualities of the hay and silage feedstocks were also measured for animal feed.

The double-cropping system developed in this study produced 47 to 56% more total biomass than planting winter triticale alone as single cropping for grain and straw. Enzymatic hydrolysis of chemically pretreated (2.0% NaOH or H_2SO_4) solids was conducted with Celluclast 1.5 L-cellubiase and Spezyme® CP- xylanase enzyme combinations. The glucan and xylan conversions during hydrolysis were 78 to 100% and 74 to 85%, respectively. The ethanol yield after fermentation of the hydrolysate from different feedstocks with *Saccharomyces cerevisiae* ranged from 0.27 to 0.34 g/g glucose or 52 to 66% of the theoretical maximum ethanol yield. The overall sugar conversion was 18 to 59% (drymass basis) for ensiled feedstocks. The ethanol yield from the ensiled feedstocks tested ranged from 0.21 to 0.28 g/g (reduced sugar basis) or 40.1 to 54.9% of the theoretical maximum ethanol yield. Quality test shows that winter triticale, sweet sorghum, and sweet stem pearl millet hays have very good relative feed value (>91%). The hays have

32 to 35% ADF, 59 to 65% NDF, and 12 to 19% protein content.

In conclusion, biofuel feedstock production may be integrated with existing livestock production systems in Montana and multi-product crops evaluated in this study may be used both for biofuel feedstock and livestock feed.

QUINOA: AN ALTERNATIVE FOR LEAF PROTEIN CONCENTRATES

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At present, the research development on green biomass have led to programs for developing large scale production (units and equipment) for maximum exploitation in more than 70 countries around the world. Obtaining foliar protein could contribute to solve the protein deficit for animal nutritional feeding. Quinoa (*Chenopodium quinua* Willd) is a pseudocereal that is tolerant to drought and frost that has potential use as human food and forage crop because the grain, stem, and leaf have high protein content and adequate amino acid composition.

The objectives of this study were to determine the optimum harvest time of quinoa in order to obtain foliar protein concentrates, and its respective quality evaluations.

Quinoa var. Chucara was sown in early June on the University experimental field under a randomized block design with eight replications. Treatments consisted of six cuttings at 4, 5, 6, 7, 8, and 9 weeks after seeding. The cuttings were done manually at 5 cm above soil level. From this material, samples (1.25 kg) of whole plants (leaf and stem) were taken and subsamples of five plants were subjected to observation on the crystals (salts) occurring on the upper and lower leaf surfaces, and stem with the optical microscope in reflected light at 50X, to determine the size and density of the crystals.

The plants (1 kg) were separated into leaf and stem, and cut into 1 to 3 cm pieces. This material was blended two times (10 s each) in a food blender with distilled water in a 1:1 proportion. The material blended was centrifuged at 6000 rpm for 30 min to separate the fibrous residues from the green protein juice. The latter was coagulated by precipitation with an acid (1 M HCl, pH 4.5) and heat (85°C for 5 min). The precipitate was washed with acidified water and separated by centrifugation (6000 rpm for 30 min). The concentrate and residues were then dried in an oven at 60°C for 72 h. At all steps of the process (leaf, stem, residues, and concentrate), samples were taken and the dry matter, nitrogen, crude fiber, ash, calcium, and phosphorus were determined.

Crystals (salts) were present on the lower leaf surface at the 4th and 5th cutting. The chemical analyses will be presented.

WINTER PEA EVALUATIONS IN NORTH DAKOTA

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Production of winter annual crops can benefit on farm workload distribution, alter pest management, and produce potentially greater yields than spring-grown crops of the same type.

The objective of this study was to determine the performance of winter pea (*Pisum sativum* L.) cultivars grown in North Dakota.

The experiment was conducted in eastern North Dakota near Prosper during the 2005 and 2006 growing seasons. The previous crop was hard red spring wheat (*Triticum aestivum* L.) each year of the study with the winter peas seeded into the standing wheat stubble that was approximately 20 to 25 cm tall. The experimental design was a randomized complete block with eight winter pea cultivars sown in mid to late September, and one spring check cultivar sown in early to mid May. Seeds were sown to establish 741,000 plants ha-1 in plots consisting of 6 rows spaced 30 cm apart and 7.6 m long. Characteristics evaluated were fall stand, winter survival, spring stand, flowering date, plant height and lodging, seed yield, and seed weight.

Winter survival was influenced by wheat stubble erectness, snow cover, and air temperature during the dormant winter period. Cultivar winter survival ranged from 15 to 45% and 80 to 95% in 2005 and 2006, respectively. The onset of flowering was approximately three weeks earlier for the winter varieties than the spring check variety for each year of the study. Yield performance was affected by the level and uniformity of spring stands. Yields of the winter cultivars ranged from 25 to 50% of the spring check variety in 2005. Harvest of the winter varieties was 10 to 14 d earlier than the spring check variety for each year of the study.

Results provide the first information regarding winter pea performance in North Dakota and although encouraging indicate further improvement in variety winter hardiness and a definition of best management practices is necessary before engaging in commercial production.

GLUTEN-FREE CEREAL PRODUCTS

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Celiac disease is the inability for a person to digest gluten. Consequently, glutinous proteins build up on the intestinal lining, limiting absorption of food. The results vary in degrees from mild indigestion and flatulence to starvation and eventual death. In 2001, an estimated one person per 15,000 was considered gluten intolerant. Definitive evaluations required intestinal biopsy tests. Today, with improved technologies in DNA analysis, the estimate of gluten intolerance is closer to one person per 1,500, an order of magnitude less than predicted five years ago.

Cereals that contain gluten (wheat) and rye or related proteins such as the hordeins of barley are not useable by celiacs. Thus, cereal consumption has been limited to corn and rice. Western diets typically rely on more substantial cereals for breads, dry cereals, crackers, and cookie-type products. The challenge was to identify new cereals that meet standards for being "gluten-free" yet make acceptable products for consumers.

The gluten-free project at Montana State University initially focused on Indian ricegrass as a gluten-free cereal. Indian ricegrass, *Achnatherum hymenoides* (Roemer and J.A. Schultes) Barkworth was acceptable, but it has a strong, rye-like flavor and is difficult to clean due to the presence of a pubescence on the seed coat. Test weights are 232 kg/m3 (18 lb/bu) and a seed count of 360 seed/g (161,920 seed/lb). This potentially leads to contamination by glutinous cereals undetectable after cleaning and dehulling. A second source of gluten-free cereal is timothy, *Phleum pratense* L., another long-lived perennial with a test weight of 580 kg/m3 (45 lb/bu) and a seed count of 2,710 seed/g (1,230,000 seed/lb). Timothy seed while small is relatively dense and can be milled without seed coat removal. Timothy flour has a flavor similar to wheat. A third crop being developed is hulless oat, *Avena sativa* L., with a test weight of 750 kg/m3 (58 lb/bu). Oats represent an annual cereal alternative.

Product development for these cereals has involved evaluation and development of breads, cookies, pastas, and dry cereals. Product from Indian ricegrass includes only bread, as other products were judged unacceptable. Timothy has provided multi-purpose flour suitable for breads, cookies, dry cereals, and pastas. Oats have been limited to bread flours, noodles, cookies, and dry cereals.

The variety of gluten-free cereals that can be substituted for common cereals is substantial. The use of the more common cereal-like grains such as oats and timothy has allowed producer flexibility, better return to the farm gate, and variety for consumers desiring commonly available foods.

THE PHENOLOGY OF SESAME (*SESAMUM INDICUM*)

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Although there are many descriptions of the morphology of sesame, there is no description of the phenology. Understanding the phenology allows farmers to anticipate farming practices in order to perform them in a timely

manner. In developing crop insurance products, it is necessary to have a description on how the crop develops in order to define when and how the seed is produced.

The objective of this paper is to provide an initial description of the phenology of sesame.

This phenology is based on observations over 30 years on over 30,000 lines and 31 varieties of sesame under nursery conditions and commercial fields in Arizona, Texas, Oklahoma, Kansas, Oklahoma, Venezuela, and India. The lines are introductions from all over the world and crosses between those lines. The conditions have varied from irrigated to semi-irrigated to rainfed; from torrential rains to drought; from low inputs to high inputs; from early to late plantings; from sea level to over 1,000 meters elevation; after very high winds, light to heavy hail, frosts, hard freezes, and snows. The emphasis on this paper is on U.S. commercial varieties.

The phenology has been divided into the following four stages: (1) vegetative (until 50% of the plants have open flowers), (2) reproductive (until 90% of the plants have stopped flowering), (3) ripening (until physiological maturity), and (4) drying (until the crop is ready for combining). Three of the stages have been divided into phases. Because sesame has indeterminate flowering, technically the reproductive, ripening, and drying stages overlap from the bottom of the plant to the top. The sequence of the stages is the same in all conditions, but the length of the stages is affected by moisture, fertility, temperature, light, and daylength.

This paper provides a starting point to compare U.S. commercial sesame with the rest of the world. Just as Ashri's determinate mutant has affected the phenology of sesame, it is anticipated that mutations and other farming practices will provide eventual additions to this basic phenological description.

INFLUENCE OF SOURCES AND LEVELS OF K FERTILIZERS ON SUGARCANE CROP IN SALINE SOIL CONDITIONS

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In many regions of the World, soil salinization is a serious problem for agricultural practices. Anthropogenic salinization induced by improper water and fertilizer use results into the deterioration of soil properties, hinders plant germination and growth, thereby causing reduction in crop yield.

In this respect, a field experiment was conducted to study the effect of K fertilizer sources and levels on sugarcane crop in saline soil conditions.

Six treatments consisted of 175, 200, and 225 kg K_2O /ha as muriate of potash (MOP) and sulphate of potash (SOP) each was replicated three times in a Factorial Randomized Block Design (FRBD). Urea (340 kg N/ha) and SSP (170 kg P_2O_5 /ha) were common for all treatments. FYM at 10 MT/ha was spread before planting. The sugarcane variety Co86032 was planted at preseason of the years 2003, 2004, and 2005 at the Vasantdada Sugar Institute, Pune, India. The pooled data obtained after subsequent three years (2003-04, 2004-05, and 2005-06) field study revealed that significantly higher cane yield, sugar yield, CCS %, germination percent, tiller ratio, plant population, and millable height of cane were obtained with the treatment where 225 kg K_2O/ha was applied as SOP followed by 225 kg K_2O/ha applied as MOP fertilizer. A decrease in pH and ESP as well as maximum sulphur percent in leaf and sulphite content (ppm) in juice was present in the SOP-treated plots. The K contents both in the soil and leaf increased at the higher (225 kg K20/ha).

Overall, the study on soil, leaf, and juice suggests that sugarcane crop responded to the higher levels of K fertilizers and the sulphate form of K fertilizer (SOP) has an advantage over the chloride form of potassium fertilizer (MOP) in saline soil conditions in the sugarcane-growing region in Maharashtra, India.

DROUGHT TOLERANT M_2 SEGREGANTS OF SOYBEAN Cv. JS 335 AND CO(SOY)3

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Soybean (*Glycine max* L.) is gaining importance in recent years as a new crop in the southern part of India. The cultivation of the crop is constrained by inadequate moisture availability during the spring and/or summer season, especially at the pod initiation and pod filling stage. Evolution of drought tolerant cultivars through hybridization is tedious because of the very fragile and small sized chasmogamous and cleistogamous flowers of soybean. Moreover, only a very narrow genetic base is available in the germplasm of soybean maintained in India. Hence, an attempt was made to irradiate the soybean seeds of the Cv. JS 335 and CO (Soy 3) with gamma rays and ethyl methane sulphonate (EMS) to induce heritable variability for drought tolerance.

The seeds of these cultivars were irradiated with gamma rays 250 GY dose, EMS with a concentration of 0.2 and 0.4%, combinations of 100 GY + 0.2% EMS, and 100 GY + 0.4% EMS. The source used for gamma irradiation was Cobalt 60, available at the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, India.

Single plant M2 segregants were observed with different root densities, leaf thickness with higher grain yield, under imposed drought stress conditions compared with the parental check cultivars. Macro mutants *viz.*, dwarf, mutants with lancelet leaflets, small leaf, tall and tiny mutants with broader leaves were observed.

In the 250 GY gamma irradiation, a higher yielding M2 segregating plant, with higher root density and with heavier 100 grain weight was selected to study its progeny in the M3 generation. Similarly, in the combination treatments of 100 GY + 0.2% and 100 GY + 0.4% EMS, higher yielding plants with thicker leaves and higher root densities were also observed, which are potential sources for the development heritable drought tolerance in future generations.

It is possible to isolate in future generations, true breeding plants from the mutant selections with higher yield potential that can tolerate moisture stress.

PRODUCTIVITY OF BIOMASS CROPS AS INFLUENCED BY LANDSCAPE POSITION

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Biomass crops have the potential to produce a variety of products for use in the expanding bioeconomy. Numerous perennial plant species have been identified to serve as dedicated and custom-tailored feedstocks for the production of bioenergy and bioproducts, while also providing numerous positive environmental quality benefits. However, no single species is adapted to all of the diverse soil environments found within a typical production field. We propose a new strategy that optimizes the placement of energy crops on the landscape to promote economic growth, ecological and enterprise diversification, and improve environmental quality. The objective of this study is to determine differences in plant growth and development between a diverse set of plant species as a function of landscape position and to understand the relationship between plant growth and environment.

Field experiments are being conducted at the Agricultural Ecology Research Farm (AERF) at the University of Minnesota Southern Research and the Outreach Center in Waseca, MN. Seven landscape positions were identified based on a detailed terrain analysis of the site. These seven landscape positions encompass a range of terrain features including depositional, summit, flat, and hillslope areas. Hillslope areas were further delineated based on slope and aspect. Eight industrial crops were established within each landscape position. Crops included alfalfa, willow, poplar, cottonwood, false indigo, switchgrass, corn, and a polyculture. Plant growth and development data were collected over time in each landscape position. Soil physical/chemical characteristics and weather data were also obtained. Preliminary results show significant differences in plant growth and development between species within a landscape position as well as differences in individual species growth between landscape positions. From this data set, we can begin formulating a strategy for designing perennial-based cropping systems that optimize eco-industrial systems to produce renewable energy and biobased products.

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POSTER PRESENTATIONS (Industrial Crops: Oilseeds)

CUPHEA GROWTH STAGING

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Cuphea (*Cuphea viscosissima* Jacq. *x C. lanceolata* W.T. Aiton, PSR23) is a new oilseed crop designed for production in the northern Corn Belt region of the U.S. Cuphea's oil is high in medium chain fatty acids that are suitable for detergent/cleaner applications and have potential for cosmetics. Cuphea is an indeterminate plant that continues flowering until a killing frost. The first seed matures at the lower regions of the main stem and begins shattering before seed at the top of the plant reaches physiological maturity. Commercialization of cuphea will require a growth staging system for proper crop management regarding timing for pest control and harvest.

The objective of this study was to create a descriptive growth staging system that is useable for cuphea production. Cuphea was grown in field trials at Prosper, North Dakota in 2005 and 2006 to determine a growth staging system. Cuphea was sown at 21 kg ha-1 in mid to late May at a 13 mm seeding depth in rows spaced 30 cm apart. Visual descriptions of growth and development were recorded during the growing season from emergence to harvest. Cuphea exhibited an active hypocotyl emergence and required 115 to 168 GDD to reach 50% emergence. Cuphea vegetative stages are associated with the development of the main stem and begin with emergence of the cotyledons followed by leaf development beginning at the second node and progressing upward as the stem elongates. Vegetative stages from V2 to Vn were determined by counting the number of nodes on the main stem that have fully expanded leaves. Generally, cuphea plants initiate reproductive growth between stages V9 to V12, i.e., 9 to 12 nodes with leaf development on the main stem.

Reproductive staging begins at the R1 stage when the first flower opens on the main stem. This stage occurs at approximately 650 GDD from seeding**.** The plant continues to produce blossoms at the top of the plant while seed capsules begin to develop from the earlier blossoms at lower nodes and branches.

When there are six or seven developing seed capsules in the main stem, the crop has reached stage R2 that is described as "full bloom".

Stage R3 is reached when the first developing seed capsules from the lower nodes begin to split open along the dorsal area. This occurs at approximately 800 GDD from seeding, and indicates physiological maturity of the seed in that particular capsule.

Stage R4 is reached at 900 GDD and when approximately one-third of the seed capsules in the main stem has split open or begins to split open.

Stage R5 or harvest maturity is reached at 1100 GDD and occurs when approximately one-half to two-third of the seed capsules in the main stem is split open and initial seed shatter has begun.

A growth staging system is necessary to promote successful crop management for those involved in research and commercial production of cuphea.

PRODUCTS DERIVED FROM LESQUERELLA OIL

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Lesquerella fendleri is a member of the Brassicaceae (mustard) family. Lesquerella is a winter annual seed oil crop native to the desert southwestern United States and is currently undergoing an intensive research effort for its successful introduction into agriculture. Lesquerella produces a small seed that has 25 to 30% oil that contains 55 to

64% hydroxy fatty acid. The hydroxy fatty acids of lesquerella are lesquerolic (55–60%, 14- hydroxy-*cis*-11-eicosenoic acid) and auricolic (2–4%, 14- hydroxy-*cis*-11-*cis*-17-eicosenoic acid). The distribution of TG is 10% nonhydroxy acyl, 15% monohydroxyacyl, and 73% dihydroxyacyl, which indicate that lesquerella oil is essentially a difunctional triglyceride in terms of hydroxy functionalities.

The objective of this study was to develop industrial products with lesquerella oil or fatty acids as a starting material. In the past, estolides have been used to develop new products from new industrial crops. Estolides from lesquerella have been synthesized with two different methods either 200oC from the fatty acid or 130oC using a tin catalyst from the fatty acid or the triglyceride.

Estolides derived from lesquerella and castor 2-ethylhexyl esters with different saturated and unsaturated fatty acids were synthesized. These fatty acid estolides produced a series of functional fluids with excellent cold temperature properties having pour points < -53oC. In addition, the triglyceride estolides were synthesized from the hydroxy moieties of lesquerella and castor oils with oleic and saturated fatty acids. These triglyceride estolides also produced a series of functional fluids with excellent cold temperature properties having pour points < -36oC. These estolides went through further chemical modifications to produce a new potential industrial fluid.

Many new and useful products and applications have been developed for lesquerella oil and fatty acids.

CHARACTERIZATION OF CUPHEA PSR23 SEED OIL

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Several *Cuphea* species of the family *Lythraceae* have been identified to contain high amounts of saturated medium chain fatty acids (MCFAs). MCFAs (C8:0-C12:0) are used in soaps, detergent, cosmetics, lubricants, and food applications. Cuphea PSR23 is a hybrid between *C. viscosissima* Jacq.(a species native to the United States) and *C. lanceolata* W.T. Aiton (a species native to Mexico). Cuphea PSR23 has been the subject of field studies for the past six years in west central Minnesota and central Illinois to establish the best agronomic management practices in preparation for its commercial production. Currently, the seeds are processed mainly for oil to support research needs, as well as for product development and testing. There are very limited published reports on the physical properties and chemical composition of Cuphea PSR23 oil available at this time. This paper will provide some of these basic information that may be useful in its handling and processing.

The Cuphea PSR23 seeds used in this study were from the 2003 and 2004 harvests from plots in central Illinois. The crude oil was obtained from pilot-scale full pressing studies conducted in our laboratory. Refined, bleached, and deodorized oil was produced by chemical refining process. The physical properties and chemical composition of the oils were analyzed following the AOCS official methods.

The bulk seeds contained 27% (db) crude oil. The typical fatty acid distribution is as follows: 69.6% capric, 2.9% lauric, 4.4% myristic, 5.9 palmitic, 9.4% oleic, and 4.8% linoleic acids. Its iodine value of 19.7 and the oxidative stability index of 157 h at 110oC are comparable to those of coconut oil. The crude oil has high free fatty acid (4.0-4.25%) and chlorophyll (200-260 ppm) contents. Phosphatides are also low as indicated by its P, Ca, and Mg contents of 170, 46, and 74 ppm, respectively. The saponification number ranged from 200 to 260 with an unsaponifiable matter of 1%.

SEEDING DATE EVALUATION ON SPECIALTY OILSEEDS IN NORTH DAKOTA

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As North Dakota and other regional producers seek to diversify with the addition of new crops, there is a need to evaluate the most effective production methods for these crops in these areas.

During the 2005 growing season, an agronomic study was conducted at the Prosper, ND research station to evaluate the effect of seeding date on crop performance.

The study was a randomized complete block design in a split plot arrangement, with seeding date the main plot and crop the subplot. Crops were sown in late May/early June and mid June. Crops evaluated included borage (*Borago officinalis* L.), camelina (*Camelina sativa* L.), crambe (*Crambe abyssinica* Hochst.), cuphea (*Cuphea spp*. L.), evening primrose (*Oenothera biennis* L.), high erucic rapeseed (*Brassica napus* L.), and soybean (*Glycine max* L. Merr.). Characteristics evaluated included stand, days to 50% flowering, plant height and lodging, seed oil content, seed oil composition, and seed yield.

The seeding date by crop interaction for seed yield indicated greater yield at the earlier seeding date for soybean and cuphea. Crambe and borage seed yields were not affected by seeding date. In camelina, the later seeding date produced a greater yield than the earlier date. Seeding date did not affect seed oil content or oil composition for any of the crops.

For many oilseed crops, it could be expected that earlier planting dates would produce greater yield due to cooler weather during reproductive development. Only cuphea had a significant increase in yield. Further research is necessary to determine the optimum planting date so that producers can be well prepared to introduce new crops into commercial production.

DRY MATTER AND GRAIN YIELDS, OIL AND PROTEIN CONTENTS OF SUNFLOWER IN RESPONSE TO CROP MANAGEMENT, SOWING DATES, AND YEARS

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Sunflower (*Helianthus annuus* L*)* is an oilseed crop for human consumption because it has high oil content with excellent quality. In Mexico, sunflower production is small, and in 2003, 152,000 ton of grain and 50,000 ton of crude oil were imported. In the arid and semiarid zones of northern Mexico, sunflower is an alternative crop for growers.

In the present work, two sunflower varieties SAN-3C and SANE 23578 were evaluated during nine cycles in the period from 1991 to 1998 in order to analyze the crop response by different environmental conditions in the semiarid zones of northern Mexico, looking for possible commercial cultivation.

Sowing was carried out from May to July during 1991 to 1998 on the University experimental field at Buenavista, Saltillo, Coahuila. The distance between rows was 0.8 m and between plants 0.25 m and the plant density was 50,000 plant ha-1. The variables evaluated were: dry matter yield (total and by component), grain yield, oil and protein contents. The environmental variables were: air mean temperature (GDD), rainfall, and evaporation. The data were analyzed by factor analyses.

The variety SAN-3C had the highest grain and dry matter yields and oil content. The factor analyses presented an inverse relation between crop year and dry matter yield. The effect of the environmental variables was more exact for grain yield than for dry matter yield.

HIGH OIL YIELDING ACCESSIONS IN THE NPGS *LESQUERELLA* GERMPLASM COLLECTION

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Lesquerella (Brassicaceae) species are native to North America and many of them occur in the southwestern United States and northern Mexico. The habitat of most of the *Lesquerella* species is located in the arid and semiarid areas with low annual rainfall ranging from 250 to 400 mm. Seeds of lesquerella contain an oil rich in hydroxy fatty acids (HFA), which are the raw material for producing coatings, corrosion inhibitors, cosmetics, lubricants, nylons, plastics, resins, and waxes. The predominant HFA of the oil, lesquerolic acid, is similar to the ricinoleic acid in castor beans. Thus, lesquerolic acid may replace or reduce the import of castor oil ($24 to $43 million), which is classified as

strategic material.

The objective of this study was to evaluate the total oil content in seeds and the oil yielding potential for selected accessions of the USDA, National Plant Germplasm System (NPGS) lesquerella germplasm collection. The total oil concentration was evaluated in seeds of over 160 accessions (12 species) using a pulsed NMR.

The highest total oil content was measured in seeds of *L. grandiflora* (27.2%) followed by *L. lasiocarpa* (26.4%), and *L. rectipes* (24.3%). The range of the total oil in the seeds of the five *L. grandiflora* accessions was from 25.2 (PI 293034) to 28.7% (W6 20835 and W6 20836). The lowest oil content was in accessions *L. ovalifolia* (10.6%) and *L. angustifolia* (11.8%). By accounting for the seed yield and the total oil concentration, the highest oil producing potential was observed for accessions of *L. lasiocarpa* (1,665 kg/ha) followed by the *L. grandiflora* accessions (1,523 kg/ha). Among the accessions of the 2 species, the highest oil yielding potential was observed for PARL 172, *L. lasiocarpa* (2,632 kg/ha). Across all species, the highest oil yielding potential was present in PI 293030, *L. gordonii* (2,911 kg/ha). In *L. fendleri*, the PI 596363 (1,900 kg/ha) and PI 355037 (1,684 kg/ha) had the highest oil yielding potentials. The PI 596363 represents improved breeding material developed by USDA-ARS scientists, and the PI 355037 is a wild population collected in Texas, USA.

The USDA *Lesquerella* germplasm collection has 201 accessions (33 species). In this number, 97% of accessions were evaluated for total oil content in seeds. These accessions were also characterized for several morphological characteristics (data may be found at www.ars-grin.gov). The genetic resources of the *Lesquerella* collection are diverse and are an excellent source for cultivar development.

SEED TREATMENT IMPROVES PURE LIVE SEED EMERGENCE IN CUPHEA

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Cuphea (C*uphea viscosissima* Jacq. *x C. lanceolata f. silenoides* W.T. Aiton, PSR23) is a new oilseed crop, with medium chain fatty acids, being developed for the North Central USA for industrial applications in the manufacture of soaps and detergents.

Seed germination and seedling emergence of Cuphea is often low compared with commercialized crops where seed treatments are a common production practice. Identification of seed treatments to improve seedling emergence and stand establishment for Cuphea will be important for successful commercial production.

The objective of this study was to determine the effect of five fungicide treatments on pure live seed emergence (PLSE) of Cuphea.

The experiment was conducted at Prosper, ND and Glyndon, MN in 2005 and 2006. Previous crops were wheat (*Triticum aestivum* L.) and sugarbeet (*Beta vulgaris* L.) at Prosper and Glyndon, respectively, for both years. The experimental design was a randomized complete block with six treatments and four replicates. Treatments were: no fungicide applied (check treatment), captan at 0.35 g a.i./kg seed, mefenoxam at 0.15 g a.i./kg seed, fludioxonil at 0.08 g a.i./kg seed + mefenoxam at 0.03 g a.i./kg seed, azoxystrobin at 0.02 g a.i./kg seed, and azoxystrobin at 0.02 g a.i./kg seed + mefenoxam at 0.15 g a.i./kg seed. Seeds were treated and planted three days later at a 12 mm depth. Plots consisted of six rows spaced 30 cm apart and 4.5 m in length.

Pure live seed emergence was evaluated 10 d after seeding at all locations by counting emerged seedlings in each plot row and adjusting for germination.

The environment (location-year) by treatment interaction indicated significant treatment effects on PLSE only at Glyndon in 2006. At this environment the mefenoxam (81% PLSE) and mefenoxam + azoxystrobin (81% PLSE) treatments PLSE was greater than the check (22% PLSE). Other treatments PLSE did not differ from the check at this environment. Significant treatment differences for PLSE were not noted at the other three environments; however, there was a tendency for higher PLSE with the mefenoxam (49% PLSE) and azoxystrobin (42% PLSE) treatments than the check (21%) at the Glyndon 2005 environment.

A preliminary analysis of dying plants collected from the Glyndon site where sugarbeet was the previous crop indicated the presence of the pathogens *Pythium* and *Rhizoctonia*.

Preliminary results suggest that seed treatment would be beneficial for commercial cuphea production when

sugarbeet precedes Cuphea or crops prone to root diseases caused by *Pythium* and *Rhizoctonia* precede Cuphea in rotation.

INTRODUCTION OF CANOLA GERMPLASM FROM MONTANA INTO NORTHWEST MEXICO

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Canola, *Brassica sp,* is a new crop in Mexico. It was commercially introduced to Northwest Mexico during the 1997 to 1998 winter season. Mexican producers are now growing various varieties, including the American IMC 204 and IMC 205 due to their high oleic acid content. The Hyola 401 Canadian hybrid has also been cultivated and it has shown the best results with regards to adaptation, agronomic response, oil quality, and grain yield. In addition, the National Research System is testing canola varieties from different world regions. Introduction and selection are the first steps in the breeding of genetic plants. In 2004, a set of canola genotypes, including open pollinated varieties, hybrids, and experimental lines were obtained from the Northwestern Agricultural Research Center , Montana State University, USA. Consequently, the objective of this study was to evaluate, characterize, and select a group of canola genotypes that could be introduced to the environmental conditions of Northwest Mexico.

The research work was conducted in the Instituto Tecnologico Agropecuario (ITA) No. 21 during the winter-spring season of 2004 to 2005. ITA 21 (now ITVY) is located in Northwest Sonora, Mexico. Thirty-six canola genotypes were studied in four yield trials with nine entries and three local checks each. Materials were separated into four groups: (1) VARIETIES, (2) VISH, (3) VISC, and (4) CHN. The randomized complete blocks statistical design was used in each experiment with four replications. The germplasms were planted on 19 December 2004. Germination vigor, bloom, maturity, reaction to diseases, insect damage, lodging, plant height, grain density, oil content, and grain yield were measured.

Significantly large differences were present among genotypes in each group, with variance coefficients of 10.6, 13.6, 9.5, and 10.6%, respectively, for the four groups. The Hyola 401 hybrid (Local Check) performed the best on each yield trial with 2931, 3408, 3439, and 3311 kg/ha, respectively. The best introduced genotypes in each group were: Hyola 357 (2085 kg/ha), VISH 033 (2463 kg/ha), VISC 00317 (1804 kg/ha), and CHN 503 (2148 kg/ha) on each test. Most of the lines showed some disarray in uniformity, perhaps due to the change of location. Thus, individual plant selections were made. Insect infestations were observed during the growth cycle with the aphid *Myzus persicae* present during bloom, and the false bug *Nysius ericae* in the mature pods.

The Hyola 401 hybrid appears to be the best variety for Mexican conditions. However, it is recommended to continue with the establishment of the segregating nursery in order to improve the stability of the selected plants, and later, to check their potential in new yield trials.

SAFFLOWER YIELD TRIAL WITH NEW EXPERIMENTAL GENOTYPES DEVELOPED IN NORTHWEST MEXICO

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Safflower, *Carthamus tinctorius L.*, is a major oil crop in Northwest Mexico. It has been cultivated in the Yaqui Valley, Sonora since 1960. The first introduced varieties were the "Saffola Group", of which "Saffola 208" performed the best. The "Gila" variety was important until 1985. In order to increase production yields and improve the oil content, quality, and to increase resistance to diseases, the Inifap Safflower Breeding Program developed varieties

such as "Kino", "Sahuaripa", "Quiriego", "San Jose", "Bacum", "Sonora", "San Ignacio", and "Quilantan", among others. Safflower is susceptible to "leaf spot" caused by *Alternaria carthami*, and "safflower rust" caused by *Puccinia carthami*. Another new pathological problem has appeared in recent years. This is the "false mildew" caused by *Ramularia carthami* that has become the most important pathological problem in Northwest Mexico. This disease vulnerability can be solved through genetic breeding. The objective of this study was to evaluate the agronomic response, quality, diseases reaction, and yield of new safflower experimental lines.

The yield trial was conducted at the Instituto Tecnologico Agropecuario (ITA) No.21 during winter-spring season 2005. ITA 21 (now ITVY) is located in Northwest, Sonora, Mexico. The treatments consisted of 10 safflower genotypes and two local checks. The randomized complete blocks design was used with three replications. The plots were 1 m wide by 6 m long with two rows each. Seeds were planted on 12 February 2005. Germination vigor, bloom, maturity, diseases reaction, plants height, lodging, grain density, oil content, and yield were measured.

Highly significant differences were present among genotypes with a variance coefficient of 8.12%. The grain yield varied from 3418 kg/ha in line 02-272Y0 to 2000 kg/ha in 04-765, with an average of 2830 kg/ha. Most of the genetic material showed standard values in agronomic behavior; the oil content ranged from 40.2% for S-518 to 34.7% for 04-765. Infection by the fungus *Ramularia carthami* was observed. The infection levels were variable among the lines. The most resistant experimental lines were 04-787 and 04-765, which only showed the presence of only traces of the disease. However, their grain yields were not the best.

The experimental safflower lines 04-787 and 04-765 exhibited resistance to the *R. carthami* fungus, the cause of the "false mildew" disease in Northwest Mexico. It is recommended to cross these germplasms with the high yield varieties and then select resistant plants with high grain yield and good agronomic characters from the progeny.

PHENOLOGICAL DEVELOPMENT AND QUALITY PARAMETERS OF SELECTED NEEM TREES (*Azadirachta indica* A Juss) IN MEXICO

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The neem tree, *Azadirachta indica* A. Juss, was introduced to Baja California Sur, Mexico, in 1997 by a group of private producers dedicated to organic horticulture in San José del Cabo. The first trees were brought from the Philippines. In 1992, neem was introduced to Northwest Mexico. It is used as a windbreak to protect crop fields, and for forestation in rural and urban areas. However, its main use is to produce biological insecticides and fungicides, as well as cosmetics and organic medical products. Neem populations have phenotypic and quality differences due to their genetic structure, nature crossing rate, and environmental action. The fruits are heterogeneous in size and form, but the oil content and quality are variable that result in unstable final products. The objective of this study was to evaluate and characterize qualitatively the morphology of 216 trees to establish any differences among the trees.

This study was conducted at the Instituto Tecnológico Agropecuario (ITA) No.21 during 2004 to 2005. ITA 21 (now ITVY) is located in the Yaqui Valley in Southern Sonora, México. The neem nursery was planted in July 2000. It has 216 trees in a square plantation of 7x7 m. The trees were characterized and selected. Tree height, stem diameter, branching type, and leaf color were measured. Fruit size, weight, form, almond proportion, oil content, and fatty acid profiles were also determined.

The trees evaluated have a high genetic variation identified by differences in height, branching type, leaf form, and color. Fruit form, size, weight, almond proportion, composition, and oil content were also variable. This is important in order to improve neem populations. Better fruits produce oils of higher quality and uniform plantations produce stable oils. Fruit weights were dissimilar for each tree. Fruit weights ranged from 0.775 g to 0.325 g. Fruit almond proportions were different. Tree #69 was registered at 31.9%, whereas tree #39 contained 21.1%, which corresponded to oil contents of 23.8% and 15.4%, respectively. The fatty acid profile analyses showed no differences. Most fatty acids had values of: Oleic Acid, 45.5%; Linoleic Acid, 16.8%; Palmitic Acid, 17.2%; Stearic Acid, 15.2%; and Linolenic Acid, 1.3%.

The neem trees located in Southern Sonora, Mexico exhibit a significant variation in their morphology, mainly with

respect to oil content. Further studies are recommended to focus on the oil content and composition as the principal asset of the tree.

LESQUERELLA FENDLERI RESPONSE TO FERTILIZATION IN NORTHERN MEXICO

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Lesquerella fendleri (Gray) Wats, is a *Brassicaceae* native to northern Mexico and southern United States. The seeds contain oil similar to castor oil that may be used for a wide array of industrial crops. The Mexican growers in the semiarid lands have the potential to cultivate *Lesquerella* if the crop can be grown in the native regions.

The objective of this study was to determine the effect of fertilization on seed yield and oil content in *Lesquerella* grown at Saltillo located in northern Mexico.

The seeds of *Lesquerella fendleri* line O1LO were sown on 19 October 2004. Nitrogen fertilizer was applied in October before the planting at 80 kg/ha, and in March (flowering stage) at 40 kg/ha. Phosphorus was applied at 60 kg/ha in one application in October and also before sowing. Irrigation was applied for germination and seedling establishment and to maintain seed moisture. The experimental design was a randomized block design with two treatments, with fertilization (T1) and without fertilization (T2) and five replications. Plant morphological variables as well as yield characteristics were measured and related to fertilizer application.

Significant differences ($P \leq 0.05$) were present between treatments for oil content and seed yield, and highly significant differences ($P \leq 0.01$) between treatments for weight of 1000 seeds and dry weight. For phenotypic correlations among variables, a positive and significant correlation was found between oil content ($r = 0.737^*$) and the weight of 1000 seeds.

Lesquerella had a positive response to fertilization, showing increments in the variables studied.

MAPPING MICROSATELLITE LOCI ISOLATED FROM *LESQUERELLA FENDLERI* (BRASSICACCEAE) TO THE CHROMOSOMAL MAP OF *ARABIDOPSIS THALIANA* BASED ON CONSERVED SEQUENCES FLANKING THE TANDEM REPEATS

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The completion of the *Arabidopsis thaliana* genome sequence has been heralded as an unparalleled opportunity for crop improvement by establishing a detailed structure of reference genes that can be used for comparative genetic mapping with closely related species. However, the apparent problem remains on how to transfer the sequence and structural information to the crop of interest, especially for new crops where little or no sequence information exists and when there is no common set of molecular markers.

As part of our breeding program for the new industrial oilseed crop *Lesquerella fendleri*, we are developing *de novo* microsatellite markers in order to characterize the genetic diversity of breeding lines and germplasm collections, and to develop genetic linkage maps for marker assisted selection for trait of interest such as oil quantity and quality. To date, microsatellite loci have rarely been used for cross-generic comparative studies because of the low transferability of the markers and the lack of conservation of microsatellite repeat motifs between species. The objective of this study was to determine whether the microsatellite loci isolated for *L. fendleri* might be homologous to *Arabidopsis*, and therefore, be of use for comparative mapping, with the goal of using a candidate gene approach for both simple and complex traits.

We employed a BLASTN search of the *Arabidopsis* genome with the 40 *L. fendleri* microsatellite loci (microsatellite repeat and flanking regions) that we have isolated to date and identified the region where the repeat motif was located. Loci orthologous to *Arabidopsis* genes (based on their Expectation value) were then given that locus

name in order to be mapped to the *Arabidopsis* genome using the Chromosome Map Tool (http://www.arabidopsis.org/jsp/ChromosomeMap/tool.jsp).

Eighty-eight percent (35 out of 40) of the microsatellite loci contained sequence that was orthologous to *Arabidopsis*; 18 could be assigned to known or proteins with hypothetical functions and the remaining 17 were orthologous to unknown proteins. When placed on the *Arabidopsis* Chromosome Map, the *L. fendleri* loci were distributed on all five chromosomes. Several loci show a close relationship with genes from the Arabidopsis Lipid Gene Database (http://www.plantbiology.msu.edu/lipids/genesurvey/), and are therefore, potentially very valuable for our understanding of the basic genetics and biology of lipid metabolism for agronomic improvement of this new crop. Sequence alignment of *L. fendleri* and *Arabidopsis* may also provide a means to develop highly conserved primers in the flaking regions that should have a higher probability of cross-species and generic amplification.

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POSTER PRESENTATIONS (Industrial Crops: Rubber and Resin)

A SIX-STEP HARVESTING PROCEDURE OF GUAYULE SMALL PLOTS FOR LABORATORY ANALYSES

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Guayule (*Parthenium argentatum* Gray) is the best potential source of hypoallergenic latex to replace latex products made with Hevea (*Hevea brasiliensis* (A. Juss.) Muell.-Arg.) latex that cause Type I allergies. Breeding programs in the past have focused on screening germplasm and developing improved lines with higher rubber and/or resin contents. Harvesting protocols in the past did not have to deal with the problem of latex loss as the plant material is being processed. A new protocol allowing harvesting of various amounts of plant material that minimizes latex loss is needed by guayule researchers. A standardized protocol will also allow better comparison of research results from various areas of the world where guayule research is being conducted.

The objective of this study was to develop a protocol that could be used to harvest various amounts of plant material from agronomic and breeding tests for laboratory analyses.

A six-step protocol was developed to harvest from 1 kg to over 20 kg of plant material from field plots in a form suitable for laboratory analyses with minimal latex loss. Step 1 was to cut the plants in the field as close as possible to ground level (50 mm). Step 2 was to transport the plants from the field to the chipping area as soon as possible in bags that kept plant samples separate. Step 3 was to obtain a fresh weight for each sample. Step 4 was to process the sample through the chipper and obtain a fresh weight of the chipped material. Step 5 was to add antioxidant solution (0.2% sodium sulfite in distilled water at a pH of about 11) so that the fresh weight of plant material collected and the antioxidant solution are in a 1:1 ratio. Step 6 was to thoroughly mix the antioxidant solution with the plant material by stirring the plant material after the antioxidant solution was added. Steps 2 to 6 were done in less than 3 h following harvest to minimize latex loss. The mixture was stored at 4 to 10C before laboratory analysis for latex. While this mixture can be stored under these conditions up to five weeks without loss of latex, samples used in our studies were processed within 3 to 5 days after harvest.

The proposed protocol was evaluated by processing samples harvested using this procedure for latex content. If samples harvested using the proposed protocol could be processed for latex using the recommended laboratory protocol without additional preparation prior to using the laboratory protocol, then we considered the proposed harvesting protocol acceptable. In addition, the proposed protocol provided samples that could be used for rubber, resin, and other laboratory analyses.

This basic protocol has been used for over five years to analyze successfully guayule plant material from plants of various ages and sizes for latex, rubber, and resin concentration. This protocol will be of use to other researchers around the world who are now beginning to conduct research on guayule.

UTILIZING NATURAL CROSSES IN A GUAYULE BREEDING PROGRAM

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Guayule (*Parthenium argentatum* Gray) is a perennial shrub native to the Chihuahuan Desert. Apomictic reproduction in guayule makes breeding progress difficult. Breeding methods to take advantage of the facultative apomixis and occasional sexual reproduction that occurs in guayule are needed for faster breeding progress.

The objective of this study was to evaluate the possibility of utilizing the pedigreed natural crossing method as a breeding method in guayule.

In the first experiment, three guayule lines (AZ 101, P10-4, and CAL-6) were interplanted with *P. tomentosum* plants in a natural crossing block. Plants were allowed to flower and set seed. Seed were germinated and the resulting plants compared with the parents to identify potential interspecific hybrids. In the second experiment, hybrid plants from crosses between diploid lines of guayule were interplanted and allowed to cross. Seeds were collected randomly and the resulting plants evaluated to identify potential hybrids.

We isolated several natural hybrids from both breeding nurseries that are the result of hybridization between the *Parthenium* species and between guayule germplasm lines. These interspecific and intraspecific hybrids have been identified by characteristics such as leaf shape, leaf color, and leaf size. Current work is underway to verify the parents by chromosomal analyses.

Plants that reproduce by apomixis and those that are highly self-pollinated both have highly uniform progenies, except for the occasional off-type. This off-type is frequently the result of out-crossing in self-pollinated species as well as in facultative apomictic species. Inter-planting of parents, allowing crossing to occur naturally, harvesting seed from the parents, and then examining the progeny for off-types can be used to develop populations for further selection and development of desirable lines. In self-pollinated species, the development of uniform lines may take several generations of selection and self-pollination, whereas in an apomictic species uniform lines may be able to be developed within one generation of apomictic reproduction. The added advantage is that any hybrid vigor associated with the original cross would also be fixed.

Preliminary studies indicate that utilizing the pedigreed natural crossing method or modifications of this method in guayule is feasible. By using this method in guayule, breeding programs could lead to faster development of germplasm lines and cultivars for industry.

A ROLE FOR THE SMALL RUBBER PARTICLE PROTEIN DURING RUBBER BIOSYNTHESIS

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Natural rubber (*cis*-1, 4-polyisoprene) is formed in cytosolic vesicles known as rubber particles, and when provided the appropriate substrates, these vesicles contain the set of proteins needed for the biosynthesis of rubber. However, the identity and function of many of the rubber particle associated proteins responsible for synthesis remains unknown. One such protein is the small rubber particle protein (SRPP) that is found in high abundance in association with rubber particles in several rubber producing species, including *Hevea brasiliensis* and *Taraxacum kok-saghyz* (Russian dandelion). Addition of SRPP to purified rubber particles increases rubber production *in vitro*, suggesting an important role of these proteins in rubber biosynthesis. Unfortunately, *in vivo* data confirming SRPP function in rubber biosynthesis do not exist.

The primary goals of this research were to characterize better the SRPP protein family and provide *in vivo* results corroborating SRPP function in rubber biosynthesis.

To address our objectives, we are using reverse genetics in the model rubber producing species Russian dandelion to describe functionally SRPPs. We have generated SRPP-RNAi dandelion plants using *Agrobacterium* mediated

transformation.

Upon analysis of the transgenics, we hope to find a correlation between SRPP levels and rubber yield, suggesting a function in rubber biosynthesis.

FUNGITOXIC EFFECT OF *FLOURENSIA CERNUA* RESIN EXTRACTED FROM NORTHERN MEXICO ON *PENICILLUM DIGUTATUM*

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Plant natural products are an alternative, efficient, and economical means to control plant diseases. In Mexico, there are many plant species widely distributed in the arid and semiarid zones that can be evaluated for their biological activity on phytopathogenic fungi. *Flourensia cernua* is native to these lands and its methanol extract has been reported to have inhibitory effects on *Rhizoctonia solani* and phytophtora infestations, and its hexane extract on *Collectrotrichum* spp.

In this work, we evaluated the effect of fresh leaf extracts from *Flourensia cernua* on mycelial inhibition and sporulation of a *Penicillium digitatum* postharvest phythogen.

The extracts were obtained with methanol:chloroform (1:1), and sequential extraction with hexane, diethyl ether, and ethanol. The evaluated concentration were 500, 1000, 2000, and 4000 ppm in the culture media PDA.

The highest resin yield (19.1%) was obtained with the methanol:chloroform extractant. Mycelial inhibition on *P. digitatum* occurred at 93.4% and 94.0%, respectively with the 500 ppm of ethanol fraction. All extracts showed fungistatic effect. The hexane extract was effective against the sporulation pathogen at 500 ppm.

SCREENING WILD RABBIT BRUSH (*CHRYSOTHAMUS NAUSEOSUS*) POPULATIONS FOR VARIATION IN RUBBER CONTENT AND QUALITY

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Natural rubber (cis-1,4-polyisoprene) latex is produced by more than 2000 plant species. The single commercial source, at present, is natural rubber harvested from the Brazilian rubber tree, *Hevea brasiliensis*. Rubber produced from *Hevea* provides 99% of the world demand. Global dependence of natural rubber is risky because *H. brasiliensis* cultivars have very little genetic variability, leaving the rubber plantations at risk of serious pathogenic attack. This encouraged research interests in the development of alternative rubber sources. Rabbit brush (*Chrysothamus nauseous*) has been known to make high quality rubber with yields ranging from 1.5% to 6.5% of shoot dry weight. Rabbit brush grows well in marginal, alkaline soils, and drought conditions making it an ideal crop for the Great Basin region of the U.S. Past studies showed a variation in the amount of rubber production among the subspecies of rabbit brush and the specific habitat.

The objective of this preliminary study was to screen wild rabbit brush populations to determine the natural variation in rubber content and quality. The amount of rubber produced in rabbit brush is known to change during the summer months. We are currently conducting an experiment to further investigate rubber production throughout the summer season.

Rabbit brush seeds, plant tissue, and soil samples have been collected from various regions of northern Nevada and eastern California. Additionally, samples were collected from selected areas of Nevada to extract rubber to check for a change in rubber production. Accelerated solvent extraction (ASE) was used to extract rubber from the collected plant tissue. The plant samples were analyzed for rubber content and molecular weight using gel permeation chromatography.

NMR analysis will be performed to determine the identity of the rubber. We are hoping to find a rabbit brush sub

species that contains higher amounts of good quality rubber.

IDENTIFICATION OF PROTEINS/GENES INVOLVED IN NATURAL RUBBER PRODUCTION

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Natural rubber is produced in over 2,000 plant species and due to its elasticity, flexibility, and resilience is irreplaceable by petroleum-based synthetics. It is required for manufacturing many industrial and medical products. In spite of the increasing demand and need for alternate sources for natural rubber, the rubber biosynthetic process still remains largely unknown.

Because classical biochemical methods have failed to identify rubber biosynthetic proteins/genes, the objective of this study was to examine rubber biosynthesis using advanced proteomic- and genomic-based techniques.

Our proteomic approach involves using comparative proteomic analyses of rubber particles from different rubber producing species. We have also generated 10,000 ESTs from both Russian dandelion root and guayule bark cDNA libraries that have been used to sort out the proteomics data.

We identified highly abundant rubber particle proteins in both species and also proteins common between different rubber producing species have been revealed by combination of 2D/1D gel electrophoresis and MALDI-TOF-TOF analyses.

Our proteomic- and genomic-based approaches have been highly successful in determining the rubber biosynthetic process, and more studies are being conducted to reveal the unknowns of the pathway.

UPPER AND LOWER HERITABILITY ESTIMATES IN GUAYULE BASED ON MODE OF REPRODUCTION

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Guayule (*Parthenium argentatum* Gray) has been difficult to improve through classical plant breeding due to both its facultative apomictic system of reproduction and the elasticity of the isoprenoid pathway. Correlations among traits and heritability of traits have been previously reported, and have been used in the determination of the most effective breeding methodologies to be used to increase rubber concentration and yield. Despite this information, increases in rubber concentration have been low, although significant increases in yield per area have been realized. Previous estimates of heritability were done with methods that assume outcrossing; however, guayule reproduces predominately by apomixis and occasionally sexually. We propose an alternative method of calculating heritability in guayule that more accurately accounts for the contributions of apomictic and sexual reproduction using a modified parent progeny regression.

Open pollinated progeny from 21 tissue culture generated parents were grown for two years in the same field where the parents had been grown the previous two seasons. Growth and secondary compound production were measured at one and two years in both the parents and the progeny. Due to unequal family sizes, weighted regressions were performed to examine parent-progeny relationships. Heritability was calculated using a modified version of the formula for single parent-progeny regression ($h^2 = 2b$): that is, $h^2 = (2 - p)\, b$, where p = proportion of apomixis and b = regression coefficient. We also examined the rank correlation among traits.

At two years of growth, there was a significant regression between the parents and the progeny for all traits measured except rubber content and guayulin A and B concentrations, with heritability estimates ranging from moderate to high for most parameters measured. Because guayule is more apomictic than sexual, most heritability values should fall closer to the midparent-progeny regression estimate ($p = 1$; complete apomixis) resulting in lower heritability estimates than previously published.

To increase rubber yield in the progeny, selection should focus on height and width in the parents because height

and width are highly correlated with rubber yield and had the highest heritability of the traits measured.

PLANT AGE, CARBON EXCHANGE, AND NIGHT TEMPERATURE CONTRIBUTIONS TO RUBBER PRODUCTION IN WINTER-GROWN GUAYULE

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Guayule (*Parthenium argentatum* Gray), a native of the Chihuahuan desert, produces the majority of its rubber during the winter months. Increased rubber production is thought to be induced by cold night temperatures, but the factors involved in rubber induction are not completely understood. The purpose of this study was to understand how immature plants (< 180 d) respond to night temperature, and the role of night temperature and carbon exchange in rubber production in mature plants (≈ 1y). This study evaluated the contributions of night temperature, carbon exchange, and plant age on rubber production during the winter months.

Immature and mature plants were grown in differentially heated enclosures over two and three consecutive winters, respectively. The warm-night plants were exposed to simulated summer night temperatures and the cold-night plants to ambient winter night temperatures. Plant responses to different night temperatures were monitored by measuring growth, carbon exchange, fresh and dry weight, and resin and rubber production.

Resin concentration was not affected by night temperature in either mature or immature plants. Rubber concentration was significantly related to night temperature in both mature and immature plants and appears to be stimulated most by temperatures below 10°C. Rubber concentration of the mature plants was higher in the cold-night than the warm-night plants for all three years. Immature plants exposed to cold nights had higher rubber concentration than the warm-night plants only in the first year, which had the lowest night temperatures. For the mature plants, dry weight was not significantly different between treatments, but rubber concentration and yield were significantly greater in the cold-night than the warm-night plants. The cold-night plants also had carbon exchange rates that were as high as or higher than the warm-night plants for all three years. Therefore, the similarity in dry weight between treatments was most likely due to increased growth in the warm-night plants and increased rubber deposition in the cold-night plants.

DISCRIMINATION OF FRESH GINSENG ROOTS AT DIFFERENT AGES USING METABOLITE FINGERPRINTING COMBINED BY MULTIVARIATE ANALYSIS OF 1H-NMR SPECTROSCOPY

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To obtain the most complete metabolic profiling, it is necessary to use a wide spectrum of analytical techniques that are rapid, reproducible, and stable in time and require only a very simple sample preparation. NMR is one of the techniques that meet those requirements. Recently, NMR in combination with principal component analysis has been applied to the metabolic profiling of several types of plants and phytomedicines.

The discrimination of fresh ginseng roots at different ages is still unclear. Until now the classical methods using the content of ginsenoside and the counting of the number of bud scale scars on the roots are applied for discrimination. However, the limitations of these methods are their reproducibility and relatively low consistency. Therefore, development of more reliable method for discrimination of the fresh ginseng roots at various ages (1-, 2-, 3-, 4-, 5-, and 6-year-old) is required. In this study, we report a 1H NMR spectroscopic method coupled with multivariate analysis for the discrimination of fresh ginseng roots at various ages.

The metabolic profiling analysis of fresh ginseng according to the roots ages was performed using 1H NMR spectroscopy and multivariate analysis techniques. A broad range of metabolites could be detected by 1H NMR

spectroscopy without any chromatographic separation. In the 1H NMR spectra of the fresh ginseng root extracts, the major metabolic constituents including aliphatic, carbohydrate, and aromatic regions were detected. The principal component analysis (PCA) used to reduce the huge data set obtained from the 1H NMR spectra of roots extracts clearly discriminated according to the roots ages.

For reliable and easy comparison of the metabolic profiling, the large 1H NMR data set obtained from various metabolites can be reduced to PC1, PC2, or PC3 using PCA. 3D scores plot using PC1, PC2, and PC3 also showed clearly separation at different roots ages. For the data set obtained from the analysis of each water extract, a three-component model explained about 90% of the variance. The main factors to differentiate the fresh ginseng root at different ages were the regions of carbohydrates and amino acids. Multivariate statistical method was found to be an ideal method to differentiate the fresh ginseng roots at different ages with each other based on a variety of metabolites. Canonical discriminant analysis could be used to identify the ginseng roots at various ages with over 90% discrimination accuracy of NMR results.

Considering all the results, 1H NMR and PCA seems to be a very promising tool for the authentication and quality control of the fresh ginseng roots at different ages.

EXPRESSION OF GENE TO INDUCE FLOWER BOLTING IN *ALLIUM CEPA* L.

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Vernalization is a term that describes the promotion of flowering after exposure to cold. In many crops in which the vegetative portions of the plant are the commodity such as cabbage, beets, or carrots, a strong vernalization requirement prevents flowering in the first growing season. Premature release of dormancy can obviously lead to cold damage, but retention of some dormancy because of insufficient chilling can lead to developmental problems in the next growing season that reduce yield. Thus, for optimal yields from some crops, it is crucial that the length of cold exposure required to break dormancy coincides well with the typical length of winter in a particular location.

One of the most crucial decisions in life cycle of a plant is when to initiate flowering, cultivated Allium cepa (onion) is a biennial plant requiring vernalization and thus a cold season to bolt and flower, but for commercial purposes, onion is grown as an annual plant to avoid bolting. Breeders were developing new varieties more resistant to bolting with breeding programs aiming to produce hybrids through sexual reproduction and crossings. The requirements for floral initiation of onion are far from being fully understood and a better knowledge of the factors regulating flowering in bulb onion, in particular, is urgently needed. Our aim was to define how bolting of onion is affected by biogenetic reaction at the time of overwintering.

The experiments were performed using two onion varieties: MOS8 male sterility strain (developed by Hyun, Dongyun, Mokpo experiment station, Korea), which is late flower bolting type and Guikum (provided by Kaneko Seed Co., Ltd, Japan), which is classified as a very early flower bolting type. Total protein extracts were prepared from basal tissues, meristematically active parts of bulbs. Samples were extracted using a 2-D electrophoresis method. Proteins were electroblotted onto PVDF membrane using a semidry transfer blotter, and visualized by CBB staining. The proteins were excised from the PVDF membrane and analyzed by Edman degradation method using a procise clc protein sequencer.

Flowering time is regulated by both environmental and developmental factors. The early bolting ecotype is sensitive to cold induction, whereas the late bolting ecotype is insensitive. Analysis of the genetic basis of cross late bolting type (MOS 8 line) and very early bolting type (Guikum) indicated 1 : 3 segregation with the late bolting dominant in the F_2 progeny. The early bolting type showed expression of mRNA level of VRN1 in basal tissue-specific, but did not show expression of FLC mRNA and histone 3 modification. It was identified that the late bolting ecotype did not reduce FLC mRNA and trimethylation of H3-K4 expression by vernalization.

The appearance of late flower bolting ecotype with vernalization may be an advantage where severe winter conditions prevent bolting and also there is a selective advantage in escaping harvesting time.

MOLECULAR CLONING AND CHARACTERIZATION OF GINSENG FARNESYL DIPHOSPHATE SYNTHASE

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Farnesyl diphosphate synthase (FPS) is a key enzyme in isoprenoid biosynthesis leading to many molecules that have an important role in cellular metabolism. It is also the branching point of pathways leading to the synthesis of a large variety of sesquiterpene and triterpene products. Ginseng (*Panax ginseng* C.A. Meyer) contains a number of ginsenosides and their roots have a large amount of saponins. Therefore, ginseng root is an ideal model to study the biosyntheses of triterpene saponins and regulation of those pathways by elicitor influences. As a first step in understanding the regulatory of isoprenoid pathways, we isolated a cDNA encoding FPS from ginseng roots and characterized the gene by molecular works.

Four-year-old *P. ginseng* was obtained from the National Institute of Crop Science (Suwon, Korea). A cDNA encoding FPS was isolated from *P. ginseng* using degenerate primers designed from two highly conserved domains. A full-length cDNA clone was subsequently isolated by rapid amplification of cDNA ends PCR.
The sequence of PgFPS (*P. ginseng* FPS) contains an open reading frame of 1038 nucleotides that codes for 346 amino acids with a molecular mass of 39.7 kDa. The deduced amino acid sequence of PgFPS exhibits 84%, 79%, and 72%, identity to those of the Artemisia annua, Arabidopsis thaliana, and Oryza stavia FPS, respectively. The artificially expressed soluble form of the PgFPS enzyme was identified by SDS-PAGE and PgFPS exhibits high specific activity that produces farnesyl diphosphate as the major isoprenoid. In Northern blot analysis, up-regulation of expression of PgFPS in hairy roots treated with methyl jasmonate was demonstrated.

Therefore, our results suggest that a cloned PgFPS from ginseng be considered as a candidate for investigating the regulation of triterpene biosynthesis.

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