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2010 New Crops: Exploring Diversity, Preserving our Future

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Program

ABSTRACTS

Plenary Session

SEARCHING FOR THE NEW BIOECONOMY IN A WORLD OF WICKED PROBLEMS

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The past decade has seen unprecedented interest in production of energy, chemicals, and structural materials from plants - the bioeconomy. Candidate species range from dedicated biomass plants (miscanthus, switchgrass, jatropha, and various trees) to crops that have traditionally been grown for food (sugarcane, maize, canola, and oil palm). Wide scale use of farm land for such crops will usher in great change to tomorrow's agricultural systems, which will be called upon not only to feed the world's population but increasingly to undergird the new bioeconomy. More efficient use of current crop acreage, the maturation of carbon markets, harvest of biomass from land not now in cultivation, and the introduction of new technologies all hold promise to help meet these dual goals. Significant challenges nevertheless remain as signs appear that the public debate on the bioeconomy is taking on the form of a "wicked problem." Key issues include: the mindset of society when the issue becomes local and economic, conflicting opinions of who pays and who benefits, impacts of major land use change on the landscape, public perception of scientists and vice versa, and the patience and long-term vision of policymakers. The complexity of these issues often goes underappreciated by scientists and technologists seeking to help introduce the bioeconomy.

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COMMERCIALLY READY YEAST BIOCATALYST FOR CELLULOSIC ETHANOL FERMENTATION

Mervyn de Souza, Pirkko Suominen, Dan Beacom, Tom McMullin, Arlene Fosmer, Chris Miller, Brian Rush, Jon Veldhouse, Gary Folkert, Liz Dierickx, Ken Finley,
Beth Mastel, Holly Jessen, Josh Lundorff, and Ana Negrete-Raymond

Cargill Biotechnology Development Center, 15285 Minnetonka Blvd, Minnetonka, MN 55345, USA

Cargill's experience in biotechnology helps customers create value through improved bioprocesses in food, feed, and bio-industrials. Expertise in biocatalyst and fermentation development resulted in the commercialization of an innovative yeast biocatalyst for the production of low pH lactic acid. This platform organism and low pH fermentation process offer considerable cost savings over conventional (bacterial) lactic acid processes. Common characteristics are required for an economically viable biocatalyst for cellulosic ethanol and lactic acid production for commodity applications like Poly Lactic Acid (PLA). These include high yield, fast fermentation, robust growth in simple media, and tolerance to organic acids at low pH. The Cargill team started with non-conventional yeast naturally possessing some of these characteristics and successfully developed it to efficiently produce a new end product (lactic acid) or to ferment new sugars (pentoses). Development of a strain capable of producing polymer grade lactic acid at commercially interesting titer, yield and productivity required concerted utilization of genome wide tools, targeted modifications, evolution and classical mutagenesis. The developed strain and low pH fermentation process offers considerable cost savings over conventional lactic acid processes. The biocatalyst, the engineering tools, and the commercial scale knowledge developed for the low pH lactic acid process are being leveraged by Cargill to create a biocatalyst capable of the commercial conversion of biomass sugars to ethanol.

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Green Metric Division

GREEN METRICS – MEASURING SUSTAINABILITY?

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There is a virtual explosion of efforts to develop and apply sustainability measures to agriculture and other sectors of the economy in the U.S. and the world. Many actors in the marketplace and in policy arenas are encouraging product suppliers to document outcomes along environmental, economic and/or social dimensions of sustainability.

This presentation will describe many of the sustainability metric efforts currently underway, some of the ways that USDA is involved, and some of the implications for green metrics in industrial crops. The efforts are occurring at the local, regional, national and international levels. Some are being developed entirely within agriculture, while others consider multiple sectors of the economy. While most recognize the importance of the entire supply chain, many are focusing at least initially on one phase, such as agricultural production. While most efforts recognize the importance of social and economic dimensions as well as environmental dimensions of sustainability, some are addressing one dimension or a few criteria, at least initially. Such limitations, while understandable for practical reasons, argue for caution in interpreting the results as measurements of sustainability.

While most efforts at developing metrics appear to be driven by markets and/or policy, they also help to focus our understanding of current science and future research needs. Research is needed both to improve the development of metrics and also to clarify the relationships between practices and outcomes, in order to help producers and the industry achieve the continuous improvement that sustainability metrics are intended to facilitate.

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SUSTAINABILITY BY DESIGN – LOOKING FORWARD TO EXPAND ADVANCED BIOFUEL PRODUCTION

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The Energy Independence and Security Act of 2007 (EISA) expanded the Renewable Fuel Standard 2 (RFS2) by requiring that United States transportation fuels contain 36 billion gallons of biofuels by 2022. These actions have created new opportunities for agriculture to contribute to the Nation's renewable energy future. With conventional biofuels from corn grain ethanol capped at 15 billion gallons, at least 21 billion gallons must be derived from other biobased materials to meet RFS2 requirements. To achieve this level of advanced biofuel production, not only must new large-scale conversion facilities that produce fungible fuels be deployed, but the equivalent of an entirely new agricultural sector that produces dedicated energy crops will have to be created. The investment required to build the 500 biorefineries needed to produce 21 billion gallons of advanced biofuel has been estimated to be $160 billion. As the acreage used to produce the feedstocks for biofuels production is scaled up, great care will be required to ensure that not only are dependable feedstock supplies delivered to biorefineries, but also to avoid disruption of existing food, feed, and fiber markets, and to protect our natural resources base upon which we depend for clean air, water, and other critical ecosystem services. This presentation provides an overview of the biophysical and economic challenges to the expansion of advanced biofuel production – particularly focusing on oil seed crops – and also considers the natural capacity of different regions to produce different kinds of dedicated feedstocks and how these will have to match different biofuel production pathways to achieve the Nation's biofuel mandates.

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INDUSTRIAL PERSPECTIVES ON BIO-BASED PRODUCTS: DRIVERS, NEEDS, SUCCESSES, AND CHALLENGES

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The volatility of oil and oil derived petrochemical feedstocks has spurred industry to investigate and develop bio-derived products and focus on sustainable value creation. The potential is that companies who succeed will gain a sizable competitive advantage. However, many challenges must be overcome including understanding and defining what is sustainable as it relates to bio-derived products and can this be done profitably. This presentation will highlight the drivers, needs, successes, and challenges of using bio-derived products to generate sustainable value creation in the chemical industry.

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BIODIESEL FEEDSTOCKS, PROPERTIES, AND PERFORMANCE

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Biodiesel consists of fatty acid methyl esters (FAME) that can be produced from almost any source of plant oil or

animal fat, as well as from waste grease and via various biotechnology routes. The primary feedstocks globally are palm oil, soy oil, and rapeseed oil; but a wide range of other materials are also employed. There is increasing interest in the utilization of oils from unconventional crops such as camelina, non-food crops such as jatropha, as well as the use of algae as a feedstock oil source. While the effect of feedstock properties on biodiesel product quality is limited by national product standards (ASTM D6751 and EN14214), biodiesel from different sources has a range of properties that in some cases can create challenges for end users. This talk will briefly discuss current and emerging feedstocks and the biodiesel production process. We will then focus on the relationship between biodiesel composition (both FAME and impurities) and critical performance properties such as storage stability, low-temperature operability, and air pollutant emissions.

Oxidative degradation reactions in biodiesel can lead to the formation of corrosive acid as well as gums that can damage engine fuel system components. Biodiesel can exhibit poor storage stability because of the presence of carbon-carbon double bonds in the FAME structure. However, a direct correlation with the number of double bonds or bis-allylic double bonds is not possible because in many cases the biodiesel contains natural antioxidants such as tocopherols. Therefore a performance based test was developed to ensure adequate stability and the results of this study are briefly described.

Operation in cold weather is an important issue for all diesel fuels, and petroleum refiners in cold weather regions adjust the properties of their product in winter months. Users of biodiesel blends have been plagued with rare but unexpected cold weather fuel filter clogging events. These events are unexpected because ambient temperatures remained above the fuel cloud point (a common performance test for low-temperature operability). We have recently shown that an impurity in biodiesel, saturated monoglycerides (SMG) can crystallize at temperatures above the fuel cloud point, and on a time scale significantly longer than the cloud point experiment (over a period of hours rather than minutes). Additionally, SMG may crystallize as a metastable polymorph that can transform to a more stable and higher melting form over a period of hours, leading to filter clogging at temperatures well above those expected to be problematic.

A major issue for biodiesel in urban areas has been its potential to increase NOx emissions from diesel engines. More highly saturated biodiesel such as that derived from animal fat has a much smaller effect on NOx than unsaturated biodiesel such as derived from soy. Recently the chemical basis for these effects has been revealed, and it has been shown that engine recalibration can eliminate this effect. However, beginning in 2010 new diesel engines are required to have NOx control catalysts that appear to eliminate any fuel effect on NOx.

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BREEDING FOR HUMAN HEALTH TRAITS, AN EMERGING FACET IN CONTEMPORARY CROP IMPROVEMENT

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Cancer, cardiovascular disease, diabetes (type-II), and obesity are major health concerns in developed and developing regions around the world. These chronic diseases are in many circumstances considered to be preventable via various facets of lifestyle. Prominent among these lifestyle factors is the type and amounts of the foods eaten, particularly those foods of plant origin. The primary mechanisms targeted for food-mediated disease risk reduction are altered glucose metabolism, chronic inflammation, excessive cellular oxidation, and/or chronic endotoxemia. Given the profound physical, psychosocial, and economic consequences of chronic diseases and the potential of food crops to meaningfully reduce chronic disease risk, we decided to challenge scientists in a broad array of disciplines to join forces in an effort to harness existing and emerging capabilities in agriculture and the biomedical sciences to reduce chronic disease prevalence. We have coined the term “biomedical agriculture” to describe this transdisciplinary research effort. This presentation will highlight promising examples of the discovery process being used to develop more healthful food crops, as well as underscore challenges being encountered in pursuing this strategy. Topics to be covered include: the role of health profiling of a crop in designing a program of research, exploitation of the biodiversity of crop varieties for identifying health characteristics for which crops have useful variation, selection of model systems for evaluating health

traits, and the use of “omics technologies” and traditional approaches to facilitate rapid characterization of traits of interest. Work on the assessment of cultivars of staple and specialty crops for differences in glucose availability and on the development and control of obesity and the risk for cancer will be presented. The metabolomic profiling of core collections of a crop’s germplasm will be used to illustrate a strategy by which a limited number of crop cultivars are selected for detailed analyses in animal models for chronic disease and the case will be made for the need for unbiased chemical profiling to identify complementary food combinations with enhanced health benefit. Candidate mammalian cell signaling pathways that are dysregulated during the development of chronic diseases and that may serve as targets of human health beneficial plant secondary metabolites will be reviewed. The ultimate goal of this effort is to define a discovery process that identifies traits that can be used by plant breeders to improve a crop’s human health attributes. As the field of biomedical agriculture develops, consumer are likely to be informed about currently unappreciated health benefits of existing food selections and to be offered new selections with improved disease prevention characteristics. It is anticipated that future dietary guidelines for chronic disease prevention will make recommendations about beneficial food crop combinations and the varieties within a crop with specific biomedical traits.

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CONVERTING BIOMASS TO SOLID OR LIQUID BIO-FUELS

Ravi Malhotra

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iCAST is a 501(c)(3) whose mission is “to provide economic, environmental, and social benefits to economically disadvantaged individuals and communities; and to provide education and training that builds local capacity.” Since its inception in 2002, iCAST has gained extensive experience developing and implementing projects using a variety of biomass-to-fuel technologies, including:

- Biodiesel
- Straight vegetable oil (SVO) as fuel
- Engineered biomass fuel briquettes
- Anaerobic digesters

Biodiesel and SVO have attracted a great deal of interest in rural communities as a means to internalize energy costs and displace diesel fuel consumption. iCAST has partnered with numerous agricultural producers, research centers and universities to demonstrate production of both SVO and bio-diesel.

iCAST has demonstrated the use of engineered biomass fuel briquettes to make coal-fired power plants greener, while mitigating waste streams such as manure, agricultural residues, coal waste, and forestry and sawmill waste. iCAST has utilized standard pelleting processes and equipment for the production of such solid fuels ad is currently evaluating ‘torrefaction’ as a process to develop a versatile, solid biomass fuel that can be co-fired in any coal power plant.

iCAST has also demonstrated anaerobic digesters as a way to generate clean electricity from bio-gas and mitigate a variety of biomass-based waste streams at the same time.

Each of these biomass-to-fuel technologies, when used appropriately, can foster economic viability, environmental stewardship and social responsibility in our agricultural communities.

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A LANDSCAPE VISION FOR INTEGRATING INDUSTRIAL CROPS INTO BIOFUEL SYSTEMS

Douglas L. Karlen

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Achieving energy independence and security through domestic production of renewable biofuels is feasible but will require a different landscape than we have with current agricultural practices. Integrating industrial crops such as Canola, Camelina, or Cuphea could offer many opportunities to enhance multiple ecosystem services. To do so, we must first address multiple challenges as an integrated system rather than as a collection of individual problems. This presentation provides a vision and suggested approach for integrating new crops into more diverse and productive landscapes. The vision is based upon on-going research that has evolved from site-specific agricultural management activities. Through it, we provide a strategy for identifying the most limiting factors, matching critical resource needs with appropriate conservation practices, and scaling the concept to a production scale. The importance of evaluating all ecosystem services before and after incorporation of the industrial crops will be discussed as the vision is illustrated using a hypothetical landscape plan. The presentation concludes by examining some of the barriers that must be overcome to implement a landscape vision for sustainable bioenergy production on America's working lands.

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Oilseeds

THE BIOLOGY OF *THLASPI ARVENSE*: IMPLICATIONS FOR DOMESTICATION AND CULTIVATION

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Field pennycress (*Thlaspi arvense* L.) is a winter annual native to Eurasian that has become cosmopolitan weed of North America. In recent years interest has increased in developing *T. arvense* as a crop for industrial oils. This talk will review the aspects of the physiology and ecology of *T. arvense* that will be important in the domestication and cultivation as well as potential areas for future research.

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EVALUATION OF FIELD PENNYCRESS (*THLASPI ARVENSE* L.) POPULATIONS

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The common winter annual weed *Thlapsi arvense* L. (field pennycress) has been recently identified as a potential new source for biodiesel and as a potential additive in petroleum based products. A unique advantage pennycress offers is a short life cycle allowing for opportunities for double cropping. Pennycress has tremendous potential for offseason production without impacting subsequent crops. The objective of this study was to collect and evaluate wild populations of field pennycress (*Thlaspi arvense* L.) for potential inclusion in a plant breeding program.

During late spring of 2008, pennycress seed was collected from 21 wild populations across the Northern United States and Canada, along with 10 accessions from the North Central Regional Plant Introduction Station in Ames, IA. Seed was planted from each population in the fall and spring of 2009 and 2010. Populations were evaluated for seed yield, total seed oil, fatty acid methyl ester content, along with several agronomic traits. Total oil content was determined by nondestructive pulsed NMR on whole pennycress seed, while fatty methyl esters were quantified utilizing gas chromatography.

Nine of the pennycress lines were identified as having no dormancy requirements and were labeled as spring lines, while the remaining 22 lines were winter lines requiring a cold period to induce flowering. Total seed yield ranged from 87 to 2,520 kg per hectare while 1000 seed weight ranged from 0.97g to 1.7g. Total oil content ranged from 25.9% to 37.2% across all the populations. The three best populations yielded over 784 kg of oil per hectare, while the lowest line produced only 28 kg per hectare. Erucic acid C22 levels ranged from 30.3 to 37.5%, while Oleic acid C18:1 ranged from 7.8 to 11.9%. All lines demonstrated excellent winter hardiness and tolerance to insects and diseases. Only the spring lines had issues with lodging when planted in the fall.

Pennycress's short growing season, high levels of total oil, and seed yield, increase its viability for commercialization and potential for plant breeding programs.

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THLASPI ARVENSE (PENNYCRESS) GERMINATION, DEVELOPMENT AND YIELD POTENTIAL

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Pennycress is being developed as an off-season rotation crop which precedes an annual soybean production. This rotation scheme may offer distinct advantages to farmers by providing additional farm income from an otherwise fallow season with little impact on the subsequent soybean production.

Pennycress was grown on multi-acre field plot and small 2 m^2 plots in the fall of 2008 and 2009. In the fall of 2008 field plots were established with a Brillion 6' Sure Stand seeder at a planting rate of 2.5 x 10^6 seeds/hectare with expected germination of 72%. Plant stand density ranged from 7.4 x 10^5 to 3.2 x 10^6 plants/hectare. Plant density remained the same throughout the entire growing season. The multi-acre field had 1 m^2 hand harvest yield range of 226 – 1,533 kg/ha (202 – 1369 lbs/acre) and the corresponding block gave combine harvest yield rang of 607 – 1087 kg/ha (542 – 971 lbs/acre). Average yield determined for the field by 1 m^2 hand harvest was 1140 kg/ha (1018 lbs/acre) and the combine average yield was 1082 kg/ha (966 lbs/acre).

In the fall of 2009, 1 m x 3 m complete randomized block design plots were established at NCAUR using a Great Plains 6' wide No-Till grain drill at a seeding rate of 2.5 x 10^6 plants per hectare. Several different thlaspi seed lots were evaluated for germination, plant stand development, maturity date, seed yield, oil content and fatty acid profile. Lines from the Beecher germplasm clearly outperformed all other lines and gave hand harvested yields of 1075 – 2534 kg/ha (1,204 – 2,263 lbs/acre) with an average yield of 2035 kg/ha (1817 lbs/acre).

The seed was found to contain 36% oil with the major fatty acid as erucic at 38.1%, iodine value of 115. Viscosity index (VI) of the methyl esters was 277 with a 40^{o}C viscosity of 5.0 cSt and pour point and cloud points of -15 and -10 ^{o}C respectively. The starting oil had a VI of 222 with a 40^{o}C viscosity of 39.1 cSt and pour point and cloud points of -18^{o}C and -10^{o}C respectively. As expected, the flash point of the methyl esters 136^{o}C was considerably less than the starting oil 234^{o}C. Oil stability index (OSI) of the oil at 100^{o}C was 39 h and 54.0 h for methyl esters.

The early harvest date of pennycress compared to other winter annual oilseed crops will make it suitable for a two crop rotation with soybeans in most of the Midwestern U.S. In addition, the physical properties of the methyl esters indicate that continued development of the oil as a biodiesel is warranted.

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PENNYCRESS, WHAT WE KNOW AND WHAT WE NEED TO LEARN

Brad Glenn

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Talk on what we currently know about raising pennycress as a crop and all the things we need to learn from a farmer's perspective.

Commercial production of pennycress in rotation with existing commodity crops is under evaluation in Central Illinois. Pennycress is a winter annual oilseed that shows potential as an alternative crop for Midwestern Farmers. One of the key aspects of pennycress is its late spring harvest which allows for nearly a full soybean production season with little to no impact on the soybean production cycle.

Pennycress from the Patton line has been evaluated on commercial fields by 9 farmers in Illinois provided several key points of understanding for its future development. Fields were planted by drill, broadcast and aerial seeding in mid to late October 2009. A variety of field conditions were examined for their potential to establish a stand of pennycress before winter. Drill and broadcast seeding were performed on freshly harvested corn and fallow winter wheat and tilled post corn harvest. Aerial seeding was performed over standing corn and the corn subsequently harvested. Late plantings on all fields resulted in no fall stand establishment. However, the spring equinox initiated germination and these spring emerged fields were allowed to grow to maturity. Direct combining of these fields were performed in early June. Combine yields of these fields were low due to late stand establishment but provided enough seed for future plantings in 2010.

Production attempts so far haven't been under the best agronomic conditions. The next step is to see what we can learn under better conditions and treatments.

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WINTER CAMELINA IN THE NORTHERN U.S. AND THE POTENTIAL OF ITS USE IN DOUBLE-CROPPING

Russ W. Gesch

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Camelina (*Camelina sativa* L.) seed oil can serve as a feedstock for advanced biofuels and may be produced more cheaply than traditional oilseeds such as soybean [*Glycine max* (L.) Merr.]. In cool, temperate climates such as that of the northern Corn Belt region of the U.S., camelina can be grown as a winter or summer crop. Because of their short lifecycle, winter cultivars might be harvested early enough to allow producing a second crop within the same growing season. Little is known about best management practices for producing winter camelina in the northern U.S. or the potential to follow it with a second crop.

A two-year field study was conducted in west central Minnesota to determine the optimal seeding date for two winter camelina cultivars, BSX-WG1 and Joelle. Camelina was sown into either chisel plowed or no-tilled soil in the fall between early-September to mid-October at 10 to 14 d intervals. To explore the potential of double-cropping, early maturing cultivars of soybean, sunflower (*Helianthus annuus* L.), and millet (*Setaria italic* L.) were planted immediately following camelina harvest.

In both years, camelina was harvested as early as June 26 to June 30. Plant population density at harvest tended to be greatest when sown in late-September to mid-October in no-tilled soil containing wheat (*Triticum aestivum* L.) stubble. Likewise, seed yield was generally greatest for late-September to mid-October sowings. Joelle out yielded BSX-WG1 both years, and was as high as 1317 kg ha^{-1} when sown October 1. Seed oil content, which was as high as 42%, was greatest for Joelle and tended to increase for both cultivars with later planting. Soybean and sunflower sown immediately after camelina harvest yielded from 70 to 76% of their full-season counterparts, and millet yielded 6.9 to 8.9 Mg ha^{-1} of forage.

Winter camelina appears to have good winter survival in the northern Corn Belt and yields best when seeded in late-September to mid-October. Preliminary evidence indicates that the gross income of double-cropped camelina and soybean exceeds that of mono-cropped soybean, thus suggesting that double-cropping with winter camelina may be a

viable option for farmers in the northern U.S.

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PRODUCTION OF CAMELINA AS BIOFUEL FEEDSTOCK IN A WHEAT-BASED PRODUCTION SYSTEM IN CENTRAL MONTANA

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Biofuel feedstock should use non-food crop and the feedstock production should not cause direct and/or indirect land use changes which may result in competition with food crops in land use and possible increased green house gas emission. Camelina (*Camelina sativa* L.), a non-food oilseed crop, has been proven a good feedstock for bio-diesel and aviation fuel, and the crop adapts well to the semi-arid area of the Northern Great Plains. The objective of this study was to develop cropping systems that use camelina as a rotation crop in wheat (*Triticum aestivum* L.) –based production systems to minimize the impact of camelina production on wheat yield and land use. In central Montana, camelina-wheat continuous cropping was compared to traditional fallow-wheat and barley-wheat systems; canola (*Brassica napus* L.)-wheat system was also included for comparison. In 2009, winter wheat yield following camelina was 1322 kg ha^{-1} compared to 1820, 1244, and 1400 kg ha^{-1} following fallow, barley, and canola, respectively. Following winter wheat, the yield of camelina, barley, and canola was 1381, 2223, and 531 kg ha^{-1}, respectively. Camelina has a great potential to become a viable energy crop to be grown in wheat-based cropping systems in the Northern Great Plains. The economic return of each crop rotation and the impact of camelina production on wheat will be assessed after more data collected in 2010.

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SEEDING DEPTH AND GENOTYPE INFLUENCE ON WINTER CAMELINA IN NORTH DAKOTA

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Seeding depth for small-seeded winter annuals is important for rapid emergence and subsequent sufficient plant development to withstand the rigors of the harsh winters associated with the northern Great Plains in the US.

The objective of this study was to evaluate the influence of seeding depth on winter camelina (Camelina sativa L.) fall stand establishment, winter survival, and crop performance.

The study was established near Prosper, ND, in the fall of 2007 and 2008. The experiment was a 2x2 factorial in a RCBD with surface/packed and 13-mm seeding depths, and genotypes BSX-WG1 and Joelle. Conventional tillage seedbed preparation was performed after harvesting of hard red spring wheat (Triticum aestivum L.) with winter camelina seeded in late Sept. Traits evaluated included fall stand rating, winter survival, plant height and lodging, seed oil content, and seed yield.

Fall stands were similar for surface/packed and 13 mm seedings for both genotypes and ranged from 8.6 to 9.1 on a low to high stand establishment scale from 0 to 10. Winter survival of stands was similar for surface/packed and 13 mm seedings for both genotypes and ranged from 94.2 to 95.0%. Genotype Joelle was 7.1 cm taller than BSX-WG1's height of 70.6 cm. Plant lodging was not influenced by seeding depth or genotype. Mean study seed oil content and seed yield were 381 g kg^{-1} and 1300 kg ha^{-1}, respectively, and not influenced by seeding depth or genotype. In this study, surface seeding/packing and seeding at 13 mm both produced similar crop performance.

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OIL CONTENT AND SEED YIELD IMPROVEMENT OF *LESQUERELLA FENDLERI* (BRASSICACEAE)

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Improvement in seed oil content and seed yield of *Lesquerella fendleri* (Gray) Wats. (Brassicaceae) could have a large impact on attracting new markets for commercialization of this new oilseed crop. There have been several previous germplasm releases for public use with improvements of these traits. The oil consists predominantly of hydroxy fatty acids (HFA) useful for industrial lubricants, greases, biofuel additives, and cosmetics. This new cultivar of lesquerella brings the crop closer to the reality of a commercial crop.

The objective of this study was to test the new cultivar 'Gail' in two Arizona locations over two years in replicated experiments to compare it to the best available germplasm. The locations were Tucson, AZ, a higher elevation and cooler environment, and Maricopa, AZ, a warmer environment in central Arizona. Plant biomass samples were obtained at harvests of both years from 10 plants/rep/ location/year. Plants were also sampled throughout the growing season. Flowering counts were done throughout the season. Seed yield was measured from individual plants, samples taken for oil content and profile, and harvest index calculated. Selection for 'Gail' was based on oil content and seed yield.

Seed yield was higher in the cultivar 'Gail' at both locations and years compared to the two germplasm lines WCL-LO3 and WCL-LO1 used as checks. The plant biomass of 'Gail' was higher than the check lines at both locations the first year and one of the locations the second year. Plants of 'Gail' began flowering earlier at both locations compared to the two check lines. Results from seed oil content will be presented.

The release of this new cultivar benefits growers and industrial markets by providing a new genetic material for use and a new base for further selection in breeding programs.

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DEVELOPING A NEW *LESQUERELLA FENDLERI* CROP FOR CASTOR OIL PRODUCTION

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Seed oil of *Lesquerella fendleri* contains a valuable hydroxy fatty acid (HFA), lesquerolic acid (20:1OH). The conventional source of HFA is ricinoleic acid (18:1OH) from castor seeds. Ricinoleic acid and its derivatives are used as raw materials for numerous industrial products, such as lubricants, plasticizers and surfactants. The production of castor oil, however, is hampered by the presence of the toxin ricin and hyper-allergic 2S albumins in its seed. *L. fendleri*, on the other hand, does not have such biological toxic compounds, thus its oil represents an alternative source of HFA. Lesquerolic acid is derived by a 2 carbon elongation of 18:1OH. By suppressing the elongation step through genetic engineering, it is possible to generate a new *L. fendleri* crop that could produce 18:1OH.

To facilitate such a genetic approach, we investigated morphological and physiological changes, as well as temporal details of fatty acid composition and gene expression during seed development. There are three distinguishable physiological periods in *L. fendleri*, an early period of rapid increase in whole-seed fresh weight, a mid-maturation period of steady increase in dry weight, and a late-maturation/desiccation period indicated by water loss. We found three HFAs accumulated consecutively, with initial appearance of 18:1OH, followed by 20:1OH and auricolate (20:2OH). Only

20:1OH reached a predominant level of 55%. Using real-time PCR, we quantified the transcript level of three key lipid genes involved in HFA synthesis, *LfFAH* (oleate 12-hydroxylase), *LfKCS3* (3-ketoacyl-CoA synthase) and *LfFen1* (oleate 12-desaturase). We found the synthesis of 20:1OH regulated mainly by gene transcription of *LfKCS3*.

We also established a stable genetic transformation system in *L. fendleri*. One of the hurdles in transforming *L. fendleri* is the high frequency of chimeric shoots which can give rise to non-transgenic gametes and progenies. With aid of a ß-glucuronidase gene (*gusA*) that confers blue color in transgenic cells for visual screening of chimeras, we developed an efficient procedure to eliminate the chimeras by 4 rounds of repeated shoot regeneration processes. Stable transgenic lines were demonstrated up to second generation.

The copy number a transgene can greatly influence the expression level and genetic stability of the transgene. To determine the copy number in the transgenic *L. fendleri*, we applied a real-time PCR assay using a known one copy endogenous gene, *LfKCS4/5*, as a calibrator, and determined the copy number of *gusA* and hygromycine phosphotransferase II transgenes. This is rapid, sensitive and accurate method, and proven to be effective in determining transgene copy number in *L. fendleri*.

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MOLECULAR GENETIC CHARACTERIZATION OF A HIGH OLEIC/NO HYDROXY FATTY ACID SEED OIL MUTANT OF *LESQUERELLA FENDLERI* (BRASSICACEAE)

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Lesquerella fendleri (Gray) Wats. (Brassicaceae) is being developed as a new crop for its seed oil that is typically comprised of ca. 55 percent of the hydroxy fatty acid (HFA) lesquerolic acid. Most breeding efforts for lesquerella have been geared towards improving harvest index, seed yield or production practices, with little attention paid to modifying seed oil composition. However, with the recent application of the half-seed method to our breeding population, we have identified greater variability in the fatty acid (FA) composition in the seed oil than had previously been characterized, including a mutant with high oleic and no HFA.

The objectives of this study were to characterize the underlying molecular genetic basis high oleic/no HFA mutation in order to inform breeding practices of lesquerella for altered HFA levels.

The oleate 12-hydroxylase gene (LFAH12) was investigated using Southern blot analysis, PCR, RT-PCR and chromosomal walking to determine the gene number, DNA sequence and expression patterns for a control and mutant.

HFA inheritance and Southern blot analyses data indicate the LFAH12 gene is present in as one copy. Further, the mutant phenotype segregates in 1 to 3 ratio revealing that it is a recessive trait. Chromosomal walking uncovered a large indel in the 3' end of the LFAH12 mutant and a corresponding premature stop codon, resulting in gene truncated by 29 amino acid residues. RT-PCR analysis of the LFAH12 mutant in developing seeds indicates that the gene is expressed, although at lower levels than the control - results that may be expected from nonsense-mediated mRNA decay. No other noticeable phenotypic differences were observed in the mutant.

The isolation and molecular genetic characterization of the LFAH12 mutant benefits the selection for altered HFA levels in lesquerella by providing a null parent to identify high HFA alleles by crossing or for transgenic HFA programs.

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LESQUERELLA PRESSCAKE AS AN ORGANIC FERTILIZER FOR GREENHOUSE TOMATOES

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Lesquerella press cake is a co-product generated during the processing of the new oilseed crop lesquerella [*Lesquerella fendleri* (A. Gray) S. Wats.]. As with other new crops, developing commercial uses for the press cake would increase the profitability of growing lesquerella. The press cake contains levels of nutrients which should make it an excellent organic fertilizer for container-grown plants.

The objective of this study was to determine the growth and yield responses of greenhouse tomatoes (*Solanum lycopersicum* L. 'Red Robin') supplemented with only lesquerella presscake as a complete organic fertilizer, compared against a chemically-fertilized control and cottonseed meal, a conventional organic fertilizer.

Tomato plants were grown in potting mix supplemented with a standard chemical fertilizer mix or either lesquerella press cake or cottonseed meal at rates of 2.5, 5.0 and 10.0 % (w/w). Both of the organic fertilizers had only minor effects on the physical properties (bulk density, total porosity percentage, total solids percentage, pH, EC) of the potting mixes with increasing rates, although there was substantially less shrinkage of media amended with 5 and 10% press cake than with the same rates of cottonseed meal. At rates of 10.0% for press cake and 5.0% for cottonseed meal (which supplied similar substrate nitrogen levels), plant heights, total tomato yield per plant and number of fruit per plant were equal to that of the chemically-fertilized control. There were no differences among treatments for average fruit weight. Chlorophyll content was generally similar among the treatments during the course of the experiments, with a trend towards lower values for the 2.5% rates of press cake and cottonseed meal near the conclusion of the experiments.

From the results of this study it appears that lesquerella press cake may be utilized as an organic fertilizer for container-grown tomatoes.

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Fiber and Cellulosics

THE ROLE OF FIBER AND CELLULOSIC CROPS IN THE PRODUCTS OF TOMORROW

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Considering that the US corn ethanol industry has been under tremendous pressure lately – with criticism that ethanol contains relatively less energy per liter than gasoline, it cannot be used as aviation fuel, and it is blamed for raising food prices – more attention is focused on converting cellulose to biofuels and bioproducts. Our USDA research team is developing biorefinery strategies beyond corn ethanol that are relevant to the Western US that will result in new uses for cellulosic fibers and new biomass feedstocks. Research directions include (1) development of novel enzymes and microbes for pretreatment of crops for cellulose-to-ethanol conversion (2) use of crop feedstocks prevalent in the West, (3) optimization of novel separation engineering for bioproduct isolation, and (4) production of complementary products, including cellulose-based composites, biodegradable plastics, sustainable chemicals, and novel nanocomposites. The goal is to add value to agricultural crops and residues. This presentation will address the differences between fibers derived from different crop sources in development of bioproducts and give specific examples of new technologies on biopolymers. Specifically, data will be presented on (1) comparing composite materials from a range of crop sources, (2) using varied feedstocks for biorefineries, including sorghum, switchgrass and municipal solid waste, and (3) nanocomposite biomaterials with novel properties.

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LONG-TERM PERFORMANCE OF THERMOPLASTIC COMPOSITE MATERIAL WITH COTTON BURR AND STEM (CBS) AS A PARTIAL FILLER

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Cotton burr and stem (CBS) fraction of cotton gin byproducts has shown promise as a fiber filler in thermoplastic composites, with physical and mechanical properties comparable to that made with wood fiber fillers. However, the long-term performance of this composite material is not known. It is important to evaluate the long-term performance of this composite as it is developed as a replacement for southern yellow pine in non-structural and outdoor building applications.

The objective of this study was to evaluate the long-term performance of thermoplastic composite with CBS as the filler, in comparison to wood-polymer composite (WPC).

An experiment was conducted by manufacturing thermoplastic composite with CBS replacing wood in varying proportions as the fiber filler. All fiber materials were ground to a size of 20-60 mesh. Wood: CBS ratios of 100:0, 75:25, 50:50, and 25:75 by percentage weight were used as the treatment. The composite used 50% of fiber filler, 40% HDPE, and 10% of other additives, all by weight. The samples were manufactured using a commercial scale single screw extruder into 25x 152 mm rectangular profile. The extruded samples were water cooled, conditioned, and then subjected to accelerated aging as per ASTM D1307 standard. All the samples were then tested for flexural strength, nail holding capacity and water absorption.

The samples from the first two three cycles of aging showed a gradual decrease in water absorption and thickness swelling. In general, the modulus of elasticity deteriorated with number of cycles of aging, while flexural strength showed a cyclic behavior of deterioration followed by some recovery. This behavior is comparable to those reported for wood polymer composites.

Long-term performance of thermoplastic composite with cotton burr as the filler was comparable to that of wood polymer composites.

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EVALUATION OF BIOMASS RESIDUAL SUBSTRATE BLENDS FOR ECO-FRIENDLY PACKAGING AND INSULATION SHEETS/PANELS

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Polystyrene is one of the most widely used plastics and is commonly produced in three forms: 1) Extruded polystyrene – disposable utensils, CD/DVD cases, yogurt containers, smoke alarm housing, etc.; 2) Expanded polystyrene foam – molded packaging materials and packaging "peanuts"; 3) Extruded polystyrene foam – insulation boards. Extruded polystyrene foam is commonly sold under the trademark name of "Styrofoam". Polystyrene packaging and insulation is a multibillion dollar a year industry. Since polystyrene is non-biodegradable, a biodegradable material that is eco-friendly is being sought as a substitute for packaging and insulation board consumers. Ecovative Design, LLC has developed a process whereby they can produce an eco-friendly packaging and insulation board product.

The objective of this research was to develop and evaluate various blends of waste material from cotton gins, commonly referred to as cotton gin trash/ cotton gin waste, as a substrate in Ecovative's process. Tests were conducted to evaluate six cotton waste blends to ASTM standards as well as conventional polystyrene. Properties evaluated included: density, strength (compressive and tensile), dimensional stability, modulus of elasticity, sterilization efficacy, colonization rate, thermal conductivity, flame retardance, energy dissipation, and accelerated aging. Results revealed blends that were superior or equal to ASTM standards and polystyrene. One of the higher performing blends was used to launch Ecovative's product (EcoCradle^{TM}) with two Fortune 500 companies during the last few months.

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NONWOOD FIBERS: GLOBAL ACTIVITIES AND CHALLENGES

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Nonwood fibers are attracting growing global attention as economically, functionally, and environmentally beneficial alternatives to synthetic fibers. These generally fast growing plant materials absorb CO_2, sequester carbon, and potentially offer sources for biofuels, composites, pulp for paper, and substitutes for timber and petroleum derived products.

This presentation will briefly and succinctly outline certain nonwood fibers, their current and potential applications, and the opportunities and challenges inherent in changing established methods and processes.

The materials that will be presented are the result of Mr. Rymsza's over 20 years of experience as a business professional developing and promoting kenaf "tree-free" papers and his additional experiences consulting and cooperating with other like-purposed research organizations and commercial projects worldwide.

While there are challenges to penetrating certain product segments or industries, growing global awareness of climate change issues, CO_2 concentrations, and corporate participation in voluntary and mandatory emission reduction programs indicate that nonwood fibers will evolve from obscurity to mainstream in the future.

This presentation will briefly cover the main benefits of nonwood fibers, and provide an outline for the further research, funding, and commercialization of these alternatives in appropriate, sustainable ways.

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Natural Rubber and Resins

GUAYULE RUBBER PRODUCTION AT SACATON, ARIZONA 1987-1990

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In 1983, the Gila River Indian Community contracted The Firestone Tire & Rubber Co. to design and build a prototype processing facility for the production of rubber (GR) from guayule (*Parthenium argentatum* Gray). In 1986, Firestone was contracted by the U.S. Department of Agriculture (USDA) to produce a total of 54 t (53 long tons) of GR. In December, 1990, after three years of operation, a total of 8.8 t (8.7 long tons) of GR had been produced.

Described here is an overview of the process development and operation phases of the Firestone guayule project.

What factors influenced the design process and, ultimately, the operation of the pilot facility? What current information would have been beneficial during the design and operation phases of the project? What was learned from the project?

What factors influenced the design process and pilot facility operation? The Firestone process involved simultaneous extraction of rubber and non-rubber components ("resin") using a two-component monophase solvent. Extracted rubber was isolated from a rubber-resin miscella by coagulation with the more polar component. The primary feedstock was "Gila I" — more correctly, AZ-101. Compared to established USDA shrub lines, AZ-101 had low rubber levels and lower-quality rubber, necessitating greater fractionation of the extracted polymer. Factors such as these influenced the selection of processing equipment, especially those components used for separation of the rubber-resin miscella from residual shrub solids.

What would have been nice to have known at the time? AZ-101 is an interspecific hybrid. The relatively low yields and unique physical properties of the rubber in AZ-101 may relate to this genetic legacy. The fractionation operation increased the level of unsaturated fatty acid triglycerides in the coagulated rubber. These components are implicated in the oxidative degradation of GR. In contrast to NR, low-protein GR would also prove especially susceptible to non-oxidative thermal degradation.

What was learned from the project? Any process must accommodate a range of potential feedstocks and extraction solvents. The primary non-mechanical problem affecting rubber production was the shrub supplied to the processing facility. Compared with USDA shrub lines, AZ-101 was distinctly inferior in terms of GR yield and quality. Mechanical problems arose from the performance of some items of processing equipment and from the impact of shrub quality on the operation of that equipment. Separation of the rubber-resin miscella from bagasse proved crucial to process optimization.

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SUSTAINABILITY OF NATURAL RUBBER-PRODUCING CROPS IN THE UNITED STATES: APPLIED BIOTECHNOLOGY LESSONS 2000-2010

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Natural rubber (NR) is a critical and strategic raw material for industrial manufacturing and national defense. Development of a US-based supply of NR is recognized in the Critical Ag Materials Act, Public Law 95–592. Domestic rubber-producing crops have been introduced in the US during times of short supply and high prices; but, development was discontinued once prices of imported NR fell. During the past ten years guayule has been re-introduced as a new crop in the southwestern US; Russian dandelion is under research and development as a rubber-producing crop for the northern US. However, commercial sustainability of domestic NR is limited by yields of NR from existing germplasm. During the past ten years the tools of biotechnology have been applied to address this issue.

Rubber biosynthesis takes place via the isoprenoid pathway to a metabolic endpoint, i.e., rubber is stored, not metabolized, by plants. The polymerization reaction proceeds by successive condensations of the monomer isopentenyl pyrophosphate (IPP) following initiation by an allylic pyrophosphate (APP). A lipid monolayer membrane stabilizes the insoluble, high molecular weight (>106 g/mole) rubber. Most of the rubber biosynthesis pathway enzymes are well established, with the exception of the rubber transferase (RuT). Assumed to be a cis-prenyl transferase, it may actually be an enzyme complex, evidence of which has emerged through systematic biochemical and molecular studies. Many proteins associated with rubber particles yet not directly involved in the rubber biosynthesis pathway have now been

identified. The role of these proteins may be in the structure of the rubber particle membrane.

Genomic information has been developed and disseminated to benefit researchers worldwide. Transformation systems have been developed for guayule and Russian dandelion, and manipulations of known pathway genes successfully completed. Laboratory results are not always predictive of field evaluations in guayule, supporting the strong influence of environment on rubber production. Strategies to improve the efficacy of metabolic engineering have evolved with that of the biotechnology toolbox including more effective promoters, multiple gene constructs, and chloroplast transformation.

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HARVEST HEIGHT AND FREQUENCY EFFECTS ON GUAYULE LATEX, RUBBER, AND RESIN YIELDS

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Guayule (Parthenium argentatum Gray) is a perennial shrub native to the Chihuahuan Desert. The commercialization of guayule for hypoallergenic latex and other products such as resin for termite resistant wood products and as an energy source have renewed interest in production practices such as harvesting height and frequency. Results from these types of agronomic studies are needed in order to develop guayule production schemes for successful commercialization. The objectives of this study were to determine the yield and concentration of latex, rubber, and resin of five guayule lines harvested at two cutting heights over three years and four harvesting schedules. The five lines with variable plant height used were AZ-2, AZ101, AZ-1, 11591, and N9-3 (tallest to shortest). Harvesting height Treatment 1 (T1) was the currently recommended 100% after two years followed by a second harvest after two years of regrowth. Treatment 2 was the same as T1, except the harvest height was only the upper 50% of the plant height. Treatments 3 and 4 were the same as T1 and T2, except the regrowth was harvested annually at 100% and 50%, respectively after the initial harvest at two years of growth. Treatments 5 and 6 were each harvested once after three years of growth at 100% and 50% cutting heights, respectively. Treatments 7 and 8 were each harvested once after four years of growth at 100% and 50% cutting heights, respectively. Each treatment was replicated four times. Yields were compared for each of the three harvest years and for total production across all four years. Harvesting at 100% of plant height gave higher yields than harvesting at 50% of plant height independent of the harvest schedule. Harvesting at 100% after four years of growth gave the highest yields, but more research is needed to determine if harvesting on a two year schedule may be easier for harvesting and extraction equipment. We did notice some plants did not regrow well when cut at 100% for three years consecutively (T3). AZ-2 and AZ101 were the largest plants, while N9-3 and 11591 were smaller with AZ-1 intermediate. The results for these lines were similar to previous studies when they were harvested at 100% of plant growth. There were significant interactions among lines and treatments. However, the interaction effects were smaller than the main effects of line and harvest schedule treatment and due mainly to the much smaller plant size of N9-3 compared to the other lines. As indicated in previous studies, the environment plays a large role in determining biomass, latex, rubber, and resin yields in guayule. In the future, optimum harvesting schemes at 100% of plant height may need to be developed for each line and environment.

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GUAYULE PRODUCTION ON THE SOUTHERN HIGH PLAINS

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Native guayule populations are scattered throughout 300,000 km^2 of rangeland in the Chihuahuan Desert and surrounding regions. The only native indigenous U.S. stands occur in the Trans Pecos region of southwestern Texas, and represent the most northern extension of the plant's habitat. Maximum air temperatures of over 38^oC are frequent and minimum temperatures of -23^oC have been recorded. The objective of our study was to determine if guayule production could be successful farther north on the Southern High Plains near Halfway, TX.

Seed used in the experiment included four released lines, AZ-1, AZ-2, AZ-3, and AZ-4; a released USDA cultivar (11591); and three unreleased breeding lines, N9-3, N6-5, and N13-1. Guayule seedlings (60 days-old) were transplanted on May 18, 2006, at the Texas AgriLife Research Station at Halfway. The experimental design was a randomized complete block with four replications. Plots were single rows (each containing 18 plants of each line) spaced 1 m apart and 6 m long. Plant height was measured November 7, 2006, June 6, 2007, October 21, 2007, and June 18, 2008. Guayule cold damage was estimated June 6, 2007, using the following index: (1) no damage, (2) slight – injury of terminals to 6 cm, (3) moderate – 2/3 of plant volume injured, (4) severe – all aerial portions killed but resprouting, and (5) complete – beyond recovery with no regrowth. Two plants from each plot were harvested by hand on April 15, 2008 and March 30, 2009, weighed, and ground in a Troy-Bilt Chipper/Shredder. Samples were collected for moisture and rubber and resin content, and stored at -20^oC. Biomass yields were determined on oven dry weights.

Following the 2006/2007 winter the cold damage index ranged from 1.2 in 11591 to 3.8 in AZ-1. The minimum air temperature recorded was -14^oC. There was minimal cold damage during the 2007/2008 and 2008/2009 winters. Biomass of the 24 month-old shrubs harvested in 2008 varied from 9,639 kg/ha in line 11591 to 13,393 kg/ha in line AZ-4. Shrub biomass in 2009 ranged from 26,721 kg/ha in 11591 to 32,951 kg/ha in N6-5. Rubber yield in 2008 was 222 and 639 kg/ha in lines AZ-3 and N6-5, respectively. Line AZ-3 yielded 717 kg/ha of rubber in 2009 while line AZ-4 yielded 2006 kg/ha.

Lines 11591 and N6-5 had the least cold damage and hold promise for establishment and rubber production on the Southern High Plains. Guayule grown here will not produce the biomass of those cultivated in the Southwest, but certain production criteria may make the Plains an ideal production site: annual rainfall averages 46 cm, irrigation water salinity is less than 1 E.C. and is pumped from only 90 m, and center pivots are available for establishing guayule by direct-seeding.

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BREEDING GUAYULE: HOW FAR HAVE WE COME AND HOW FAR CAN WE GO?

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Guayule lines from the 1940s yielded less than 350 lb rubber/acre/year. Using the available germplasm from this earlier era, guayule rubber yields have increased significantly, between 830 lb rubber/acre/year and 1,000 lb rubber/ acre, through the efforts of a few, but dedicated researchers. Improved guayule germplasm lines have been developed and released, and these lines are now grown worldwide and are available for further improvement in specific environments or for specific traits.

Selection in guayule has been aided by the description of the components of yield and their relationships to rubber production, and the measurement of the heritability of these characters. In general, rubber content (%) is not correlated with rubber yield, and in fact is often negatively correlated. Fresh and dry weights, as well as other characters related to biomass production, are highly and consistently correlated to rubber yield. Heritability estimates for these traits, made in

mature stands (2- to 3-year-old plants) by parent-progeny regressions, were essentially zero, but it has been shown since then that this is from the compounding of environmental effects over the years that a guayule plant is in the field. We now know that the greatest gains made from selections are by making selections in the first year of growth.

We still need to improve many characters, and even though there are problems in working with guayule from a breeder's point of view (perennial growth habit, rubber produced in response to cold, and reproduction by apomixis), improvements have and will contine to be made.

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General Crops and Products

IN VITRO ANTIFUNGAL ACTIVITY OF POLYPHENOLIC FRACTION OF *LIPPIA GRAVEOLENS* AGAINST *PENICILLIUM* SP.

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Fresh fruits and vegetables are very importants to the human food. However, they are products highly perishable. Postharvest decay of fruits and vegetables cause economics loss in the world horticultural industry every year. There is a worldwide trend to explore new alternatives to increase storage life, giving priority to methods that reduce horticultural product decay avoiding negative effects to human heath and environment. *Lippia graveolens* (Mexican oregano) an aromatic plant native from the Chihuahuan Desert, is used for its flavor in traditional food of the region, as to as natural remedy to heal respiratories, intestinal and other fungi diseases. There are reports about microbicidal and antioxidant properties of *Lippia graveolens* extracts attributed to the essential oils thymol and carvacrol. Nowdays *L. graveolens* extracts can inhibit the development of mycelial fungi in very low doses.

The objectives of this study were to evaluate the antifungal activity *in vitro* of the *L. graveolens* polyphenolic fraction against *Penicillium* sp., in postharvest fruits, as well as, to determine the chemical characterization of the active compounds.

The *L. graveolens* plants were collected at the southern of Coahuila State in Mexico. The ethanolic extracts were carried out in the ratio 1:2 (m/v), plant/solvent, during 48 h at room temperature. The polyphenolic fraction was obtained in a column chromatographic and the chemical compounds were characterized by HPLC. The polyphenolic extracts inhibitory effect was evaluated *in vitro*, by means of the mycelial growth of *Penicillium* sp. in Potato Dextrose Agar (PDA) infusion on Petri dishes.

We obtain a high inhibitory effect of the polyphenolic extract due the nature of the chemical compounds of this specie and also to the results reported for the *L. graveolens* crude extracts, toward different microorganism. This is the first report of the antifungal activity of hydro soluble polyphenols obtained from ethanolic extract of *L. graveolens.* This knowledge contribute to both the scientific research and useful comercial applications of this aromatic plant native of the Chihuahuan Desert in Mexico.

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EVALUATION OF ORGANOSOLV DELIGNIFICATION OF *ACACIA DEALBATA* FOR BIOETHANOL PRODUCTION BY SSF

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Society's increasing demand for transportation fuels has assured a viable future for the development of renewable fuels. Although first-generation biofuels are dependent on starches, sugars and vegetable oils, the need to generate higher volumes of biofuels at lower cost has shifted the research focus to cellulosic ethanol. Among lignocellulosic biomass, *Acacia dealbata* constitutes in Chile a new forest alternative as an opportunity of development for degraded lands and low agricultural yield, since these species present characteristics that allows them to adapt to hard conditions of soil and climate, exhibiting favorable results of growth, which allows to reach economic returns at early age.

The objective of this study was to evaluate the wood pretreatment of *A. dealbata* with the white-rot fungus *Ganoderma australe*, combined with organosolv delignification process at different severities, with the proposal to optimize and reach better ethanol yields than reported to date for *A. dealbata* with minimal energy consumption.

A biological pretreatment with the white-rot fungus *G. australe* was applied on wood chips of *A. dealbata* for 30 days. After biotreatment, the wood chips were delignified by an organosolv process using ethanol/water (60/40 v/v) as solvent, liquor/wood ratio 6/1, at different degrees of severity expressed as H-factor (2500, 5000, 7500 and 10000) to produce a substrate with low lignin content. The obtained pulps were submitted to simultaneous saccharification and fermentation (SSF), using the enzymes Cellulase (Celluclast, 20 FPU) and β-Glucosidase (Novozyme, 40 CBU) for enzymatic hydrolysis, and the yeast *Saccharomyces cerevisiae* for the fermentation of glucose, at 40 ºC and 10% substrate consistency.

The biological pretreatment of *A. dealbata* wood chips produced a favorable effect in the chemical composition of wood chips, showing a preferred degradation of lignin, which favored the later organosolv delignification, producing bio-pulps with higher classified pulp yield, and lower rejects and lignin content than control pulps. The SSF of organosolv pulps produced high ethanol yields (29-31 g/L). These results, indicates the susceptibility of *A. dealbata* wood chips to the bio-organosolv pretreatment, and the pulps produced were good substrates for bioethanol production.

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OPUNTIA COLLECTION AT THE NATIONAL ARID LAND PLANT GENETIC RESOURCE UNIT

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There are over 150 accessions of *Opuntia* (nopales) in the fields of the National Arid Land Plant Genetic Resources Unit (NALPGRU) which is part of the National Plant Germplasm System (NPGS). The collection focuses mostly on *Opuntia ficus-indica* although there are accessions from 20 other *Opuntia* species.

The objective of this collection, as is true of others in the NPGS, is to make the material available to those who want to develop or research the crop. This plant material is free and can be requested through the Germplasm Resources Information Network (GRIN).

Products of *Opuntia* are the pads (cladodes) used fresh as forage or for human consumption (the less spiny or spineless accessions are preferred for these uses), the preserved pads (canned), and fresh fruits used as food or for juice or jelly production. Two additional products are natural dyes, one extracted from the fruits and the other is the valued cochineal dye, extracted from the scale insects (*Dactylopius coccus)* that feed exclusively on *Opuntia*.

The San Joaquin Valley area where the collection is located has Mediterranean climate, with hot and dry summers and cloudy, rainy winters; in these suboptimal conditions some accessions have suffered damage from excessive winter moisture although most individuals have survived. Some summer irrigation is provided to accelerate the growth of the collection's plants in order to maintain a good supply of cladodes for customers. At NALPGRU, *Opuntia* has almost no pests, but occasional pesticide spray is needed for scale insect control. Additional care includes weeding of the plots,

removal of damaged cladodes and propagation of damaged individuals.

Plants in the *Opuntia* genus thrive where few species can live and while high productivity cannot be expected, they can be the source of several products, some with high value. The *Opuntia* collection at NALPGRU is a valuable resource for those looking for a low-input multi-purpose crop.

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RESPONSE OF CASSAVA GENOTYPES TO DIFFERENT MICROPROPAGATION MEDIA

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Cassava is one of the most important staple foods in the human diet in the tropics, where it ranks fourth as a source of energy, after rice, sugar cane and maize. Since it is a vegetative propagated crop, the use of *in vitro* propagation is very important to preserve the germplasm free of pest and diseases and to multiply the germplasm for exchange purpose. Several protocols for *in vitro* cassava micropropagation have been used, in which the main results were large differences in the performance of different accessions to a specific medium. The establishment of a culture medium efficient for a large number of genotypes remains one of the great challenges.

The objective of this study was to evaluate the performance of contrasting cassava genotypes under different culture media in order to achieve the best results for establishing a comprehensive protocol for cassava micropropagation.

Six cassava genotypes with contrasting performance under *in vitro* cultivation were submitted to ten different culture media, with different combinations and concentrations of hormones (IAA, NAA, BA, GA) and adenine sulfate. For each genotype and medium, apical and axillary node explants, from approximately two month old in vitro cultures, were placed in six magenta vessels; three vessels with apical nodes and three vessels with axillary nodes (five explants/vessel). After six weeks, the responses of plants were evaluated by: number of nodes, roots, leaves and stems; leaf area; length and fresh weight of roots and shoots; and the presence of callus.

The genotypes showed different performance with significant growth difference among the different media and dependent on the type of explants. In general, the apical explants grew faster and produced more biomass in the roots and shoots. The different behavior of genotypes can be attributed to the fact that they are adapted to diverse ecosystems, they have different genetic structure (native and improved varieties) and because of the contrasting levels of hormones (NAA, BA and GA) and amino acid (adenine sulfate) used.

The use of cassava genotypes adapted to stressful environments has helped in proposing at least two culture media, for different explants, which should be tested in a larger number of accessions.

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ENDEMIC VASCULAR PLANTS WITH INDUSTRIAL APPLICATION FROM THE STATE OF COAHUILA, MEXICO

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A review of the endemic plants was carried out, following the Megacoahuila concept, which increased the state area for over 100 %. The region has climatic and physiographic variation that leads to the development of at least 13 main vegetation types, being the desert shrubland the dominant one. Most of Coahuila´s territory is included in the Chihuahuan Desert thus contributing more than any other state to the number of endemic species in this great arid zone. Among the floristic richness we find Cuatrocienegas Ravine vegetation and flora; as well as Los Angeles Experimental Cattle Ranch rangelands near Saltillo; besides alpine and subalpine flora of Northeast Mexico, and the vulnerable and endangered cactaceae in Sierra of Parras and in Sierra La Paila.

The objective of this study was to provide endemic species with a more natural geographic frame of reference not strictly restricted by state limits, thus, the Megacoahuila concept is adopted.

In this study, the species considered as endemic are the ones in Coahuila which may spread their distribution to Megacoahuila. This last concept implies expanding the study limits to the following neighboring entitites: Gulf Coast Plain, Sierra Madre Oriental Province, and Mexico´s High Plateau which are three physiographic provinces that converge in the area. Altitude interval ranges from 190 m. up to 3450 m. at mountain tops located southeast of Coahuila. The weather is dry continental type, mainly in Coahuila´s ravines, and warm to subhumid type at the highest parts of the Sierras. The northeast part has humid and hot weather with high sea influence. Most part of the year there´s little rain, its annual average ranges from 146 to 632 mm. Temperature varies from 8ºC during winter up to 38ºC in the summer.

Endemic vascular plants richness for Coahuila and some nearby areas (Megacoahuila) consists of 350 species and subspecific taxaceae, which represent an 11.2% of the total native flora estimated for Coahuila. 190 species constitute 54.5% of the total quantity above-mentioned and limit their distribution to the territory of the administrative entity. Besides, 15 species are considered as endemic for Megacoahuila. The endemic element in the region is distributed among 50 families which represent 34% of the total. They include 10 or more taxaceae of restricted distribution as: Asteraceae (75), Cactaceae (48), Brassicaceae (15), Agavaceae (12), Acanthaceae (10), etc.

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CHANGES IN SUGAR CONCENTRATION OF SWEET SORGHUM JUICE AS AFFECTED BY MATURITY AND STORAGE

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Sweet sorghum (*Sorghum bicolor* Moench) is being investigated as a transitory biofuel crop for arid and semiarid lands. While this crop has advantages over the current standard of corn (*Zea mays*) in Arizona, transportation and storage of the juice are distinct hurdles to the widespread production of ethanol from sweet sorghum. We have shown in other studies that small-scale production is possible, but protection of the sugars from degradation has yet to be sufficiently addressed. We began this study to determine the optimal combination of factors to prolong the “shelf life” of sweet sorghum juice. We also evaluated the sugar profile – how does the ratio of sugars (glucose, fructose, and sucrose) change over time as the plants mature?

Juice for the storage studies was collected in the fall of 2009 from three sweet sorghum varieties (Cowley, M81E, and Topper) by pressing the stalks in a roller mill. Samples were treated by altering pH, temperature, and adding sodium metabisulfate. Subsamples were taken at intervals and analyzed by HPLC with a refractive index detector. Sugar profiles were constructed from samples collected from June to November 2009, and from another planting of the same varieties beginning in July of 2010.

When juice was stored at 37.3°C (average daytime temperature at harvest), changes in relative concentrations of sugars could be seen beginning after 30 hours. While sucrose decreases gradually, amounts of glucose and fructose rise slightly, keeping the total concentration essentially the same. After approximately 80 hours, total sugar decreases significantly until 100 hours, when the total concentration is almost half of the initial. At a pH of 3.96, degradation progresses more rapidly. Addition of sodium metabisulfate (up to 100 mg/L) may help stabilize the sugars in the juice, but subsequent fermentation is hindered by an excess of sulfate. Phosphoric or nitric acid may be acceptable substitutes

that do not retard yeast activity.

All three varieties displayed similar trends in sugar accumulation. Very little glucose and fructose are present up to late July (84 days after planting), less than 10 g/L of each. Sucrose concentration is below detection limits (5 g/L) until the end of August (119 days after planting), when a rapid increase up to and in excess of 100 g/L occurs at the final harvest in November (at physiological maturity, almost 200 days after planting).

It is hoped that by understanding sugar development of sweet sorghum grown in Arizona, harvest time can be optimized. Although the extracted juice can be stored at ambient temperature for up to 30 hours, longer-term storage will be necessary. Maximum protection of sugars may be obtained from a combination of pre-treatments, such as heating juice to 90°C for one to five minutes, and adding other preservatives.

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CHARACTERIZATION OF PROSO MILLET (*PANICUM MILIACEUM* L.) GERMPLASM

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Proso millet (*Panicum miliaceum* L.) is a short-season summer crop, which is a low cost-of-production alternative for winter wheat based dryland cropping system in the western central region of the United States and is suitable for diversifying and intensifying dryland/rainfed production systems. There are only six proso varieties commonly grown. Because the germplasm base of these cultivars is very narrow, there is a dire need to introduce diversity into proso breeding programs. There is wide genetic diversity available in proso millet germplasm. The objective of this report is to characterize proso millet core germplasm for morpho-agronomic traits and molecular markers. A total of 95 proso germplasm lines obtained from USDA-ARS NCRPIS, Ames were grown in the field for evaluation of various agronomic traits (plant height, flowering time, panicle length, seed weight and seed color). These lines were also genotyped for various molecular markers (RAPD, ISSR, and SSR).

There was significant variation in the morpho-agronomic traits among the germplasm set tested in this report. Plant height ranged from 25 to 100 cm although majority of the lines were about 60 cm in height. Flowering times of the lines varied from 35 days after planting (DAP) to 50 DAP. There were several lines which were never flowered and seed characteristics were not recorded for these lines. Panicle length ranged from 10-30 cm. Thousands seed weight ranged from 1 to 8g although majority of the lines fall between 4-6g. Seed color ranged from cream, yellow, brown, and red with different intensity. This set of proso millet germplasm also was equally diverse with respect to molecular marker profiles. Genetic relationships were reported among these set of proso germplasm based on morpho-agronomic traits and molecular markers. The morpho-agronomic traits reported here were based on 1-2 years data at one location. Further evaluation of the selected lines with desirable traits (early flowering, large seed, longer and thinker panicle with large number of seeds) will be necessary at multiple locations to test stability of these traits. These set of germplasm will serve as source of desirable traits in proso millet variety development.

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CAN PROSO MILLET (PANICUM MILIACEUM L.) BE USED FOR FERMENTATION BASED ETHANOL PRODUCTION?

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Proso millet (*Panicum miliaceum* L.), a short duration crop with shallow root system, is a major alternative crop for winter wheat based dryland cropping system in the western central region of the United States, which covers substantial parts of western NE, KS, SD and eastern CO, WY. The region is characterized by high elevation semi-arid climate and agronomically, proso millet is an ideal summer crop for pest (weed, disease, insect) management in wheat fields in the region. Currently, in the USA, proso millet use is limited primarily to the bird seed industry, which results in extreme price volatility in the proso millet grain market. Finding alternative, value-added uses of proso will expand its market, minimize price volatility, and increase proso millet acreage in the region. One potential alternative use of proso millet grain is for ethanol production. Objectives of this report are: (1) To determine chemical composition of selected proso millet varieties, (2) To determine the fermentation efficiency of proso millet grain either alone in combination with corn, and (3) to evaluate feed value of the resulting DDGS based on its chemical analysis. Fermentation was conducted using 100% proso millet, corn, or mixture of proso and corn at different ratios in 250 ml conical flask in the laboratory with 3 replications. Chemical composition of proso millet and DDGS was determined by standard method.

Proso millet has significantly lesser starch than corn. Whereas, proso millet has higher protein, fat, fiber and ash than corn. Fermentation efficiency for ethanol production was higher using 100% proso or mixture of corn and proso compared to 100% corn. Ethanol yield was higher when mixture of proso (10% or 25%) and corn (90% or 75%) was used compared to 100% corn, 100% proso or other grain mixtures. This may be due to protein quantity or quality present in proso millet and further experiments will be necessary to understand the differences. Fermentation experiment in a large capacity bioreactor will be necessary to scale up the fermentation, and obtain more "industry relevant" information. Proso millet can be fermented to produce fuel ethanol using identical procedures those used for conventional corn fermentation and ethanol production efficiency may be improved significantly by using proso millet, along with corn in the same fermentation mixture.

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VALUATION OF FIELD CULTIVATED DAFFODIL BULBS AS A SOURCE OF NATURAL PHARMACEUTICAL COMPOUNDS

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Daffodil bulbs are a recognized source of pharmaceutical compounds with efficacy in treating chronic aging diseases such as Alzheimer's and cancer. We are currently working with a local pharmaceutical company with an interest in developing commercial medicines from two of the active alkaloid compounds found in daffodil bulbs. At the present time, the two alkaloids, galanthamine and a second compound, cannot be economically synthesized, and therefore must be isolated directly from the daffodil bulbs. The level of alkaloids is usually low in bulb tissue, but is strongly influenced by many factors, including variety and environmental growth conditions. This research tests the potential of several daffodil cultivars to produce these alkaloids under the conditions present in the Norfolk Sand Plains region of southern Ontario. If feasible, the potential of using the bulb processing waste as a feedstock for anaerobic digestion to produce green energy will also be examined.

Twelve daffodil cultivars were obtained from commercial bulb growers in Holland. Cultivar choice was based on known production levels of galanthamine and production of other alkaloids. The cultivar 'Carleton' is currently the industry leader for galanthamine production in Europe and was included for comparison. The average bulb size was 10 to 12 cm in circumference. The bulbs were planted at a density of 1 kg per m^2 into a randomized complete block design with four replications at 3 separate locations. Planting was done in early fall (between Oct. 15^{th} and Nov. 15^{th}). Bulb harvest was done the following year in late July after complete senescence of the foliage.

Bulb yields and alkaloid concentrations in the bulb tissue varied considerably between cultivars and location. Several promising cultivars were identified, but further research (e.g. fertility, length of growth period etc), is needed to

improve the yields of desirable alkaloids to economically significant levels.

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POSTER PRESENTATIONS (Fibers and Cellulosics)

COTTON MUTANTS WITH DIVERGENT FIBER QUALITY CHARACTERISTICS

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In the U.S. cotton (*Gossypium hirsutum* L.) industry there is a need for improved fiber quality to compete in International Markets. This market demands for cotton fibers that are longer, stronger and more mature than the fibers produced by conventionally grown U.S. cotton cultivars. From 2006 to 2010, a study was done to select divergent fiber quality traits in mutant populations of TAM 94 L-25 and Acala 1517-99 Upland cotton cultivars known to have good fiber quality. High and low selections were made for micronaire, strength, length, and AFIS maturity. The divergent lines identified by this process will be ideal for both breeding studies and the development of molecular markers specific for these fiber quality characteristics. The selected mutant lines ranged from a mean low fiber length of 1.04 to a high of 1.27; low fiber strength mean of 25.9 to a high of 31.5; a low micronaire value mean of 3.4 to a high of 4.9; and low maturity ratio mean of .98 to a high of .82 across both populations.. These highly divergent fiber quality lines will help to create high quality fiber upland cotton cultivars while maintaining high fiber yields and wide adaptation across the cotton growing areas of the U.S.

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SWITCHGRASS ESTABLISHMENT AS AFFECTED BY SEEDING DEPTH

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Switchgrass (*Panicum virgatum* L.) has been identified as a potential bioenergy crop for the North Central Region of the USA. One of the limitations to a successful production of switchgrass is the poor seedling establishment affected by the interaction between seeding depth and soil physical characteristics.

The objective of this study was to determine the effect of seeding depth in different soil types on seedling establishment. A greenhouse experiment and a field experiment were conducted. The greenhouse experiment included six seeding depths (0, 13-, 25-, 38-, 51-mm, and 64-mm deep), one cultivar, Dacotah, and three soil types brought into the greenhouse from three Experimental Stations' of North Dakota State University, from Fargo (silty clay, 6.1% organic matter (O.M.)), Prosper (loam, 3.3% O.M.), and Carrington (silt loam, 2.5% O.M.). The experimental design was an RCBD with a factorial arrangement and four replications. The field experiment was conducted at Fargo and Prosper, ND, in 2010 and included four seeding depths (13-, 19-, 30-, and 38-mm deep) and two cultivars Dacotah and Forestburg.

Results from the greenhouse experiment indicated pure live seed emergence (PLSE) differed among seeding

depths and soil types. Seeding depth by soil type interaction was not significant for any of the variables (PLSE, emergence index, and plant density) evaluated. Only the surface seeding (0-mm depth) had a significantly lower PLSE. Seeding depths from 13-mm to 64-mm depth were not significantly different and fluctuated between 64 and 74% PLSE. The Fargo soil had significantly higher PLSE (74%) across all seeding depths than the Prosper and Carrington soil types (60% PLSE).

In the field experiment, there was no significant interaction between location and seeding depth. The Forestburg cultivar had very poor emergence in all treatments, highest PLSE was observed for the 13-mm depth at both locations, 8 and 9.8% at Fargo and Prosper, respectively and it was significantly different from the other three depths. The PLSE for Dacotah across both locations was 80%, 42, 18, and 5% for the 13-, 19-, 30-, and 38-mm depths, respectively. Under controlled conditions (greenhouse experiment) seeding depth did not seem to be a factor affecting seedling establishment except for the surface seeding where the lack of seed and soil contact reduced emergence. In field conditions, the 13-mm depth had significantly higher PLSE indicating other factors are interacting with the seeding depth such as compaction caused by the planter, or rainfall immediately after planting prevented the seed from emerging rapidly from deeper depths. Switchgrass' poor seedling establishment was more cultivar dependent than seeding depth.

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POSTER PRESENTATIONS (General Crops)

THE IDENTIFICATION AND QUANTIFICATION OF LEAF MESOPHYLL OIL BODIES DURING THE DEVELOPMENT OF NATIVE OR ADAPTED PLANT SPECIES

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Oil bodies have recently been identified in mesophyll cells of several species of angiosperms. These oil bodies are predicted to store triacylglycerides (TAGs) similar to storage oil bodies found in seeds of several plant species. Seed TAG oil is a common feedstock used for production of biofuels.

The objective of this study was to examine the production and composition of these oil bodies in four plant species to determine if leaf oil could be used as a new feedstock for biofuel production. The species studied were species predicted to grow well in different climatic regions of Texas including regions of marginal land with environmental stress: *Agastache foeniculum* (Pursch) Kuntze (Anise Hyssop), *Asclepias incarnate* L. (Swamp milkweed), *Cynara cardunculus* L. (Cardoon), and *Helianthus maximiliani* Schrad. (Maximilian sunflower).

Leaf oil body production was monitored throughout the entire plant over four months of development for each species. Leaf oil body production was quantified using a new method developed, in which images of free-hand sectioned leaves stained with Sudan IV were analyzed. Also extractable oil per leaf dry weight was monitored over development using Accelerated Solvent Extraction (ASE). Extracted oil from each species was separated using thin-layer chromatography (TLC) to determine the lipid composition of leaves from each species and to determine oil body composition.

The main results of this research showed that in each plant species oil bodies accumulated in the leaves as the leaves senesced. The amount of extractable lipids from each species varied over time, and membrane lipids appeared to be the dominant extractable lipids out of a leaf rather than oil body lipids. Correlation analysis showed few correlations between the presence of oil bodies in leaves and the total amount of extractable lipids from leaves, suggesting that oil bodies are poor predictors of extractable lipids in leaves. TLC showed that the oil bodies may not be TAGs, or if they are, the TAGs are below a detectible level, except for *Asclepias incarnata.*

Whether oil bodies can accumulate enough to become the dominant extractable lipid from a leaf is questionable from the results of the study. Also, these oil body positive species lacked accumulated TAGs.

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NON-DESTRUCTIVE SEED EVALUATION OF SELECTED INDUSTRIAL CROP GERMPLASM ACCESSIONS

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In genbanking, seed quality is essential for maintaining the seed viability for extended periods of time. High pre-storage germination is a good indicator of the seeds expected post-storage viability in species that can endure long-term storage. Knowledge of the seeds physical characteristics may offer an insight on germination levels. An X-ray technique allows for a non-destructive evaluation of seed fill, mechanical damage and potential insect injuries. Seeds of new crops germplasm often have a low germination, especially non-domesticated accessions.

The objective of the study was to assess physical appearance of seeds for selected accessions from four different new crops germplasm collections using an X-ray technique.

A total of 29 accessions from the National Plant Germplasm System collections of *Cuphea, Limnanthes, Opuntia* (6, 6 and 7 accessions respectively) and *Parthenium argentatum* (7 accessions plus 3 cultivars from industry) were evaluated. From each accession, four replications of 100 randomly selected seeds were viewed in a XPERT (Kubtec) X-ray cabinet. The seeds were separated into five different categories, as 'full', '≥50% filled', '≤49% filled', 'damaged' and 'empty'. Seeds in each category were germinated according to AOSA germination standards. All non-germinated seeds were exposed to a TZ test that indicated the viability status of the seeds embryo. Data were evaluated by ANOVA (Tukey-Kramer HSD, α 0.05; JMP 7.0, SAS).

In the *Cuphea* accessions the fraction of 'full' seeds was between 69.8 to 99.3 % and the 'empty' fraction varied from 0 to 25.0 %, and was strongly correlated with the seed germination level. The same trend was observed for the *Limnanthes* and *Parthenium* accessions. In the seed group of '≥50% filled', the germination was from a few percent to >60%, whereas it was 0 to about 20% in the group of '≤49% filled', a few percent in the 'damaged' and 0 in the 'empty' seed groups.

The X-ray non-destructive seed evaluation is a good indicator of the seed germination potential and may be considered as a complementary tool for evaluation of seed sample quality and provide some elucidation on reasons for low germination. This technique may be a good tool in evaluation of seed lot quality.

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EARLINESS, MORPHOLOGICAL, AND REPRODUCTIVE VARIATION AMONG 16 SUNN HEMP (*CROTALARIA JUNCEA* L.) ACCESSIONS IN GRIFFIN, GA

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Sunn hemp (*Crotalaria juncea* L.) is a leguminous species used for cover cropping in subtropical and tropical countries. It has great potential as a new crop in the southeastern U.S. because of its ability to supply follow-up crops with adequate nitrogen levels for rotated crop sustenance. However, little is known about its capacity to be grown in the Piedmont region near the Griffin, GA geographic area.

The objectives of this study were to evaluate 16 sunn hemp accessions for biomass, apical dominance, open flowers, plant height, earliness, branching, and seed production variability in Griffin, GA.

Seedlings from 16 sunn hemp greenhouse grown accessions were transplanted to field plots arranged in a split plot design during May through August 2008 and 2009 at Griffin, GA. Main plots were planting dates and subplots were sunn hemp accessions. Sunn hemp accessions were evaluated for biomass, apical dominance, branching, open flowers, earliness, plant height, and seed reproduction afer 2 – 6 months from greenhouse planting.

Significant variability occurred for all traits evaluated among the 16 sunn hemp accessions. Accessions PI 250486, PI 314239, PI 322377, and PI 391567 produced significantly more seed earlier during both years than most of the other accessions. Higher leaf area accumulating accessions included PI 234771, PI 248491, PI 561720, and PI 295851 during both years. An earlier planting date (May) was superior to later planting dates (June and July) especially for seed production. Leaf area and primary lateral branches were significantly higher among sunn hemp accessions during the earliest planting date.

Superior accessions can be used as breeding material for development of superior sunn hemp cultivars for use in the southeastern U.S.A.

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POSTER PRESENTATIONS (Oilseeds)

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SPRING SEEDING OF CANOLA, BROWN MUSTARD AND CAMELINA IN WESTERN NEBRASKA

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Spring planting of brown mustard (*Brassica juncea* cv. Arid), canola (*B. napus* cv. Hyola 401) and camelina (*Camelina sativa* cv. Boa) has become important due to increased interest in producing seed oil crops in the Nebraska Panhandle. Determining the influence of spring planting dates on development stages, seed yield, oil content, and fatty acid profile was the objective of this study. At Scottsbluff, NE, field trials were conducted in the spring of 2005 and 2006. Planting dates were 24 Feb, 24 Mar, 7 Apr, 21 Apr and 5 May in 2005, and 3 Mar, 3 Apr, 10 Apr, 27 Apr, 11 May, and 2 Jun in 2006. With later planting, emergence was quicker compared to earlier dates. Although flowering date was later with later planting, flowering occurred within a range of physiological degree days. Fruiting was affected by both planting date and degree days. Seed matured at the same time regardless of planting date or degree days. Fleabeetle (*Phyllotreta* spp.) damage was high in the two Brassica species. Damage by bird feeding, primarily house finch (*Carpodacus mexicanus*), was a major problem with brown mustard planted before mid April and in canola, only with the first planting. Fleabeetles and birds did not affect camelina. April planting gave the best yields, and canola could yield over 2200 kg ha^{-1}. Oil content of the Brassica was highest when seeding was in late Mar or later. Planting date had no effect on camelina oil content. In the two Brassica species, 60% to 65% of oil was C18:1 whereas in camelina, it was about 15%. Content of C18:1 was increased with later planting for the three crops. The second major fatty acid in the oil was C18:2 with 20% in brown mustard, 18% in canola and 20% in camelina. Later planting increased C18:2 in camelina only. Camelina's major fatty acid was C18:3. Camelina contained 32 to 37% of C18:3 and earlier planting increased its

content of this fatty acid. In Camelina, C20:1 comprised about 12% of the oil and was highest with April planting. Canola and camelina seeded in April could be grown for oil successfully in western Nebraska.

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DIVERSITY IN CAMELINA GERMPLASM FOR SEED AND OIL QUALITY TRAITS: FATTY ACID COMPOSITION, OIL CONTENT AND GLUCOSINOLATE CONTENT

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Camelina is a promising feedstock for the biofuel, animal feed and nutraceutical industries, due to its oil composition. Critical factors such as oil content, fatty acid composition and glucosinolate content will determine its success as an alternative crop. The objective of this preliminary study was to determine the variability of camelina from the USDA-ARS-NCRPIS germplasm collection assessing the seed and oil quality traits.

Thirty-five camelina accessions were planted in individual cages for half-sib seed increase in 2009. Harvested seed was used for nuclear magnetic resonance (NMR) determination of oil content, fatty acids profile by gas chromatography (GC), and glucosinolate content of both defatted meal and full fat seed by high precision liquid chromatography (HPLC) and Accurate-Mass Quadrupole Time-of-Flight (Q-TOF LC-MS).

Base on NMR analysis, camelina accessions show significant variation in oil content (22.9% - 36.8%). The results for fatty acid profile show that camelina is mostly composed of linoleic acid and linolenic acid (Omega-3) with a mean of 22.2 and 33.6% respectively, oleic acid with 12.4% and eicosenoic acid 11.9%. Linoleic acid and linolenic acid content ranged from 18 to 29.5% and 25.7 to 40% respectively. In addition, linoleic and linolenic content were negatively correlated. Glucosinolate (GS) content results show that GS9, GS10, GS11 and total glucosinolates varies greatly in either defatted meal or full fat seed, the total GS ranging from 7.76 to 14.01 mg/g for deffated meals and 6.26 to 10.98 mg/g in full fat seed (mg/g). Both ranges were similar to or lower than values found in broccoli sprouts.

In conclusion, promising accessions for fatty acid profile, oil content and glucosinolate content were indentified as good sources of genetic variation to support breeding programs that meet the basic requirements for biodiesel production (long fatty acid chains), animal feed (low glucosinolates in meal) and nutraceutical industry (high Omega-3 fatty acid content).

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EFFECT OF TEMPERATURE GRADIENTS ON GERMINATION OF PENNYCRESS GERMPLASM

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Pennycress (*Thlaspi sp*), is one of the potential oilseed species for biofuels industry and is naturalized throughout

the Midwest U.S. Its seeds contain 36% oil, and erucic acid is the mayor fatty acid, with content of 38.1 %. Additionally, the physical proprieties of the methyl esters are in the range to satisfy the needs of the biodiesel industry. The meal has shown novel biofumigant properties (volatile compounds). Due to its valuable characteristics (spring and winter types, cold tolerance, early harvesting, fatty acids profile, etc.), pennycress could be used as a crop in the Midwest. However, biological and agronomical issues must be understood to overcome practical limitations.

The objective of this preliminary study was to assess the effect of temperature on germination of *Thlaspi* accessions from the USDA-ARS germplasm collection for optimal germinations temperatures and time. The experiment was done in the North Central Regional Plant Introduction Station (NCRPIS) in Ames, IA using a thermogradient table (TGT) Type 5008.00.00 (Seed Processing Holland). *Thlaspi* accessions were evaluated in three temperature gradients, 18-20ºC (64-68ºF), 11-14ºC (52-57ºF), and 4-7ºC (39-45ºF) with three replicates per accession per temperature range. Each experimental unit was a petri dish with 50 seeds. The response variables were the germination rate per day and the cumulative germination rate. Readings were taken every 24 hours for 18 continuous days.

The results show that the germination is highly variable within accessions and across temperatures gradients. The germination data after 18 days in the temperature range of 18-20ºC were grouped in three classes; good germination rates, > 67 % of germination (eight accessions); fair germination, from 13 to 67 % (five accessions); and poor germination, between 0-12 % (3 accessions). The good accessions group included the non-*T. arvense* accessions (*T. perfoliatum*) with better germination performance across all temperatures ranges. Nevertheless, two *T. arvense* accessions had acceptable values under the low temperature range. Fair and poor germination groups were also tested for seed viability with a tetrazolium test; just one accession was unviable. Moreover, historical germination tests show that some of those accessions had good germinations rates, indicating that dormancy issues may be involved. Further experiments should be conducted to understand the mechanisms involved in response to germination under low temperatures and methods to overcome or deal with seed dormancy.

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EXTRACTION OF FIELD PENNYCRESS SEED OIL BY FULL PRESSING

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Field pennycress (*Thlasphi arvense* L., *Brassicaceae*) is a winter annual that grows widely in the temperate North America. Its seeds contain up to 36% oil (db) with the major fatty acid as erucic acid (38 %). With an estimated seed production of 1,700 – 2,200 kg/ha, pennycress can be a major source of oil for biodiesel. Also, the early harvest date of pennycress compared to other winter annual oilseed crops makes it suitable for a two-crop rotation with soybeans in most of the Midwestern United States. This allows for the production of oil for industrial application without displacing commodity crops for food use.

The 2009 harvest of about 1,500 kg of pennycress seeds (32.9% oil, db) from a wild stand near Peoria, Illinois provided our first opportunity to conduct oil extraction optimization studies. The goal of this study was to determine the optimum moisture content (MC) of pennycress seeds for oil extraction by full pressing. Two levels of starting seed moistures were employed: seed MC during storage (9.5%) and seed MC at harvest (16%). The latter was obtained by spraying the seed with predetermined amount of water and allowing to equilibrate for at least 24 h. Seeds (60 kg) with 9.5 and 16.0% initial MCs were cooked and dried (82-104 ^{o}C) using a French Laboratory Seed Cooker/Conditioner (Model 324). The residence times were varied to produce cooked seeds with MCs ranging from 1.0 to 13.0 %. The cooked seeds were pressed immediately using a heavy duty French Laboratory Screw Press (Model L250). Uncooked seeds with 9.5% MC were also cold-pressed to serve as control. The residual oil in the press cakes was determined and the amounts of oil extracted were calculated. The oils were also analyzed for solids content (foots), free fatty acid (FFA) content, and color.

Cold pressing pennycress seeds with 9.5% MC produced press cake with 10.7% oil (db), extracting 75.1% of the oil. Cooking and drying the seeds to 4% MC provided the lowest residual oil at 6.2%, or 86.3% of the oil recovered. There was a slight improvement in the amount of oil extracted (88.0%) when the starting seed moisture was at 16% and then cooked and dried to 4%. Compared to the oil from cold-pressed seeds, the oils from cooked seeds had higher foots (1.55-1.73% vs. 0.52%), FFA contents (0.40-0.46% vs. 0.30%), and red values in AOCS RY color scale (4.1R -6.2 R vs.

2.4R). These results showed that tempering pennycress seeds to higher moisture is unnecessary for maximizing oil recovery. In addition, cooking and drying the pennycress seeds to 4% MC before pressing had minimal effect on the oil's quality with respect to FFA content and color.

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PLANTING DATE, HERBICIDE, AND SOYBEAN ROTATION STUDIES WITH FIELD PENNYCRESS (*THLASPI ARVENSE* L.)

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Thlapsi arvense L. (field pennycress) is a new crop being investigated for its potential as a possible off season source for biodiesel and as an additive to petroleum based products in the Midwest. For pennycress to be successfully adopted by producers, off season production must have minimal impact on the current crop rotations.

One objective of this study was to determine the optimal fall planting date for field pennycress in Illinois to maximize seed yield in early spring. Other objectives were to identify potential herbicides for pennycress production and to assess the impact of pennycress residue on subsequent soybean crops.

During the fall of 2009, the winter line 'Patton' was planted in replicated plots from September 1st to November 3rd. In spring 2010, each plot was evaluated for seed yield, total seed oil, fatty acid methyl ester content, along with several other agronomic traits. Replicated herbicide trials with active ingredients alachlor (Intrro), pendimethalin (ProwlH2O), and clopyralid (Stinger) at three different labeled rates were conducted across 2 growing seasons. Replicated soybean plots were planted following pennycress across 5 planting dates in 2009 and 2010. Soybeans were evaluated for seed yield, stand establishment, seed protein and oil quality and compared to soybeans following fallow ground.

Planting dates when soil temperatures were above 15.5^{o}C resulted in an average of 1,568 kg ha^{-1}. Seed yields declined steadily as soil temperatures drop to 10^{o}C. Below 10^{o}C, fall planted pennycress seed did not germinate until spring. Total oil steadily declined while fatty methyl esters remained uniform across planting dates. Alachlor and pendimethalin demonstrated the least amount of pennycress injury. Pennycress rotation with soybeans resulted in no impact on soybean stand establishment or protein and oil quality across all five planting dates.

Early fall planting, the potential for herbicide use, and no impact on following soybeans helps pennycress move forward as a viable crop in the Midwest.

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EVALUATION OF PLANTING METHOD AND SEEDING RATES WITH FIELD PENNYCRESS (*THLASPI ARVENSE* L.)

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Thlaspi arvense, L. is a common winter annual weed throughout the United States that produces nearly 36% oil content per seed in early spring. Current estimates of wild population seed yields are over 2,240 kg ha^{-1}. Variety

selection has begun on this crop to identify high yielding lines, however, to commercialize pennycress, the correct planting method and seeding rate needs to be established to maximize yield and minimize impact on producers.

The objective of this study was to determine the optimum planting method and seeding rate to produce high seed yield, uniform stands for harvesting, and quality oil in spring planted pennycress.

The non-dormant spring pennycress line 'Spring 32' was planted on April 1, 2010 in Macomb, IL following bare ground. Plots were established by drilling on 19cm rows and by broadcasting and at 1.2, 2.2, and 4.9 kg seed per hectare. Five replicated plots were established for each method and seeding rate combination. On June 18, each plot was harvested and evaluated for seed yield, total seed oil, fatty acid methyl ester content, and several other agronomic traits.

Drilled pennycress plots had a significantly larger number of established plants than the broadcast plots of the same seeding rate. The average seed and oil yield was not significantly different between the drilled and broadcast plots at the three seeding rates. However, seed oil yield per hectare was significantly different between the drilled and broadcast plots but not at the various seeding rates. Plant height decreased with increasing plant populations. More studies will need to be conducted exploring a greater range of seeding rates.

Pennycress as a commercial crop is an economically viable and sustainable source of oil for biodiesel and can be developed as an insertion crop which will have little, if any, competition with food production.

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DEVELOPMENT OF MOLECULAR MARKERS IN SAFFLOWER (*CARTHAMUS TINCTORIUS* L.)

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Safflower *(Carthamus tinctorius* L.) is an oilseed crop considered to be one of the most drought tolerant crops in the world. An extensive rooting system gives safflower the ability to utilize water unavailable to most crops and scavenge nutrients leached down the soil profile. Recently characterized safflower accessions have the ability to be seeded in the fall and harvested in the spring, giving farmers a valuable crop to incorporate into a cropping rotation. A large amount of diversity between safflower accessions offers the potential for improved agricultural traits such as increased oil content and modified fatty acid composition. Traditional plant breeding has made improvements to this crop, but little molecular work has been done to date. Using molecular markers, our goal is to further characterize inter and intra-safflower accession diversity in hopes of increasing oil content and producing a profitable crop for farmers in the Lower Great Plains and other arid regions across the globe. Recently a mini-core collection of safflower representing the wide range of diversity within the species was characterized using AFLP analysis. Using SSR along with AFLP molecular marker techniques, we plan to further characterize this mini-core collection in addition to several known winter-hardy safflower accessions. We will be specifically looking to identify markers associated with increased oil content, modified fatty acid composition, and winter hardiness. With the aid of such molecular markers, winter planted safflower can be enhanced to give farmers a profitable crop in conditions where other crops would struggle to compete.

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INFLUENCE OF WATER AVAILABILITY ON YIELD COMPONENTS OF CASTOR

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Castor (*Ricinus communis* L.) is an important oilseed crop grown in low rainfall regions of the semi-arid tropics and sub-tropics. Castor is almost entirely grown under dryland conditions, without irrigation under reduced or irregular water precipitation. One the most important characteristics of this species is its ability to adapt a wide range of environmental conditions. This study's objective was to measure how the yield components of castor were affected by changes in the soil water availability. The semi-dwarf cultivar Hale was grown under seven subsurface drip irrigation treatments varying from 0.0 to 6.1 mm day^{-1} at Lubbock, TX on an Amarillo sandy, silt soil series. Plant population was 11,111 plts/ha. Total rainfall was 188 mm and the applied water + precipitation, across the treatments, varied from 38 to 144% of ETo during the plant growth cycle. Each raceme was harvested as they turned brown, oven dried (70°C) before weighting and counting seeds. Oil seed content was measured by NMR. Yield components of oil yield (g/plant) = number of raceme/plant x number of seed/raceme x mean seed weight (g) x oil content (%). The relative contribution of each of these yield components to the variation in total oil yield was estimated using regression analysis. Oil yield varied from 36.5 g/plant (405 kg/ha) in the treatments without irrigation to 134.5 g/pl (1494 kg/ha) under the highest irrigation level. The main components for increasing oil yield were the number of raceme/plant and the mean seed weight, which contributed to 50.5% and 38.0% of the variation, respectively. The oil content (10.9%) and the number of seed/raceme (0.6%) had secondary importance for the variation in the total oil yield. Based on these results, most of this plasticity was dependent on the number of raceme/plant, while the size of racemes (number of seed/raceme) and the seed oil content had only a marginal influence. A plant with few racemes (1 to 3), preferentially initiated in a short period of time, would be ideal for optimizing the harvesting operation and farm management. However, a plant with this characteristic would probably lose most of its plasticity for adapting to water availability. It was shown that seed oil content is not strongly influenced by environment, even under severe drought stress. Because oil yield of castor was strongly influenced by water availability, and most of the variation was due to the number of raceme/plant and the mean seed weight, these traits should be emphasized in plant improvement program.

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AN INTERSPECIFIC BC_2 LESQUERELLA HYBRID YIELD TRIAL

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Lesquerella [*L.fendleri* (A. Gray) S. Watson] is a domestic oilseed source of hydroxy fatty acids (HFAs) that could be grown on thousands of acres in the arid southwestern USA. The oil from lesquerella is similar to castor oil and can be used in lubricants, greases, coatings, and as an additive to biodiesel to improve lubricity. Increased yields of seed, oil content, and hydroxy fatty acid content are needed to successfully commercialize lesquerella. Wild relatives of *L. fendleri*, such as *L. pallida*, have lesquerolic acid contents up to 85% compared to 55% from *L. fendleri*, indicating that enzymes must be present to selectively incorporate the fatty acid at the *sn*-2 position of triacylglycerol. Hybrids between the two species thus could potentially increase the HFA content of *L. fendleri* from the current levels.

The objective of this study was to evaluate six yield and six oil traits of an improved lesquerella germplasm line, WCL-LO3 (Reg. no. GP-33, PI 642047) compared with four interspecific BC_2 generation hybrid lines of *L. fendleri* x *L. pallida*. The five lines were planted in a randomized complete block of three replications during the 2007-08 lesquerella growing season. Silique subsamples were analyzed from 68 plants to determine the mean values of seed per silique, sound seed weight, and total seed weight per silique. Plant dry weight and total seed weight were used to determine percent seed produced from 74 harvested plants. Seventy one plants produced enough seed for half gram NMR total oil percent analysis. Ten single seed subsamples from each of 74 harvested plants were analyzed for fatty acid composition on a HP 6890 gas chromatograph.

The means of the four hybrid lines compared to the control line WCL-LO3 were not significantly different either as a group or individually for five of the six yield traits (seed per silique, total seed weight/silque, plant dry weight, total seed weight, and percent seed). As a group the hybrids were significantly heavier (0.667 g/1000 seed) than WCL-LO3 (0.573 g/1000 seed). The total oil for the group of hybrid lines (22.95%) was significantly less ($P<0.05$) than that of the WCL-LO3 (28.67%). In contrast the percentage of linolenic acid was significantly higher ($P<0.05$) for the hybrids (11.65%) than for WC-LO3 (11.04%). No significant differences were found between the hybrid lines and WC-LO3 for the percentage of the other fatty acids evaluated (oleic, linoleic, lesquerolic, and auricolic). Twenty six of the hybrid plants expressed varying yellow seed color characteristics. Utilization of an interspecific backcross/selection method is a conventional breeding strategy that may introgress desirable yield traits from *L. pallida* to *L. fendleri*.

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SALT AND DROUGHT TOLERANCE IN CASTOR (*RICINUS COMMUNIS L.)*

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Castor (*Ricinus communis L.)* is a short lived, perennial, oilseed crop that is native throughout the tropical areas of the world. Castor is currently being grown as a short season, high yielding, oil crop, being researched in the Trans-Pecos and High Plains regions of Texas. This crop could provide an economical feedstock for both industrial chemicals and renewable fuels. The study for salt and drought tolerance in castor began in 2007 at the Texas A&M AgriLife Research Station in Pecos, TX (Salt) and at the Texas Tech Research farm at Lubbock, TX (Drought). This study consisted of 32 geographically diverse varieties of castor with four replications in each year and location. In the Trans-Pecos region of Texas the concentration of salts, in irrigation water is approximately 3500 ppm, and the soils are classified as Hoban silty, clay loam with a pH of 8.2. Four genotypes of castor appeared to be adapted to high saline conditions at Pecos and a separate set of four genotypes appeared to be tolerant to the dry conditions at Lubbock. Compared to the control cultivars of Hale and Brigham, some of these lines had 30 to 60 percent yield increase under either salt or drought stress. These data indicate that it may be possible to select individual cultivars for production sites limited by either drought or saline conditions that have very high seed and oil potential.

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COLLECTING *LESQUERELLA* FOR CONSERVATION AND RESEARCH ON COMPARATIVE SEED DORMANCY AMONG WILD POPULATIONS

Von Mark V. Cruz and David A. Dierig

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Lesquerella (Brassicaceae) collecting explorations remain paramount in getting diverse germplasm for continuing efforts in developing promising new crop varieties. Exploration activities in Southwestern states were conducted in April to June 2010 to obtain seeds from wild populations of two species in the genus and gather samples for testing differences in seed dormancy among populations and plant sizes.

A total of 28 sites of *L. fendleri* and *L. gordonii* were visited in Arizona, New Mexico, and Texas. Seven of the 28 sites are near or at previous collection sites sampled in the mid-1990's, while 21 are considered as new sites. Bulk

seed samples were obtained from 10-50 plants in each site as well as seed samples from 8-20 individual plants classified as either normal or small-sized.

Ongoing experiments to determine the effects of salt treatments (LiCl and $MgCl_2$) during afterripening at various temperatures (5, 25, and 35^{o}C) and different storage durations (4, 6, 12 weeks) are still in the first month. The differences between sites, plant size, and species based on samples subjected to the enumerated treatments will be studied and reported subsequently.

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JATROPHA CURCAS L. PROJECT: POTENTIAL BIOFUEL FOR NORTHEAST MEXICO

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Jatropha curcas L. an alternative feedstock for building a sustainable biodiesel industry. Jatropha is a topical crop native to Mexico and Central America. It is highly probable that the center of origin of the Jatropha is in Mexico. The tree is well adapted to tropical and arid conditions in states of Sonora, Sinaloa, Michoacan, Guerrero, Oaxaca, Chiapas, Tamaulipas, Veracruz, Tabasco, Yucatan, Quintana Roo, Puebla, Hidalgo and Morelos. This is commonly know as "piñón", "piñoncillo", "pistache mexicano", etc. A number of new development projects and plantations involving hundreds of thousands of hectares with investment of billions of dollars have initiated during the year 2006.

The objective of a four year ITESM research grant was to develop sustainable practices for optimal Jatropha oil yields in the northeast of Mexico. The second objective of this project was to make biodiesel in laboratory scale, using oil extracted from Jatropha. This study was conducted at the ITESM Campus Monterrey during 2006 to 2010. The field strip is located in the Hualahuises Valley, in state of Nuevo Leon, in northeast Mexico. Jatropha agronomy that was examined included: Nursery technology, propagation methods, transplanting seedlings, soil & soil preparation, planting density & geometry; cultural operations: irrigation, fertilization and organic production, pruning, weed control, harvesting, oil extraction & biodiesel production.

Jatropha grows on a wide range of climates and soils in the states of Nuevo Leon and Tamaulipas. This tree can be established on degraded, gravelly, sandy or saline soils with low nutrient content. It grows well in areas with an average annual rainfall between 300 and 1200 mm. Jatropha occurs mainly at lower altitudes (0-800 m). Therefore, it is suggested that the areas with low temperature and experiencing frost should not be promoted for Jatropha plantations due to its adverse effect on growth and damages to plantation. In Hualahuises Valley freezing occurs in January of 2009 and 2010 with temperatures ranging from -3 to -1 °C. The low temperatures adversely affected yield. The project envisages establishing an integrated biodiesel plant. Jatropha oil can be used locally to fuel vehicles (Expreso ITESM, motorcycles, VW Jetta and Rabbit diesel), diesel generators, etc.

In Mexico, the cultivation of Jatropha can potentially provide jobs and greater income for millions of agricultural workers and farmers. In the next five years, the introduction of Jatropha curcas in large-scale plantations will be a reality. Thousands of hectars have been slated for planting in Chiapas (15000 ha), Tamaulipas (10000 ha), Michoacan (10000 ha), Morelos, Yucatan and Veracruz (9000 ha). The key to the future of biodiesel is finding inexpensive feed stocks that can be grown by farmers on marginal agricultural land.

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THE PHENOLGY OF THE *JATROPHA CURCAS* L. IN TWO PRODUCTION SYSTEMS IN NUEVO LEON, MEXICO

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The Jatropha is a tropical plant used in the biofuels, specifically for the production of biodiesel. In Mexico, you can find the plant almost everywhere, but there is not a good seed production because in each state the weather characteristics are different and in most of them the weather is not tropical. In the state of Nuevo Leon, the plant is also found as a wild plant, not as a production plant. Now the jatropha has been introduced to the state for the evaluation of the adaptation of the plant as a production plant for oil extraction from the seeds in two systems production: organic and inorganic.

The main objective is to determine if it is convenient to manage the farming under the organic or inorganic systems by a statistical study of the evolution of the plant in nursery and field, cost efficiency and agronomic evaluation. Due to the extreme weather conditions in the state of Nuevo Leon there could be some problems in nursery and field transplant. Other difficulty could be the evaluation of the two systems to see the efficiency of the adaptation, development and cost of the first year of the plant.

Nursery technology was initiated in ITESM Campus Monterrey and transplanting seedlings in Hualahuises Valley, during 2008 to 2009. The methodology to develop is for the management and care of the farming, to identify the cost of each of the production systems. For this reason, it is important for the two systems measuring the high, trunk thickness and number of leaves of the plant after the transplant from nursery to the field, as it is the phenology of the plant.

The obtained results of the statistic part were similar, there was not a big difference between one system or the other, however, in the phenology part the organic system obtained a better development of ramification, for which the benefit goes to the organic production system with a lower water consume, however, the observed results from the average graphs demonstrated that the inorganic system had a better development in the three variables that were measured. In the cost part of the first farming year, it was obtained that the organic system is less expensive than the inorganic system.

With this, it is concluded that to obtain a successful farming, one must manage an organic production system, as it not only obtains a good plant development, but at the same time it benefits the environment. To conclude it is recommended that this kind of farming is better managed in the middle and southern regions of the country, dew that there would be no need of adaptation to the weather changes as there are in the northern region.

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