AAIC

Association for the Advancement of Industrial Crops

30th Annual Meeting

Pathway to Commercialization of Industrial Crops

September 23 -26, 2018. London, Ontario, Canada www.AAIC.org

AAIC 2018 ASSOCIATION FOR THE ADVANCEMENT OF INDUSTRIAL CROPS

INTERNATIONAL CONFERENCE

"PATHWAY TO COMMERCIALIZATION OF

INDUSTRIAL CROPS"

23-26 September 2018

London, Ontario, Canada

Sponsors

Ontario Agricultural College, University of Guelph

Bioindustrial Innovation Canada

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General Crops & Products	Ana Luisa Fernando, Nova University of Lisbon, Lisbon, Portugal
Medicinal & Nutraceutical Plants	Diana Jasso De Rodríguez, Universidad Autónoma Agraria Antonio Narro, Saltillo, México

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Conference Program

Sunday, September 23

4:00-5:30	Registration Desk Open	Grand Ballroom East Foyer
3:00-5:00 PM	CGC meeting	Boardroom 1
4:00-7:00 PM	Poster Set up	Grand Ballroom East
5:30-6:30 PM	AAIC Board of Directors Meeting	Boardroom 1
7:00-9:00 PM	**Welcome reception**	**Windsor Club**

Monday, September 24

Plenary Session
Moderator: Jim Todd
Room: Grand Ballroom Centre

8:00-10:00 AM	Registration Desk Open and Poster set up	Grand Ballroom East Foyer
8:00 AM	Welcome and introduction	Jim Todd, OMAFRA
8:15 AM	Michael Faba, Project manager for Bioindustrial Innovation Canada	Building the Canadian bioeconomy – bioproducts technologies and the importance of industrial crops
9:00 AM	Dave Park, President of the Cellulosic Sugar Producer's Co-operative. Andrew Richard, Founder and Chief Technology Officer, Comet Biorefining	Collaboration in the bio-economy
9:45-10:00 AM	**Coffee Break: Grand Ballroom East**	
10:00 AM	Suresh Narine, Professor, Physics & Astronomy and Chemistry at Trent University and Director of the Trent Center for Biomaterials Research.	High value phase change energy storage materials from vegetable oils: from idea to commercial launch
10:45 AM	John R. Dutcher, Professor of Physics, Senior Canada Research Chair in Soft Matter and Biological Physics, and Director of the Nanoscience program at the University of Guelph.	Phytoglycogen nanoparticles: commercialization of a unique, value-added agricultural nanotechnology for applications in food, personal care & biomedicine
12:00-5:00 PM	**Technical Tour**	**Commercial anaerobic digester tour** **Craft brewery** **Ginseng and medicinal plant farm**

Tuesday, September 25
TECHNICAL SESSIONS
Concurrent sessions

1. Oilseeds Division
Moderator: Efthymia Alexopoulou

Room: Suite 300

8:00 AM	***Keynote speaker:*** Federica Zanetti	Is camelina leading the rural renaissance in Europe?
8:25 AM	***Keynote speaker:*** Liv S. Severino	The challenges for mechanized production of castor are being overcome in Brazil
8:50 AM	Christina Eynck, Y. Khedikar, A. Zatylny, R. Bennett, and I. Parkin	Towards identifying quantitative trait loci for agronomic and seed quality traits in Ethiopian mustard (*Brassica carinata* [A.] Braun) using nested association mapping
9:10 AM	Russ W. Gesch, and H.L. Matthees	Improving productivity of relay-cropping industrial oilseeds with soybean
9:30 AM	Efthymia Alexopoulou, and M. Christou	Screening trials for camelina (*Camelina sativa* L.) in Greece
9:50 AM	Zinan (Lily) Luo, J. Brock, J. Dyer, T. Kutchan, M. Augustin, D.P. Schachtman, Y. Ge, N. Fehlgren, and H. Abdel-Haleem	Genetic diversity and population structure of *Camelina sativa* spring panel
10:10 AM	Hussein Abdel-Haleem, Z.L. Luo, P. Tomasi, G. Lohrey, S. Park, H. Wang, N. Fehlgren, M. Jenks, and J.M. Dyer	Camelina leaf wax constituents and distributions, phenotypic variations and allele identification
10:30 AM	**Coffee Break – room: Grand Ballroom East**	
11:00 AM	Michał Krzyżaniak, M.J. Stolarski, J. Tworkowski, and J. Kwiatkowski	Seed and oil yield of *Camelina sativa* (L.) Crantz cultivated in temperate climate of central Europe
11:20 AM	Alex Wittenberg, M.T. Berti, D.P. Samarappuli, S. Cabello, B. Andersen, S. Podder, A. Peterson, and J.V. Anderson ***Travel award recipient***	Morphological characteristics of winter- and summer-biotypes of camelina [*Camelina sativa* (L.) Crantz]
11:40 AM	Federica Zanetti, G. Cappelli, F. Ginaldi, C. Eynck, D. Righini, M. Christou, M. Krzyżaniak, E.N. Van Loo, D. Puttick, A. Monti, and S. Bregaglio	Modelling camelina growth and productive traits across Europe and Canada
12:00 PM	**Lunch: Room: Grand Ballroom East** Sponsored by Ontario Agricultural College, University of Guelph	

1:30 PM	Mariusz J. Stolarski, and M. Krzyżaniak	Efficiency indices of spring oil crops production
1:50 PM	Roque L. Evangelista, M.P. Hojilla-Evangelista, T.A. Isbell, and S.C. Cermak	Fractionation of mucilage and protein from lesquerella (*Physaria fendleri*) seeds
2:10 PM	A.G.F. Costa, Liv S. Severino, V. Sofiatti, J.G. Freitas, T.M.S. Gondim, and G.D. Cardoso	Pre-harvest desiccation of castor crop (*Ricinus communis* L.) using herbicides
2:30 PM	Augusto G.F. Costa, V. Sofiatti, J.G. Freitas, and G.D. Cardoso	Selectivity of post-emergence herbicides for the management of eudicot weeds in castor crop (*Ricinus communis* L.)
2:50 PM	Augusto G.F. Costa, R.H. Bendassolli, D.J. Soares, and A. Chaim	Spray deposits with different application rates and nozzles on castor (*Ricinus communis*) capsules focusing on the management of gray mold (*Amphobotrys ricini*)
3:10 PM	**Coffee Break – room: Grand Ballroom East**	
4:10-4:30 PM	**Oilseeds Division Meeting- Division Chair: Efthymia Alexopoulou**	
4:30-5:30 PM	**Poster Session: Grand Ballroom East**	

Concurrent session

2. Medicinal and Nutraceutical Plants Division

Moderator: Diana Jasso de Rodríguez
Room: Duke of Edinburg

8:00 AM	***Keynote speaker:*** Sean Westerveld and A. Shi	Efficacy of fumigants and biofumigants for the control of ginseng replant disease
8:40 AM	Sánchez, R. Rodríguez-García, F.D.H. Castillo, M.L.V. Díaz-Jiménez, J.A. Villarreal-Quintanilla, F.M. Peña-Ramos, and D.A. Carrillo-Lomelí	Antifungal activity of *Juglans* spp. and *Carya* sp. against *Fusarium oxysporum*, on tomato plants under greenhouse conditions
10:00-10:30 AM	**Medicinal and Nutraceuticals Plants Division Meeting- Division Chair Diana Jasso de Rodriguez**	
10:30 AM	**Coffee Break – room: Grand Ballroom East**	
12:00 PM	**Lunch**: **Room: Grand Ballroom East** Sponsored by Ontario Agricultural College, University of Guelph	

Concurrent Session
3. Fibers and Cellulosics

Moderator: Dilpreet Bajwa
Room: Duke of Edinburg

11:00 AM	***Keynote speaker:*** Omar Faruk, Ford Motor Company	Advancement and commercialization of biofiber based composites
11:40 AM	Dilpreet S. Bajwa, G. Pourhashem, A.H. Ullah, and S.G. Bajwa	The changing paradigm of lignin production and utilization in the emerging bioeconomy
12:00 PM	**Lunch**: **Room: Grand Ballroom East** Sponsored by Ontario Agricultural College, University of Guelph	
1:30 PM	M. Pelletier, Greg A. Holt, J. Wanjura, E. Bayer, and G. McIntyre	Acoustic evaluation of a mycological bio-composite
1:50 PM	Bhooma Nepal, C.S. Chin, and S.W. Jones	Sustainable development of agricultural straw as fiber reinforcement in concrete
2:10 PM	Efthymia Alexopoulou, F. Zanetti, and E.G. Papazoglou	Switchgrass: a valuable industrial crop for marginal lands
2:30 PM	Efthymia Alexopoulou, D. Li, and F. Zanetti	Long-term field studies on kenaf (*Hibiscus cannabinus* L.) in Greece
2:50 PM	Ana Luisa Fernando, A. Catroga, B. Cumbane, J. Costa, B. Barbosa, and E. Alexopoulou	Screening of kenaf (*Hibiscus cannabinus* L.) cultivars for phytoremediation of heavy metals contaminated soils
3:30-4:00 PM	**Fiber and Cellulosics Division Meeting- Division Chair Dilpreet Bajwa**	
4:00- 4:30 PM	**Coffee Break – room: Grand Ballroom East**	
4:30- 5:30 PM	**Poster Session: Grand Ballroom East**	

Wednesday 26 September

TECHNICAL SESSIONS
Concurrent Sessions
4. General Crops & Products Division

Moderator: Ana Luisa Fernando
Room: Suite 300

8:00 AM	***Keynote speaker:*** Marisol Berti, B.L. Johnson, H. Kandel, J. Ransom, A. Wick, D. Franzen, D. Ripplinger, J. Nowatzki, A. Peterson, M.S. Wells, A. Lenssen, S. Patel, R.W. Gesch, F. Forcella, and H. Matthees.	CROPSYS-CAP- A novel management approach to increase productivity, resilience, and long-term sustainability of cropping systems in the northern Great Plains-research update
8:30 AM	Alan Peterson, M.T. Berti, D.P. Samarappuli, S. Cabello, B. Andersen, and S. Podder ***Travel award recipient***	Maximizing cover crop performance by interseeding cover crops into standing soybean
8:50 AM	Jordan Graham, and N. Thevathasan	Influence of herbaceous biomass crops on soil organic carbon contents in Ontario soils
9:10 AM	Sean C. Simpson, M. Thimmanagari, E. Lyons, K. Dunfield, and N. Thevathasan	Influence of biomass crop species and age on soil organic carbon sequestration, and plant growth promoting rhizobacteria enhancement of biomass crop yields in Ontario
9:30 AM	Efthymia Alexopoulou, F. Zanetti, M. Christou, A. Monti	Which industrial crops could be cultivated on marginal lands?
9:50 AM	L. Gomes, J. Costa, B. Barbosa, F. Santos, and Ana Luisa Fernando	Can industrial crops be produced in heavy metal contaminated soils?
10:10 AM	Eleni G. Papazoglou	Phytoremediation of cadmium contaminated agricultural land and biomass production for industrial uses
10:30 AM	**Coffee Break – room: Grand Ballroom East**	
11:00 AM	Vance Owens, B. Baldwin, J. Fike, R. Karrow, D. Lee, W. Rooney, and T. Voigt	Potential yield of dedicated energy crops across the USA: results and outcomes of the multi-year sun grant regional feedstock partnership
11:20 AM	Mariusz Jerzy Stolarski, and M. Krzyżaniak	Energy efficiency of biomass production: short rotation coppices versus grasses and other herbaceous crops
11: 40 AM	Michał Krzyżaniak, M.J. Stolarski, and K. Warmiński	Life cycle assessment of Virginia mallow (*Sida hermaphrodita* Rusby L.) production with different fertilization options
12:00-1:30 PM	**Lunch: Room: Grand Ballroom East Sponsored by Bioindustrial Innovation Canada**	

1:30 PM	B.K. Hanson, and Burton L. Johnson	An old crop, industrial hemp, becomes a new crop again in the USA
1:50 PM	Li Tian, M. Mushtaq, L. McNea, K. Van Overloop, X. Hao, A. Dutta, and B.H. Gilroyed	Supercritical carbon dioxide explosion as a pre-treatment of lignocellulosic biomass to improve biogas yield
2:10 PM	Steven F. Vaughn, A.E. Larson, R.W. Ames, J.A. Kenar, M.A. Jackson, S.C. Peterson, and M.A. Berhow	Biochar produced from anaerobically-digested sugarbeet (*Beta vulgaris* L.) sludge as a slow-release organic fertilizer
2:30 PM	Shakirudeen A. Salaudeen, S. Tasnim, M. Heidari, B. Acharya, and A. Dutta	Utilization of eggshell as a CO_2 sorbent in the calcium looping gasification of biomass
2:50 PM	A.G. Taylor, M. T. Loos, M. Amirkhani, J. Cummings and G. C. Bergstrom	Industrial hemp seed investigations
3:10 – 3:30 PM	**General Crops Division Meeting- Division Chair Ana Luisa Fernando**	
3:30-4:00 PM	**Posters Session and coffee break: Grand Ballroom East**	
4:00- 4:50 PM	**Workshop: Special Issue in Industrial Crops and Products How to write a research article for a peer-reviewed journal: Process, Submission, and Ethics Marisol Berti, Editor-in-Chief Industrial Crops and Products (Queen Suite 300)**	

5:00-6:00	**AAIC board meeting (Boardroom 1)**
6:30-7:00	**Mixer**
7:00-9:00 PM	**AAIC Awards Banquet- Grand Ballroom East**

Concurrent session
5. Natural Rubber and Resins
Moderator: Hussein Abdel-Haleem
Room: Duke of Edinburg

8:00 AM	***Keynote speaker:*** Katrina Cornish	Alternate rubber research, development and commercialization – where are we now?
8:50 AM	D.F. Placido, V.M.V. Cruz, D.A. Dierig, G. Ponciano, C. Dong, N. Dong, T. Huynh, and Colleen McMahan	Field evaluation of guayule (*Parthenium argentatum* A. Gray) plants varying in allene oxide synthase gene expression
9:10 AM	M. Taurines, L. Brancheriau, Serge Palu, D. Pioch, E. Tardan, N. Boutahar, P. Sartre, and F. Meunier	*In-vivo* determination of polyisoprene and resins contents of guayule plants by near infrared spectroscopy
9:30 AM	Xianjie (Tony) Ren, and K. Cornish	Endurance and sustainability of guayule (*Parthenium argentatum,* A. Gray) natural rubber composites are improved synergistically by eggshell and silica reinforcing fillers
9:50AM	Mingde Liu, and K. Cornish ***Travel award recipient***	Improvement of rubber dandelion (*Taraxacum kok-saghyz*-L.E. Rodin) by manipulating the inulin biosynthesis pathway
10:10 AM	D.A. Ramirez-Cadavid, F. Michel Jr., and Katrina Cornish	Alkaline pretreatment of *Taraxacum kok-saghyz* (TK) roots to improve yield and purity of natural rubber (NR)
10:30 AM	**Coffee break – room: Grand Ballroom East**	
11:00 AM	**Rubber and Resins Division Meeting, Division Chair Hussein Abdel-Haleem**	
12:00-1:30 PM	**Lunch: Grand Ballroom East Sponsored by Bioindustrial Innovation Canada**	
3:10-4:00 PM	**Posters Session and coffee break: Grand Ballroom East**	
4:00- 4:50 PM	**Workshop: Special Issue in Industrial Crops and Products How to write a research article for a peer-reviewed journal: Process, Submission, and Ethics Marisol Berti, Editor-in-Chief Industrial Crops and Products (Suite 300)**	

5:00-6:00	**AAIC board meeting (Boardroom 1)**
6:30-7:00	**Mixer**
7:00-9:00 PM	**AAIC Awards Banquet- Grand Ballroom East**

Posters Presentations
Room: Grand Ballroom East

FIBER AND CELLULOSICS		
1	J. Shojaeiarani, Dilpreet S. Bajwa, S.G. Bajwa, and P. Pandey	A numerical model approach to predict moisture absorption in densified solid biomass during storage
2	J.R.A. Pires, V.G.L. Souza, and Ana Luisa Fernando	Valorization of lignocellulosic residues as a source for nanocellulose production
3	Eleni G. Papazoglou, E. Alexopoulou, and J. Vangronsveld	Kenaf tolerance to pollutants and their bioaccumulation to the above ground plant biomass
4	Eleni G. Papazoglou	Phyto-management of serpentine soils by giant reed (*Arundo donax* L.)
5	J. Liaw, Dilpreet S. Bajwa, L. Jiang, and S.G. Bajwa	Corn distillers dried grains with soluble (DDGS) – a value added functional material for wood composites
6	Efthymia Alexopoulou, and M. Christou	Preliminary trials for sunn hemp in Greece
7	Efthymia Alexopoulou	Rediscover industrial hemp
GENERAL CROPS		
8	J. de Mattia, F. Santos, and Ana Luisa Fernando	Sugarcane (*Saccharum* spp.) juice potential in a biorefinery context
9	N.A. Olson, K. Yilmaz, and Burton L. Johnson	Industrial hemp plant population effect on crop performance in North Dakota
10	K. Yilmaz, N.A. Olson, and Burton L. Johnson	Seeding date and genotype maturity effect on grain sorghum performance in North Dakota
MEDICINAL AND NUTRACEUTICALS		
11	V.G.L. Souza, C.P. Rodrigues, J.R.A. Pires, M.P. Duarte, I.M.R. Coelhoso, and Ana Luisa Fernando	*In vitro* bioactivity of novel chitosan bionanocomposite incorporated with different essential oils
12	J. Bradley Morris, M.L. Wang, and B. Tonnis	Sennosides in *Senna* genetic resources
13	Diana Jasso de Rodríguez, D.Y. Leger, R. Rodríguez-García, M.L.V. Díaz-Jiménez, Z.A. Genisheva, J.A. Villarreal-Quintanilla, and D.A. Carrillo-Lomelí	Mexican semi-desert plants inhibit cell proliferation and induce apoptosis in four human cancer cells
14	Diana Jasso de Rodríguez, G.N. Puente-Romero, M.L.V. Díaz-Jiménez, R. Rodríguez-García, J.A. Villarreal-Quintanilla, D.A. Carrillo-Lomelí, and Z.A. Genisheva	*In vitro* gastrointestinal digestion assessment of *Flourensia* spp. encapsulated extracts
15	L. Díaz-Jiménez, S.C. Hernandez, Diana Jasso de Rodríguez, and R. Rodríguez-García	Conceptualization of a biorefinery to revalorize the byproduct of ixtle from *Agave lechuguilla* Torrey
16	Diana Jasso de Rodríguez, F.A. Trejo-González, N.E. Rocha-Guzmán, M.R. Moreno-Jiménez, R. Rodríguez-García,	Antibacterial activity of *Rhus muelleri* Standl et Barkley against multidrug resistant bacteria causing urinary tract infections

	M.L.V. Díaz-Jimenez, J.A. Villarreal-Quintanilla, D.A. Carrillo-Lomelí, and F.M. Peña-Ramos	
RUBBER AND RESINS		
17	Nikita Amstutz, and K. Cornish	Growth and performance of *Taraxacum kok-saghyz* (Rodin) in different soil types
18	X. Zhuang and Katrina Cornish	Comparative genomic analysis of a putative rubber transferase subunit in rubber tree (*Hevea brasiliensis* Müll. Arg.), guayule (*Parthenium argentatum* Gray), and rubber dandelion (*Taraxacum kok-saghyz* Rodin)
19	S.K. McNulty, and Katrina Cornish	Phenotypic and Genetic Characterization of *Taraxacum kok-saghyz* (Rodin) polyploids
20	Claire Heinitz, D. Placido, and C. McMahan	Development of an in-vitro phenotyping assay for rubber and resin content in guayule (*Parthenium argentatum*) germplasm – preliminary results and progress
OILSEEDS		
21	James V. Anderson, A. Wittenberg, H. Li, and M. Berti	Analysis of fatty acid profiles and percent oil and protein content in seeds of summer- and winter-biotypes of *Camelina sativa* using Near Infrared Spectroscopy
22	Steven C. Cermak, J.A. Kenar, and J. Zhu	New biting fly repellent from a coconut oil source
23	V. Roslinsky, Christina Eynck, and K. Falk	Development of a FAD2B/FAE carinata-turnip addition line with ultra-high erucic acid content
24	Federica Zanetti, A.M. Jeromela, J. Vollmann, D. Righini, A. Borghesi, S. Cvejić, and A. Monti	Preliminary evaluation of new camelina genotypes suitable for southern Europe
25	J. Costa, L. Gomes, F. Zanetti, A. Monti, and Ana Luisa Fernando	Phytoremediation potential of heavy metal contaminated soils by *Crambe* spp. under irrigation with wastewaters
26	Federica Zanetti, T. Isbell, R.W. Gesch, R. Evangelista, A. Vecchi, and A. Monti	Effect of seeding rate on pennycress agronomic performances across contrasting environments
27	Eleni G. Papazoglou, G. Economou, E. Alexopoulou, and G. Kanrantounias	*Ricinus communis* L. growth under water stress conditions
28	Eleni G. Papazoglou, G. Kosmadakis, R.A. Babahmad, A. Outzourhit, and A. Ouhammou.	Could *Jatropha curcas* L. be a profitable crop for cultivation in Morocco?
29	Efthymia Alexopoulou, M. Christou, I. Eleftheriadis, I. Papamichael and K. Tsiotas	Safflower and castor two promising industrial crops to be grown on marginal lands

PROGRAM ABSTRACTS

KEYNOTE SPEAKERS AND PLENARY SESSION

BUILDING THE CANADIAN BIOECONOMY – BIOPRODUCTS TECHNOLOGIES AND THE IMPORTANCE OF INDUSTRIAL CROPS

Michael Faba

Bioindustrial Innovation Canada (BIC), Sarnia, ON

Canada is uniquely positioned to be at the forefront of renewable bioindustry. An abundance of natural feedstocks and availability of competent technical expertise, existing infrastructure, and logistics options has formed a strong foundation on which the bioeconomy is being built and sustained. The presentation will highlight the development of the bioeconomy in Ontario, including the Sarnia-Lambton region, as well as other provincial and national efforts to further innovative and renewable technologies. The valorization of under-utilized agricultural feedstocks will be highlighted, as well as specific examples of ongoing work in the sector and the important role that industrial crops are holding in the emergence of these new technologies.

Contact: Michael Faba Project Manager, Bioindustrial Innovation Canada (BIC), Sarnia, ON, Canada. Tel: 226.778.0020. Email: michaelf@bincanada.ca

COLLABORATION IN THE BIO-ECONOMY

Dave Park[1], and Andrew Richard[2]

[1]Cellulosic Sugar Producers Cooperative, ON
[2]Comet Biorefining, Inc., Sarnia, ON

Dave Park a local farmer will discuss how the partnership and collaboration with Comet Bio-Refining a biotechnology company with roots in London, Ontario developed, to create one value chain where both farmers and the biorefinery are able to profit and meet market demands for sustainably sourced ingredients. Dave Park is a partner at Parkland Farms which is located in Sarnia, Ontario and currently grow 5868 ha (i.e. 14,500 acres) of cash crops such as corn (*Zea mays* L.) soybean [*Glycine max* (L.) Merr.], wheat (*Triticum aestivum* L) and winter barley (*Hordeum vulgare* L.). Parkland Farms adds value by growing, processing, and retailing seed soybean varieties to its customers in Southwestern Ontario. It's this philosophy of value adding to its core products which initially sparked park's interest in the bio-economy and agricultures place within it. Andrew Richard is the founder and chief technology officer of Comet Bio-refining, a company whose proprietary cellulosic dextrose technology converts non-food biomass, such as agricultural and forest material, into high-purity dextrose sugar. Andrew will discuss the development of the partnership between Comet Bio-refining and the farmer driven Cellulosic Sugar Producers Co-operative.

Contact: Dave Park, Operations Manager, Parkland Farms, 2302 Confederation Line, Sarnia, Ontario N7T 7H3, Canada. E-mail. davepark@parklandfarms.ca; Andrew Richard, founder and chief technology officer, Comet Biorefining, Inc., 1475 Vidal St. S Sarnia, ON N7T 8G6, Canada. Tel: 519-336-5095.

HIGH VALUE PHASE CHANGE ENERGY STORAGE MATERIALS FROM VEGETABLE OILS: FROM IDEA TO COMMERCIAL LAUNCH

Suresh Narine

Trent University, Peterborough, ON

Vegetable oils are versatile feedstock for the chemical industry, presenting sustainable opportunities for the synthesis of a wide range of materials due to their uncomplicated chemistries and industrial production. However, their use as commodity feedstocks are challenged by the requirement to compete with petroleum crude, and to a certain extent by the fact that vegetable oil prices are linked to crude oil prices because of the large dependence of agriculture in the whole on fossil fuels. This behooves the utilization of vegetable oil feedstock only in high value applications where non-toxicity, sustainability and functionality are more important than the lowest cost. The use of vegetable oils to produce high performance phase change materials will be highlighted in this presentation, as well as the life cycle and challenges of commercializing laboratory scale innovations.

Contact: Suresh Narine, Professor, Physics & Astronomy and Chemistry at Trent University, and Director, Trent Centre for Biomaterials Research. 1600 West Bank Drive, Peterborough, ON K9J 7B8 Canada. Tel: 705 748 1011 Ext. 6105.

PHYTOGLYCOGEN NANOPARTICLES: COMMERCIALIZATION OF A UNIQUE, VALUE-ADDED AGRICULTURAL NANOTECHNOLOGY FOR APPLICATIONS IN FOOD, PERSONAL CARE AND BIOMEDICINE

John R. Dutcher

University of Guelph, Guelph, ON

Nature offers amazing examples of nanostructured molecules and materials. An excellent example of this is phytoglycogen, a highly branched polymer of glucose that is produced in the form of dense, monodisperse nanoparticles by some varieties of plants such as sweet corn (*Zea mays* L.). The particles are chemically simple, but it is their dendrimeric or tree-like physical structure that produces interesting and unusual properties such as extraordinary water retention, and low viscosity and exceptional stability in water. These properties lead to a wide variety of applications ranging from cosmetics to food and nutrition to drug delivery. I will describe our journey from the initial serendipitous discovery of the particles to our study of their physical properties to the commercialization of this natural, sustainable PhytoSpherix nanotechnology in our Guelph-based spinoff company Mirexus.

Contact: John R. Dutcher. Dept. of Physics, University of Guelph, 50 Stone Road E., Guelph, ON, Canada, N1G 2W1. Tel: 1-519-824-4120 x 53950. E-mail: dutcher@uoguelph.ca

ABSTRACTS

OILSEED DIVISION

ORAL PRESENTATIONS

CHAIR

EFTHYMIA ALEXOPOULOU, CRES, ATHENS, GREECE

IS CAMELINA LEADING THE RURAL RENNAISSANCE IN EUROPE?

Federica Zanetti

Dept. of Agricultural and Food Sciences (DISTAL), University of Bologna, Italy

Camelina [*Camelina sativa* (L.) Crantz], native species of Europe, was widely cultivated mainly in the central and northern part of the continent until the beginning of the 19th century, but afterward it was replaced by more productive oil crops, like oilseed rape (*Brassica napus* L. var. *oleifera*). The recent renaissance of camelina is mainly driven by its wide environmental suitability, low input requirements, good tolerance to pests and diseases, and variegate portfolio of derived products covering biofuels, biobased products and more recently also food and feed applications. Within the last two framework programs (FP7 and H2020), launched by the European Commission, several research projects focused on this species have been granted with many millions of euro. The European interest for camelina is dated back almost twenty years ago with the first studies on this unique oilseed species authored in the mid '90s by Austrian and Danish researchers. Thereafter many studies on this species have been published and up to now about 400 papers are authored by European researchers covering very different aspects such as: food sciences, aquaculture, agronomy, biotechnology and genetics, biofuels and chemistry, etc. The real renaissance of camelina is began in the last decade when the interests of researchers for this multipurpose ancient crop has finally matched those of European farmers who were looking for alternatives to be easily enclosed in their typical crop rotations being able to give satisfactory yields accompanied by valuable ecosystem services, such as increased biodiversity, reduction of nutrient leaching and break of typical soil diseases. Camelina is nowadays a "work-in-progress" crop with a lot key issues that still have to be addressed before considering this species an established oilseed for Europe, but at this stage all the fundamental prerequisites to become a real opportunity for European Rural Renaissance are fulfilled demonstrating its high potential.

Contact: Federica Zanetti, Dept. of Agricultural and Food Science, DISTAL, Alma Mater Studiorum, University of Bologna, Viale G. Fanin 44, 40127 Bologna, Italy. Email: federica.zanetti5@unibo.it

THE CHALLENGES FOR MECHANIZED PRODUCTION OF CASTOR ARE BEING OVERCOME IN BRAZIL

Liv S. Severino

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Many industrial crops have high market potential, but increasing the production is a challenge because of the many requirements in each specific production chain. Castor (*Ricinus communis* L.) is one of those industrial crops recognized as a platform for many high value products in the chemical industry; however, the increasing demand is not met by the limited production capacity. The three most important producing countries (India, China, and Brazil) depend on hand harvest, and the recent economic development inflated the labor costs and made the castor prices soar. In the last few years, many technical developments are overcoming the barriers for castor production in large scale, and this industrial crop is having an opportunity to experience a significant increase in planted area and production. These changes are occurring particularly in Brazil, where the crop found its room as a profitable option for crop rotation in the soybean-corn-cotton system. The two most important steps that allowed the acceptance of castor were the development of herbicide protocols for weed management and of a header for mechanized harvest. The region where castor is being promoted in Brazil adopts a cropping system with heavy use of inputs and mechanization, and weed management could not be made by hand hoeing just as harvesting could not be made manually. The mechanized harvest is still experiencing low efficiency (about 30% of harvesting loss), but the system is keeping profitability while improvements are made in the header, in the crop termination, and in the improvement of cultivars with the required traits. Besides the profitability of castor crop, the local producers are being attracted to this oilseed because of its ability to reduce the population of two nematodes species (*Melodogyne incognita* and *Pratylenchus brachyurus*) which are causing heavy losses to the other crops in the system. In some situations, the increased productivity of cotton and soybean planted after castor in nematode-infested areas brings more benefits that the income of castor seed. The area planted with castor in the State of Mato Grosso is insignificant in the figures of world production, but it calls attention for the potential growth in the following years. The area planted with castor in the world is around 1.2 million ha, while the area under mechanized harvest in Brazil was only 2,500 ha in 2018, and it is expected to increase to 10,000 ha in 2019. This is less than 1% of the global area. However, if the castor production remains profitable in the following years, there are some millions hectares of available land for growth. A problem that needs to be solved is the management of the disease caused by the fungus *Amphopotrys ricini* (gray mold), which can cause total loss of the field if not properly managed. The region is very favorable to that fungus, and the current productivity is low because the crop is being planted late in the season in order to escape the most favorable periods for the disease. Some fungicide protocols are being adopted, but its efficacy needs to be evaluated for some seasons. A ricin-free transgenic castor was recently developed by Embrapa (not released to the market yet), and it will potentially increase the profitability of the crop due to the use of castor meal as feed. Unlike the negative public perception of ricin in the United States and some other countries, people has no fear and there is no legal restriction for castor in Brazil. The only precaution is to prevent contamination of castor seeds into lots of soybean and corn.

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TOWARDS IDENTIFYING QUANTITATIVE TRAIT LOCI FOR AGRONOMIC AND SEED QUALITY TRAITS IN ETHIOPIAN MUSTARD (*BRASSICA CARINATA* [A.] BRAUN) USING NESTED ASSOCIATION MAPPING

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Brassica carinata (Ethiopian mustard, carinata) is a member of the Brassicaceae family and has recently been developed as an industrial crop in Canada. Its seed oil is high in long and very long chain monounsaturated fatty acids, rendering it a well-suited feedstock for the production of biofuels, especially bio-jet fuel. The agronomic attributes of carinata, such as high yield potential, shatter resistance and tolerance to abiotic stress such as drought and high temperatures make it an attractive alternative oilseed crop, particularly for the drier regions of the Canadian Prairies. Carinata cultivar development mainly involves the use of traditional breeding techniques and the application of molecular markers to assist in routine breeding activities has been limited to only a few traits. In order to facilitate faster and more efficient cultivar development, this work aims to develop a set of molecular markers associated with desired agronomic and seed quality traits as well as corresponding assays that will enable the identification of plants with favorable trait combinations at an early stage. Trait-associated markers for carinata will be developed using Nested Association Mapping (NAM), a powerful technique that combines the statistical power of quantitative trait locus (QTL) mapping with the gene level resolution of association mapping. A carinata NAM population was developed by crossing fifty genetically diverse lines ("founders") with one reference line and subsequent selfing for four generations, resulting in 2,500 recombinant inbred lines (RILs). These RILs, alongside the parental founders and checks, were grown in the summer of 2017 in Saskatoon in a field nursery in a modified augmented design (MAD) and phenotyped for 21 in-field and eight post-harvest traits. Assessments were carried out by a combination of manual measurements and laboratory analyses (NIR, GC, and UPLC). Furthermore, we explored the use of remote data acquisition by drone and GoPro technology through collaboration with the Plant Phenotyping and Imaging Research Center at the University of Saskatchewan. Concurrent with the phenotyping efforts, the fifty founder lines were densely genotyped by whole-genome shotgun sequencing, whereas the RILs were genotyped using the 90K Brassica Illumina Infinium SNP array. Genome-wide association analyses of adjusted phenotype data with the genotypic data resulted in the identification of SNPs associated with a number of agronomic and seed quality traits. The results of this study will be validated through a second year of phenotyping in the summer of 2018. This work is a fundamental step toward the development of molecular markers for important agronomic and quality traits in carinata to be used in any breeding program.

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IMPROVING PRODUCTIVITY OF RELAY-CROPPING INDUSTRIAL OILSEEDS WITH SOYBEAN

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Economically producing oilseeds for biofuels and bioproducts in the U.S. is challenging. Camelina [*Camelina sativa* (L.) Crantz] and pennycress (*Thlaspi arvense* L.) can be grown as winter annual oilseeds that additionally can be double- or relay-cropped with soybean (*Glycine max* L. Merr.) and other short-season summer annuals, potentially making production of these oilseeds for industrial purposes more attractive to farmers. Relay- rather than double-cropping with soybean can be more productive in northern U.S. climates. However, improved management of these systems is needed to boost their productivity. A replicated field study was conducted in western Minnesota, U.S. to determine the effect of soybean cultivar (Maturity Group 0, 1, and 2) and planting date (early, normal, and late) on overall relay system productivity, including seed and oil yields of camelina and pennycress. Soybean planting did not affect camelina or pennycress yields the first year, but did cause a decline in pennycress yields in year-2, which increased with late planting. Seed oil content of pennycress was unaffected by relay cropping, but was increased in winter camelina. Pennycress oil content was about 34% across both years while camelina oil content averaged 42% the first year and 38% the second. Soybean cultivar but not planting date affected relayed soybean yields and seed oil content. A Maturity Group 2 soybean relayed into winter camelina yielded as great as 3804 kg ha^{-1} and was only about 7 to 11% lower than full-season controls. Total oil yield of winter oilseeds relayed with soybean was often much greater than a single soybean crop. Improved productivity for relay-cropping winter camelina and pennycress with soybean, and the environmental benefits provided by growing these winter annual oilseeds may spark greater farmer adoption.

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SCREENING TRIALS FOR CAMELINA [*Camelina sativa* (L.) Crantz] IN GREECE

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Camelina [*Camelina sativa* (L.) Crantz, Brassicaceae family] is an important non-food oil crop for the chemical industry as feedstock for high-added value bioproducts. Camelina seeds contain 38 to 43% oil and are considered as valuable source for medium-chain fatty acids (MCFA, C10–C14). Currently, in the view of the EU research project COSMOS (http://cosmos-h2020.eu), the appropriate agronomic practices (sowing dates, plant densities, nitrogen rates and rotation cycles) for camelina are being studied (Greece, Italy, and Poland), among other research activities. Moreover, camelina screening trials are being carried out to select the best cultivars for the aforementioned countries. The aim of this research work is to present and discuss the results of five screening trials that had been carried out in Greece (2015-18) for 13 cultivars (Omega, Midas, CS0887, 13CS0787-05, 13CS0787-15, 13CS0789-02, 13CS0787-06, 13CS0787-09, 13CS0787-22, 13CS0787-27, 14CS0886, 14CS0787-08, WUR2015001) in three blocks. The tested cultivars, apart from the cultivar Omega (Poland) and WUR2015001 (developed by WR in the Netherlands), had been developed by LINNAEUS company in Canada. Screening trials had been established four times as in spring and one time in winter and the sowing dates were: 6 April 2015, 21 March 2016, 20 March 2017, 13 December 2017, and 19 March 2018. The size of the experimental plots was 1.5 x 6 m and the distances between the rows were 15 cm. In all trials, a number of measurements had been carried out (number of plants in one meter row in the beginning and at the end of the growing season and plant height). At the end of each growing cycle a final harvest of 5 m^2 (5x1) per plot took place by hand and the harvested biomass had been first weighted and then the seeds were separated and weighted. Samples from both plant fractions (seeds and straw) had been collected for laboratory analyses (oil and protein content for the seeds and biomass characterization for the straw). The seed yields were strongly affected by the sowing date, the specific climatic conditions of each growing period and the cultivar. The least yields were recorded in the first trial that the sowing took place very late (6 April) and the highest ones in the winter trial (2017-18; mean seed yields of 2068 kg/ha). In the first and the second trial the mean seed yields were almost the same (around 1250 kg/ha), while in the third year were 1734 kg/ha. The harvesting of the last screening trial will be done at the end of June 2018. The best cultivar (as a mean) of the four trials was 13CS0787 – 09 (1722 kg/ha) and the least was CS0887 (1282 kg/ha). It should be pointed out that the mean seed yields of the two European cultivars were quite high and were 1705 kg/ha for Omega and 1587 kg/ha for WUR2015001. The moisture contact of the straw at harvest was 25 to 35% depending on the year and the cultivar. The ration between seed and straw yields varied from 1:2 to 1:2.5 in all years that could be considered relatively high but can be expected since the final harvest took place by hand. Camelina straw had mean ash content of 6.96% and the gross calorific value 4341 kcal/kg.

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GENETIC DIVERSITY AND POPULATION STRUCTURE OF *CAMELINA SATIVA* SPRING PANEL

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There is a need to explore renewable alternatives (e.g. biofuels) that can produce energy sources to help reduce the reliance on fossil fuels. In addition, the consumption of fossil fuels adversely affects the environment and human health via the generation of waste water, greenhouse gases, and waste solids. Camelina [*Camelina sativa (L.)* Crantz], originated from southeastern Europe and southwestern Asia. It is being re-embraced as an industrial oilseed crop due to its high seed oil content (36-47%) and high unsaturated fatty acid (>90%) which is suitable for jet fuel, biodiesel, high-value lubricants and animal feed. Moreover, its agronomic advantages include early maturity, low requirement for water and nutrients, adaptability to adverse environmental conditions and resistance to common cruciferous pests and pathogens. These attributes make it an ideal crop for sustainable agricultural systems and growth on marginal lands. However, the lack of genetic and genomic resources and information has slowed the progress of developing this into a viable oilseed crop. A core collection of 213 spring camelina accessions was genotyped, and further characterization of the genetic diversity and population structure was used to infer how plant breeding and selection might have affected the formation and differentiation within camelina natural populations and how their genetic diversity can be used in future breeding efforts. A total of 6,192 high-quality single nucleotide polymorphisms (SNPs) were identified using genotyping-by-sequencing (GBS) technology. An average polymorphism information content (PIC) values of 0.29 indicates moderate genetic diversity for camelina spring panel. Population structure and principle coordinates analyses (PCoA) based on SNPs revealed two distinct subpopulations. Sub-population 1 (POP1) contains accessions that mainly originated from Germany while the majority of POP2 accessions (>75%) were collected from former Soviet Union. Analysis of molecular variance (AMOVA) identified 4% variance among and 96% variance within subpopulations, indicating a high gene exchange (or low genetic differentiation) between the two subpopulations and high genetic differentiation within subpopulations. Our findings provide important information to enhance genetic gain in camelina breeding programs by allele/gene identification using genome-wide association analysis studies (GWAS) and marker-assisted selection (MAS).

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CAMELINA LEAF WAX CONSTITUENTS AND DISTRIBUTIONS, PHENOTYPIC VARIATIONS AND ALLELE IDENTIFICATION

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Camelina [*Camelina sativa* (L.) Crantz] is an old world crop newly introduced to the semi-arid regions of the Southwestern US. Recently, camelina gained attention as a biofuel feedstock crop due to its relatively high oil content, polyunsaturated fatty acids, short growing season with fairly good adaption to marginal lands, and low input requirements in agricultural systems. To expand camelina growing area into more arid regions, it is important to develop new drought resistant cultivars that can grow under water-limited conditions. Plants having cuticles with low permeability to water can possess elevated dehydration avoidance and improved drought tolerance. Our objective is to identify and develop molecular markers controlling genes underlying these wax-related traits and apply them for future marker-assisted selection (MAS) in breeding programs. Toward this end, the cuticle chemical compositions among seventeen accessions representing four camelina species were analyzed. Among all the leaf wax compositions, the primary alcohols (ALC) and alkanes (ALK) were the predominant classes, followed in abundance by wax esters (WE), fatty acids (FA) and aldehydes (ALD). Further, we analyzed the phenotypic variations within domesticated *Camelina sativa* using a core collection of 213 spring camelina accessions originated from Europe and North America. The diversity panel exhibited a wide range in total leaf wax contents, wax classes and constituents. Among primary alcohols, the dominant constituents were the ALC24, ALC26 and ALC28 homologues, while the ALK31 homologue was the most abundant alkane. High heritabilities in primary alcohol and its dominant constituents suggest the feasibility for selection of these traits during entry stage in camelina breeding programs. Genome-wide association studies (GWAS) revealed a total of 42 significant SNP markers that are putatively associated with wax-related traits, in which one significant marker was identified in ALC26 and total ALC, and ALK. The putative functions of these 42 SNP markers can be clustered into three major categories: peroxisome movement, defense in pathogen attack and repression of photomorphogenesis. This WAX-GWAS study provides important information for the alleles/genes that are putatively controlling wax-related traits and will be useful in future breeding efforts to help select the camelina cultivars with superior abiotic resistance traits.

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SEED AND OIL YIELD OF *CAMELINA SATIVA* L. CRANTZ CULTIVATED IN TEMPERATE CLIMATE OF CENTRAL EUROPE

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The European Union's Bioeconomy Strategy proposes the use of renewable biological resources and their conversion into bioproducts. The strategy ensures that agriculture will deliver more feedstock in a sustainable way. Therefore, it is very important to use local biological resources, e.g. oil crops. Camelina [*Camelina sativa* (L.) Crantz] is a crop with relatively high seed yield that ranges from 1.0-3.0 Mg ha^{-1}. Oil content has been reported to be 30-49%. The oil is rich in oleic, linoleic, linolenic and eicosenoic acids. Thus it can be used for production of biodiesel, hydroprocessed jet fuel, polymers and chemical products, e.g. nanocomposite materials, monomers, alkyd resins and adhesives. The aim of this three-year study was to determine seed and oil yield potential of ten cultivars of camelina cultivated in climate conditions of north-eastern Poland. Field trial was carried out in 2015-2017 and was set up in a randomized design at the Didactic and Research Station in Łężany, owned by the University of Warmia and Mazury in Olsztyn (UWM). The crop was sown at density of 500 seeds/m^2. Observation of growth and development of the plants was carried out during the growing periods. Seeds were harvested with plot combine harvester. Subsequently, the seeds yield was determined per plot and per hectare. In the laboratory, the content of oil in seeds was determined, and then oil yield potential of the tested cultivars was calculated. The results of the tests were analyzed statistically using STATISTICA 13 software. The mean yield of seeds from three years amounted to 1.85 Mg/ha d.m. and it was strongly diversified between years (1.33-2.23 Mg/ha d.m.), due to different weather conditions. The significantly highest seed yield was determined for entry 787-08 and the Omega cultivar, 2.03 and 1.88 Mg/ha d.m. respectively. The highest oil content had entry 886 (40.32% d.m.), and the lowest Omega (37.56% d.m.) and 787-06 (37.19% d.m.). The significantly highest oil yields (0.8 Mg/ha) were recorded for entries 787-08 and 787-15. Weather conditions in individual years of research were very diverse and significantly influenced plants' features. Therefore, it was decided to continue field trials in order to obtain more stable and reliable results.

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MORPHOLOGICAL CHARACTERISTICS OF WINTER- AND SUMMER-BIOTYPES OF CAMELINA [*Camelina sativa* (L.) Crantz]

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Camelina has two distinctive biotypes, summer and winter, with winter biotypes requiring a vernalization treatment to enter the reproductive phase. Increased interest in broadening the diversity of winter-hardy cover crops in the northern Great Plains of the U.S. to reduce soil erosion through the winter months has led seed companies to offer winter camelina seed outsourced from other states. Regrettably, in 2017, outsourced camelina seed from other states turned out to be summer biotypes that did not survive the North Dakota winter. The objectives of this study were to determine the morphological characteristics of seed and seedlings from summer- and winter-biotypes. To determine differences in seed wavelength absorbance between winter- and summer-biotypes both visible and near infrared spectra were examined, which encompass 400 to 2498 nm wavelengths. Mixtures of cultivars Joelle (winter) and Blaine Creek (summer) were analyzed using a near infrared spectroscopy (NIRS), XDS Analyzer; seed mixtures were prepared in increments of 5% of 'Joelle'. Morphological characteristics of seedlings were determined by growing fifteen summer- and fifteen winter-biotypes in an environmental chamber set at 16 hours days and 22° C. The experimental design was a RCBD with three replicates. Growth stage, total leaf length, petiole length, leaf width, number of leaf lobes, and plant height were taken two weeks after planting and then every week for the following three weeks. Spectral wavelengths obtained from seeds were significant except for wavelengths between 900 and 1100 nm. Results indicate the NIRS can more accurately predict seed of a winter- compared to a summer-biotype at 2400 nm; however, NIRS was not able to detect significant differences if the seed sample contained greater than 75% of a winter biotype. At 400 nm predictive ability among seed mixtures was observed; however, prediction ability was enhance at 2400 nm. Plant height ranged between 31 to 423 mm at five weeks after planting. Biotypes within each category varied in plant height at all measuring dates. Due to bolting of the summer biotypes, the last three samples dates had a large difference ($p<0.0001$) in plant height. The experimental data from most evaluation dates indicate that winter- and summer-biotypes, averaged across all genotypes, differ in blade length at both the uppermost developed leaf and the second uppermost leaf. Differences in seed and seedling morphological characteristics can be used to differentiate winter- or summer-biotypes. Having a rapid method to determine the percentage of winter camelina in an unknown seed sample will be very favorable for all producers, as well as seed companies, interested in growing winter camelina as either a winter-hardy cover crop or as a winter annual cash crop.

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MODELLING CAMELINA GROWTH AND PRODUCTIVE TRAITS ACROSS EUROPE AND CANADA

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Camelina [*Camelina sativa* (L.) Crantz] is rapidly increasing its importance as a promising new oilseed crop both in Europe and Canada, as proved by the large number of scientific papers and research projects recently released. Compared with similar species, belonging also to the *Brassicaceae* family, e.g. rapeseed (*Brassica napus* L.) and Indian mustard (*Brassica. rapa* L.*)*, camelina is characterized by wider environmental adaptability, higher resilience to pests and diseases and minimal agronomic input needs. These benefits along with the recent market availability of improved cultivars pave the way for the inclusion of camelina in crop rotations, leaving its "niche" attitude. Mid-term trend analyses of camelina productivity across different environment conditions and management options might thus become a research priority, especially in light of changing climatic conditions. At this scope, we developed a new modelling solution targeting the quantitative and qualitative aspects of camelina productions, by coupling the crop model WOFOST-GTC with a process-based dynamic simulation of the oil fractions also considering the impact of soil water availability on growth dynamics. The new modelling solution has been calibrated and evaluated on a multi-year, multi-location and multi-genotype dataset, including three spring camelina lines (Midas, Cypress and Pearl, all supplied by Linnaeus Plant Science, Canada). The field experiments were carried out in three years (2015, 2016, and 2017) and eleven locations (four in Europe and seven in Canada) covering latitudes from 38° to 54° N, and longitude from 24°E to 121°W. Three camelina lines have been chosen in relation to contrasting productive traits. 'Cypress' is characterized by larger seed size (+40%) and resulted the highest productive across all sites, 'Pearl' is characterized by a modified oil profile (increased oleic and decrease linoleic acid contents) and resulted the least productive across all sites, and 'Midas' is considered as a reference cultivar since it produces steadily in all environmental conditions. In all test locations camelina was grown following a common experimental protocol, including plot size, seeding rate, fertilization, and harvesting management. The development of cultivar-specific model parameter sets will allow the further application of the modelling solution under contrasting pedo-climatic and management scenarios, in order to identify the future potential of camelina productivity by taking into account the associated sources of uncertainty while testing possible adaptation strategies to increase crop productivity in the next future.

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EFFICIENCY INDICES OF SPRING OIL CROPS PRODUCTION

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Biomass is the main feedstock used in the production of biofuels for transport. In Europe, rape (*Brassica napus* L.) is the main oil crop in industry and in food production. Camelina [*Camelina sativa* (L.) Crantz] and crambe (*Crambe abyssinica* Hochst ex R.E. Fries) can be an alternative to rape, especially on poorer soils. Camelina and crambe are oil crops which are becoming an attractive feedstock in bio-industry owing to their beneficial properties, such as a short growing season, resistance to drought and frost, low requirements regarding fertilizer and pesticide consumption, as well as a high content of oil in seeds and its valuable composition. These crops have been attracting the interest of research centers and industry interested in using their oil and biomass for the production of bioproducts and biofuels. The aim of this study was to determine the energy and economic efficiency of camelina and crambe biomass production. The study was based on a three-year large-scale trial, carried out in Poland on agricultural areas owned by the University of Warmia and Mazury, Olsztyn. In each trial, seeds of crambe 'Galactica' and camelina 'Midas' were sown at a rate of 13 kg/ha and 6 kg/ha, respectively. Camelina production was characterized by a higher energy gain and lower energy intensity of production of seeds, straw and oil content in seeds, compared with the average values of these indices for crambe. The average energy efficiency ratio for the production of camelina seeds was higher compared with the average value for crambe by 5.7%. From the economic point of view, camelina production was also found to be more interesting because the income from camelina seeds was higher and seed production costs were lower compared with the average values of crambe seed production. The average revenue from camelina seed production was 36% higher than from crambe. Further studies should be done to verify these results and make further improvements in production technology, reduce energy inputs and costs as well as improving the efficiency of seed harvesting (reducing losses during harvest). This should contribute in the future to an increase in the energy and economic production efficiency of these two oil crop species.

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FATTY ACID COMPOSITION AND ANTIOXIDANT ENZYME ACTIVITY OF *BRASSICA NAPUS* L. CULTIVARS AS AFFECTED BY BIOENGINEERED ZINC NANOPARTICLE

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FRACTIONATION OF MUCILAGE AND PROTEIN FROM LESQUERELLA (*PHYSARIA FENDLERI*) SEEDS

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Lesquerella [*Physaria fendleri* (A. Gray) O'Kane & Al-Shehbaz] is an oilseed crop belonging to the Brassicaceae (mustard) family that is native to the southwestern United States. The seed oil contains 54-60 % lesquerolic (14-hydroxy-cis-11-eicosenoic) and 3-5 % auricolic (14-hydroxy-11, 17-eicosadienoic) acids. Hydroxy fatty acid is used in a variety of industrial applications such as lubricants, corrosion inhibitors, engineering plastics, plasticizers, emulsifiers, and coatings. The seed also contains 30 % (dry, fat-free basis) crude protein and a significant amount of seed coat mucilage. Previous studies evaluated the seed coat mucilage recovered by shearing either hydrated whole seed or defatted meal. Also, protein was characterized using defatted meal without removing the mucilage. In this study, the mucilage and protein were produced as separate products, in addition to the oil. One scheme first recovered the mucilage from the whole seeds but kept the hydrated seeds (1:20 w/v seeds-to-water ratio) intact; the succeeding steps were drying, defatting, and protein extraction. The other scheme started with oil extraction by pre-pressing and hexane extraction followed by mucilage recovery from the defatted meal, and, finally, extracting the protein. The aqueous protein extraction (1:10 w/v meal-to-water ratio) was done at pH 9 and then precipitation at pH 5.5 by addition of 1 N HCl. The recovered proteins were redispersed in water (pH 6.8), dialyzed against deionized water, and then freeze-dried. All mucilage and protein extractions were conducted at room temperature. The starting lesquerella seeds had 27.8 % oil, 21.5 % crude protein (% N x 6.25), and 46.6 % total carbohydrates. The mucilage recovered from intact whole seeds after three extractions accounted for 21.5 % of the starting material and contained 1.4 % oil, 9.2 % crude protein, 4.1 % ash, and 83.1 % total carbohydrates. The removal of mucilage followed by defatting of the seed increased the protein fraction in the meal to 44 %. Protein extraction yield was 10 % of the mucilage-extracted, defatted meal. On the other hand, mucilage fraction recovered from only pre-pressed defatted meal was around 60.1 % of starting material and contained < 0.1 % oil, 24.1 % crude protein, 7.5 % ash, and 68.3 % total carbohydrates. The mucilage fraction required reprocessing to reduce the meal solids content. The alkali extract from defatted meal did not yield any acid-precipitated protein. The sequence of mucilage and oil extraction will affect the composition and purity of the mucilage and protein produced. If lesquerella seeds are defatted first, the mucilage and protein recovery can be combined by employing alkali extraction. The soluble fraction, which contains the protein, may be separated from the extract if desired.

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PRE-HARVEST DESICCATION OF CASTOR CROP (*RICINUS COMMUNIS* L.) USING HERBICIDES

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Castor is an industrial crop that depends on mechanization of harvest for increased production. The presence of green leaves and fresh fruits at harvest time affects the combine operation. Defoliation and desiccation are a requirement for efficient mechanized harvest. The objective of this study was to define an herbicide combination that provide an efficient desiccation of castor crop. The experiments were conducted in Embrapa Cotton's experimental farms in a semiarid region of Brazil. The first assay was carried out in two locations: under rainfed conditions in Lagoa Seca, PB (07°09' S; 35°53' W) and under irrigation in Barbalha, CE (07°17' S; 39°16' W). The 12 treatments were composed by a control (no herbicide) and the following herbicides: glyphosate (1440 g/ha), diquat (400 g/ha), paraquat (400 g/ha), carfentrazone (50 g/ha), saflufenacil (70 g/ha), 2,4-D (1340 g/ha), glyphosate + diquat (1080 + 300 g/ha), glyphosate + paraquat (1080 + 300 g/ha), glyphosate + carfentrazone (1080 + 35 g/ha), glyphosate + saflufenacil (1080 + 50 g/ha), and glyphosate + 2,4-D (1080 + 1000 g/ha). Mineral oil adjuvant was added in all spray solutions (0.5% v/v). The herbicides were applied at 75 days after emergence (DAE) in the experiment under rainfed condition and at 121 DAE in the experiment under irrigation condition. The second experiment was carried out under irrigation in Barbalha, CE. The 12 treatments were combinations of two doses of 2,4-D (670 and 1340 g/ha) with three doses of glyphosate (1440, 1880, and 2160 g/ha), the same doses isolated, and a control treatment. The herbicides were sprayed at 90 DAE. The irrigation was continued for 21 days after herbicide applications (DAA) in Barbalha, CE for both assays. The experimental design was randomized blocks with three and four replications for the first and second experiment, respectively. Data was taken on phytointoxication at 7, 14, and 21 DAA and leaf number at 21 DAA for both experiments. The shoot humidity of the plants was evaluated in the first assay at 21 DAA. For the second experiment, number of racemes, number of seeds per raceme, seed weight, and seed yield was evaluated at 27 DAA (117 DAE). The treatments with paraquat and paraquat + glyphosate resulted in phytointoxication values higher than 90% only under irrigation. For both conditions, glyphosate with carfentrazone promoted high phytointoxication (86%) and glyphosate in combination with carfentrazone or saflufenacil resulted in defoliation between 93 and 97%. The applications with 2,4-D and 2,4-D + glyphosate caused the highest phytointoxication (87 to 100%) and defoliation (98 to 100%) levels in the both locations and also affected the water content in the aerial part of the plants, which mean values of reduction in relation to control were 44% under rainfed and 88% under irrigation condition. In the second experiment, it was found that 2,4-D promoted full desiccation at any dose regardless of association with glyphosate, and the plants were killed one week after spraying, resulting in 100% of defoliation at 21 DAA. Glyphosate did not promote complete desiccation of castor plants in the doses tested. Seed yield was not affected in any treatment. In conclusion, 2,4-D was found the herbicide with the highest desiccation capacity as harvest aid for castor crop when applied either isolated or in combination with glyphosate.

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SELECTIVITY OF POST-EMERGENCE HERBICIDES FOR THE MANAGEMENT OF EUDICOT WEEDS IN CASTOR CROP (*RICINUS COMMUNIS* L.)

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Castor (*Ricinus communis* L.) is an attractive alternative for rotation with major grain crops in tropical agricultural systems. However, the control of eudicot weeds relies in only one herbicide (chlorimuron-ethyl) selective to castor in post-emergence application. Chlorimuron-ethyl is also selective to soybean, and this is a problem when castor is planted after soybean. The aim of this work was to evaluate the selectivity of post-emergence herbicides on castor crop. The experiment was carried out in Embrapa Cotton's experimental farm in Barbalha, CE (07°09' S; 35°53' W), under irrigation, in a completely randomized design with four replications. The fifteen treatments were constituted by a hand-hoeing control and the following herbicides and doses: chlorimuron-ethyl (10 g/ha), chlorimuron-ethyl (15 g/ha), metamitron (2800 g/ha), metamitron (4200 g/ha), ethoxysulfuron (60 g/ha), ethoxysulfuron (80 g/ha), halosulfuron-methyl (75 g/ha), halosulfuron-methyl (112.5 g/ha), chlorimuron-ethyl + metamitron (10 + 2800 g/ha), chlorimuron-ethyl + ethoxysulfuron (10 + 60 g/ha), chlorimuron-ethyl + halosulfuron-methyl (10 + 75 g/ha), metamitron + ethoxysulfuron (2800 + 60 g/ha), metamitron + halosulfuron-methyl (2800 + 75 g/ha), and ethoxysulfuron + halosulfuron-methyl (60 + 75 g/ha). The treatments including two herbicides consisted in sequential applications. The first herbicide in all treatments was applied when castor plant had six true leaves. When the treatment included a second herbicide, the spraying was made two weeks after the first one. Spreader-sticker adjuvant was added at 0.3% (v/v) to the spray solutions of metamitron, and mineral oil was added at 0.05% (v/v) to the chlorimuron-ethyl and at 0.5% to the halosulfuron-methyl solutions. The herbicides were applied with a CO_2 pressurized backpack sprayer, equipped with a bar with spray nozzles of flat fan of expanded use (XR 11002VS), spaced 0.5 m, at a pressure of 160 kPa, and spray solution consumption of 200 L/ha. During the experimental period, the plots of all treatments were kept free of infestation by hoe weeding. Data was taken on visual phytointoxication at 7, 14, 21, and 35 days after the second application (DAA); height and stem diameter of the plants at 35 DAA; number of racemes, number of seeds per raceme, seed weight, and seed yield (117 DAE). The plants showed only very mild symptoms due herbicide applications in all evaluations. The herbicides did not cause significant effect on height, stem diameter, yield components, and seed yield. The conclusion was that chlorimuron-ethyl, metamitron, ethoxysulfuron, and halosulfuron-methyl, in single or sequential post-emergence applications in the doses tested in this study, were selective to castor plants in the stage of six true leaves.

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SPRAY DEPOSITS WITH DIFFERENT APPLICATION RATES AND NOZZLES ON CASTOR (*RICINUS COMMUNIS*) CAPSULES FOCUSING ON THE MANAGMENT OF GRAY MOLD (*AMPHOBOTRYS RICINI*)

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Gray mold (*Amphobotrys ricini*) is one of the most serious castor diseases worldwide. This disease affects mainly the reproductive structures of the plant. Under favorable climate conditions the disease can cause total yield loss, mainly because there are no resistant genotypes, and the management with fungicides is not well established. Under controlled conditions, some fungicides were proven effective to prevent the disease development; however, when these fungicides were applied under field conditions the results were not satisfactory. One hypothesis for these inconsistent results is that, to be effective, the fungicide needs to reach and evenly cover the reproductive structures of the plant. In this context, studies to evaluate the spray technology, especially regarding the application rates (spraying volumes) and nozzles types are essential to provide an effective disease management. The aim of this study was to evaluate different application rates and nozzles on the spray deposition on castor capsules. The experiment was carried out in Embrapa Meio Ambiente's experimental farm in Jaguariúna, SP, Brazil. The treatments consisted of combinations of nozzle types and application rates: MGA9001 at 125 L/ha, MGA9002 at 250 L/ha, MGA9004 at 500 L/ha, BD11001 at 125 L/ha, BD11002 at 250 L/ha, BD11004 at 500 L/ha, and BD11001 with electrostatic system coupled at 147 L/ha. The models MGA (hollow cone) and BD (flat fan low drift) nozzles produce very fine/fine and fine/medium size droplets spectra, respectively. The spray solution was composed by carbendazin (250 g a.i. /ha) and rhodamine B as a tracer (0.1 g/L) to determine the deposits volumes on the castor capsules. Applications were done with a CO_2 pressurized backpack sprayer, equipped with a boom with nozzles spaced 0.5 m. The application rate of 500 L/ha resulted in the highest absolute deposit value for both nozzle types. Intermediate deposit average was obtained with flat fan nozzle at 250 L/ha. Considering the deposit volumes adjusted to application rate of 100 L/ha, the highest deposits resulted from electrostatic spraying at 147 L/ha and flat fan nozzle at 250 or 500 L/ha. The lowest adjusted values were obtained with hollow cone at 125 or 250 L/ha. The conclusion was that the highest absolute deposits were acquired with the application rate of 500 L/ha, regardless nozzle type. The application was more efficient with the electrostatic technology at 147 L/ha and with the conventional spraying with flat fan nozzle at 250 L/ha.

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ABSTRACTS

MEDICINAL & NUTRACEUTICAL PLANTS DIVISION

ORAL PRESENTATIONES

CHAIR

DIANA JASSO DE RODRIGUEZ, UNIVERSIDAD AUTONOMA AGRARIA ANTONIO NARRO, SALTILLO, MEXICO

EFFICACY OF FUMIGANTS AND BIOFUMIGANTS FOR THE CONTROL OF GINSENG REPLANT DISEASE

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North American ginseng (*Panax quinquefolius* L.), is a medicinal herb native to the deciduous forests of temperate regions of eastern North America. Ontario, Canada is the largest producer of ginseng in the world, outside of Asia with exports of $250,000,000 CDN of dried root annually. Ginseng suffers from a replant disease that prevents production of the crop on the same land twice, even if the second crop is planted decades after the first crop. Due to this disease, suitable sandy soils for ginseng production are becoming scarce in the primary production region. Research was conducted from 2013 to 2016, in order to identify the causes of the disease and to test the efficacy of different fumigants, a standard grower practice, and biofumigants on controlling the disease. Treatments included tarped chloropicrin (Pic Plus), tarped and untarped metam-sodium (Busan 1236), untarped modified mustard meal (Mustgrow), an untarped capsaicin and mustard product (Dazitol) and both a tarped and untarped control. Treatments were applied in summer 2013, followed by seeding one month later. The crop was monitored by stand counts monthly, following germination in spring 2014 for three growing seasons. Harvest occurred in September 2016. Stand counts rapidly declined in the untarped control, Mustgrow and Dazitol treatments, with virtually no plants remaining in these plots by harvest. The fumigated and tarped control treatments resulted in the lowest disease severity, but marketable yield was lower than what would be economical for a grower. The tarped control provided comparable control of the disease to the untarped fumigated treatments, with the tarped fumigant treatments resulting in the lowest disease severity. This suggests that a solarization effect may have occurred in the tarped treatments. The soil-borne fungus *Ilyonectria mors-panacis* (A.A. Hildebr.) A. Cabral & Crous was isolated from all diseased roots and confirmed as the cause of the disease. However, observations suggest that other unknown factors are involved in disease development. Further research will focus on solarization as a potential alternative management strategy and improvements to fumigation methodology.

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TAILORING THE PHOTOCATALYTIC ACTIVITY OF ZINC OXIDE NANOPARTICLES IN CALLUS CULTURES OF *AJUGA BRACTEOSA*

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STRATEGIES FOR THE ELICITATION OF IMPORTANT ANTICANCER SECONDARY METABOLITES IN CELL CULTURES OF *FAGONIA INDICA*.

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MINT (*MENTHA* SP.) CULTIVARS FOR COMMERCIAL PRODUCTION IN WESTERN NEBRASKA

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ANTIFUNGAL ACTIVITY OF *JUGLANS* SPP. AND *CARYA*SP. AGAINST *FUSARIUM OXYSPORUM*, ON TOMATO PLANTS UNDER GREENHOUSE CONDITIONS

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In Mexico, tomato (*Solanum lycopersicum* L.) is one of the main vegetables cropped, due to its high production levels. Nevertheless, this crop is susceptible to fungi attack, mainly by *Fusarium oxysporum*, which decrease all most 60% its production. The biocontrol of pathogens with plant extracts has been studied, as they do not pollute the environment nor cause resistance in the fungi. In the country, grows a variety of interesting species, among them the Juglandaceae family, such as *Juglans mollis*, *J. microcarpa*, and *Carya ovata*. However, to date, scientific information about its antifungal activity against *F. oxysporum* was not found. Therefore, the aim of this study was: to evaluate the antifungal activity of ethanol extracts of leaves and branches of *J. mollis*, *J. microcarpa*, and *C. ovata* against *F. oxysporum*, in tomato Saladette, cv. Río Grande, under greenhouse conditions. The plant material was collected randomly in wild sites located in Coahuila and Nuevo León States. Plant extracts were obtained using Soxhlet extraction, and stock solutions of each extract were prepared. Total phenolic content (TPC) and antioxidant activity were determined. Seedlings of tomato Saladette, cv. Río Grande were inoculated with *F. oxysporum* and then transplanted. The extracts solutions were foliar applied on the plants. The variables incidence, severity, plant growth, fruit yield and quality, and root weight were evaluated. The three extracts showed antifungal activity against *F. oxysporum*, highlighting *J. mollis,* and *J. microcarpa* leaves at 5000 mg/L, which decrease the incidence to 37.5%. *J. mollis*, *J. microcarpa*, and *C. ovata* extracts are a great source of phenolic compounds with antioxidant activity and represent a natural alternative to be employed in the biocontrol of *F. oxysporum*.

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ABSTRACTS

FIBERS & CELLULOSICS DIVISION

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ADVANCEMENT AND COMMERCIALIZATION OF BIOFIBER BASED COMPOSITES

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Increasing oil prices, depletion of fossil resources, and increasing greenhouse gas emissions have encouraged the development of new bio-based materials produced from renewable resources. In this respect natural fiber-reinforced polymer composites have been developed to replace synthetic composites. There are more than 1000 species of cellulose plants available in fiber form and a number of them are being investigated as composite reinforcement materials. Recent reports indicated that the future of the bio-composites market looks promising with opportunities in building and construction, automotive, industrial and consumer goods industries. According to the reports the global bio composites market is expected to reach an estimated $7.6 billion by 2023 and is forecast to grow at a compound annual growth rate (CAGR) of 7.9% from 2018 to 2023. Current products made with biocomposites are decking, railing fencing, cladding, door panels, and dashboard and it is increasing significantly in various new applications day by day. The biocomposites end-product market is expected to reach an estimated $12.2 billion by 2023. The increasing demand for Wood Plastic Composites (WPC) in the construction industry due to its wood finish like appearance and durability, and growing use of Natural Fiber Composites (NFC) in automotive interiors due to its aesthetics and growing concern for passenger safety are the major growth drivers for this market. These emerging trends, which have a direct impact on the dynamics of the bio-composites industry, include the emergence of new applications, and government support to innovate and commercialize the use of bio based composites. In addition, nanocellulosic fibers extracted from various industrial crops and wood fibers have showed different applications and market expansion due to its unique properties. This presentation will provide an advancement and commercialization of biofiber based composite materials focusing on current applications and future trends in various industrial sectors.

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THE CHANGING PARADIGM OF LIGNIN PRODUCTION AND UTILIZATION IN THE EMERGING BIOECONOMY

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Lignin is the second most abundant natural occurring material on earth. Commercially it is generated as a waste product from the paper and ethanol production. The worldwide production of lignin is approximately 100 million tons/year valued at $732.7 million in 2015. It is expected to reach $913.1 million by 2025 with compound annual growth rate (CAGR) of 2.2%. Two principal categories of lignin are ligno-sulphonate (~88%) and kraft lignins (~9%), however a new category organosolv (~2%) is now gaining popularity due to the production of second generation biofuels (bioethanol production). The organosolv lignin segment is expected to experience the highest growth over the coming years, at an estimated CAGR of over 5% from 2016 to 2025. Chemically, lignin is a polyaromatic macromolecule. The complexity and richness of its functional groups makes it attractive for converting into a variety of value-added products like high performance carbon fiber, bio-oil, vanillin, and phenolic resin to name a few. Over the years lignin has been predominantly burnt as fuel for heat and power. Less than 2% of the available lignin was sold, primarily in the formulation of dispersants, adhesives and surfactants. However, in the last decade lignin-based research and new product development has picked significant momentum due to the biorefinery concept as aging pulp and paper mills need to diversify their products portfolio to maintain their vitality. The emerging biofuel/bioenergy technologies are working to develop value-added co-products from lignin and bio-oil as a means of making the processes more cost effective. There is a resurgence in the demand for lignin for use in binders, adhesives, bioplastics and concrete admixtures. Effective “upstream” and “downstream” valorization techniques are facilitating fine tuning of lignin as a building block for high value chemicals. Other market dynamics driving lignin use are stringent regulations for dust control, demand for high quality concrete admixtures and dispersants, and carbon rich products (activated carbon, carbon filler, resins, etc.). To further accelerate development of lignin based products consumer awareness and gap between research and development and consumer products need to be reduced.

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ACOUSTIC EVALUATION OF A MYCOLOGICAL BIO-COMPOSITE

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This research examined the use of a novel renewable resource for use in acoustic absorption applications. The material that was tested is an all-natural biopolymer consisting entirely of pure fungal mycelium that is cultured at elevated-temperatures from 30 to 35°C, so that the fruiting bodies are completely suppressed. The study examined the acoustical absorption properties of this material over the frequency range from 500 Hz to 3 kHz. The results of the study indicate this new class of pure mycelium foams is a promising bio-based alternative for acoustic shielding products, especially for applications that seek to attenuate low to mid-frequency range noise, such as is common for road noise filtering in automobiles and buildings next to highways. The results also indicate that for best results, the biopolymer should be paired with a more traditional absorber, such as cork or felt, to handle the higher frequencies. In this manner both materials would contribute unique complementary absorption characteristics. It was found that both felt and cork are suitable complimentary pairing materials. The performance of the biopolymer was found to out-perform a locally obtained ceiling-tile when examined on a path-length independent basis. In summary, this new class of biopolymer holds promise for providing a sustainable alternative to traditional acoustic absorbers that are most commonly constructed with petroleum based glues and synthetic fibers.

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SUSTAINABLE DEVELOPMENT OF AGRICULTURAL STRAW AS FIBER REINFORCEMENT IN CONCRETE

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Increasing demand of construction products worldwide has raised a serious concern towards the carbon emissions of concrete. A new frontier of research towards sustainable concrete has started but the direct applicability of such concrete and its industrial production is minimal. There is a huge challenge and gap in research that can directly address the industrial problems. The focus should be to develop not only a sustainable solution but also it should not compromise in the strength and durability that normal concrete provides. Agriculture straw of rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) are discarded or openly disposed all over the world after harvesting. Rice and wheat being the staple food for majority of the world's population there is abundant production of this straw which has no significant usability. It is mostly used as roofing and packing material, livestock feed fertilizer and fuel in small quantities. These uses are however unprofitable and most farmers look for easy ways of disposal such as open-air burning. Legislation has been put in place in most countries regarding air pollution, but burning is still a common practice. This research presents the physical and chemical study of rice and wheat straw and its performance as fiber reinforcement in concrete. In this work, tensile strength of straw fiber was initially determined. The straw was then formed into fibers, which were then mixed in concrete. The concrete samples in the shape of cubes, cylinders, beams and slabs were then tested. Based on the compressive strength, tensile strength and tests on slabs, the results of the raw straw fibers and treated straw fibers was compared in detail with plain concrete and a commercially used fiber. Polypropylene fiber is widely produced and mixed in concrete. The results of straw fiber were compared with that of polypropylene fibers and it was seen that the straw fiber can provide significant ductility characteristics even in its raw form. Several modifications that can be made to the raw straw fiber will be presented and suggested so that it can perform at par with the commercial fibers. The research lays foundation of straw fiber reinforcement in concrete and presents alternative treatment methods. It is a valuable resource for the development of an industrial straw fiber reinforcement.

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SWITCHGRASS: A VALUEABLE INDUSTRIAL CROP FOR MARGINAL LANDS

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Perennial grasses considered as valuable industrial crops to be grown on marginal lands and can provide feedstock for biobased products and bioenergy. Most of the perennial grasses [switchgrass (*Panicum virgatum* L.), miscanthus (*Miscanthus x giganteus* Greef et Deu) and giant reed (*Arundo donax* L.)] produced high biomass yields (with high percentage of cellulose and hemicellulose) even when grown on marginal lands. Currently in the framework of MAGIC project perennial grasses had been selected as promising industrial crops to be grown on marginal lands facing natural constraints. Switchgrass is a perennial grass that has the advantage to be established by seeds and can be cultivated successfully from 30^0S to 45^0N. Initially, the selection and experimentation on switchgrass started in USA in the beginning of 1980s and a decade later the research on this crop continued in Canada, Europe and China. Its yields vary from 8 to 25 t/ha depending on the site and the cultivar. The research in Europe on switchgrass had been funded by several EU projects: 'Switchgrass for Energy (www.switchgrass.nl)', 'Bioenergy Chains (www.cres.gr/bioenergy_chains)', and OPTIMA (www.optimafp7.eu), while currently has been included in the EU projects MAGIC (www.magic-h2020.eu), and BeCOOL (www.becoolproject.eu). In Greece, the field trials started in 1998 and are still on-going. The aim of all these trials was to identify the appropriate cultural practices (cultivars, nitrogen and irrigation rates, plant densities, harvesting time and length of its lifetime, etc.) of switchgrass when grown on marginal land (had been left fallow for almost two decades) in central Greece. The tested factors of these two trials were: 10 cultivars in three blocks in the first and five cultivars in three nitrogen rates (0, 75 and 150 kg N/ha) in the second (1998-2017). The tested cultivars were Caddo, Alamo, Blackwell, Cathage, Cave-in-Rock, Forestburg, Kanlow, Pangburn, SL 93-2, SL 93-3, SL 94-1, SU 94-1, and Summer. During all growing periods (1998-2017) the final plant height and tiller density had been measured. Each year a final harvest took place after a killing frost in order to determine the fresh and dry matter yields and yields components. The biomass yields were maximized in the second growing period and come up to 20 t/ha (oven-dried) that almost double to the yields recorded at the establishment year. In the 3rd year, a yield reduction had been measured that varied from 5% to 20% depending on the tested cultivar. The yields reduction continued in year 4 and for more than a decade the dry matter yields varied from 12 to 14 t/ha. A further reduction had been recorded from Year 18 to Year 20 of the plantation and the mean dry yields varied from 8 to 10 t/ha at that period. During the two decades of the trials the lowland cultivars gave always higher yields but the superiority of the lowland over upland was statistically significant (P<0.05) only in the first years (till the sixth growing period). Lowland ecotypes were higher with stronger stems and thus had higher lodging resistance compared to upland ones. It should be pointed that the lodging problems had been recorded for the upland cultivars in half of the tested years at the end of summer after a strong rainfall with high winds. In the first years no significant effect of nitrogen fertilization on growth and yields were recorded. In the year 5 some differences were recorded. From Year 6 until Year 20 the dry biomass yield for switchgrass cultivars were always higher in the plots that received 150 kg N/ha as top fertilization and statistical significant differences were recorded among the three nitrogen rates (P<0.05). After 18 years, switchgrass plants started to look quite old and the tiller density had been greatly reduced.

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LONG-TERM FIELD STUDIES ON KENAF (*HIBISCUS CANNABINUS* L.) IN GREECE

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Kenaf (*Hibiscus cannabinus* L., Malvaceae) is a bast fiber crop that grows quickly and in four to five months can reach a height 3 to 5 m depending on the area of its cultivation. Its roots are in ancient Africa and although is cultivated long (3500 to 4000 BC) is considered as an old-new crop. In the beginning of the 20th century, it was introduced in China where reached its highest planting area in 1980's. Soon after its introduction in USA (in 1940s), efforts to bring kenaf from experimental crop status to an accepted alternative in established cropping systems were started and are still on progress. In Europe, the research started in 1990s as non-food multipurpose crop since its feedstock could be used for the production of high number biobased products. In Greece, the research on some preliminary kenaf field trials started in middle of 1990s and continued in the beginning of 21st century in the view of the EU research project entitled BIOKENAF (www.cres.gr/biokenaf; 2003-07). In BIOKENAF, the appropriate cultural practices (cultivar, plant populations, sowing dates, irrigation and nitrogen rates) were tested, among other research activities. It was found that high biomass yields could be achieved when the sowing took place until the beginning of May and the plant density was from 20 to 40 plants/m^2. It was also found that higher yields were recorded from the late-maturity kenaf cultivars(Everglades 41, Everglades 71, Gregg, Whitten, SF 459, Tainung 1, and Tainung 2) compared with the early ones (G4, PI 3234923, PI 318723 and PI 248901). Recently, kenaf had been exploited in the view of another European research project entitled FIBRA (www.fibrafp7.net; 2012-15) in which a mirror research group from China had been included. For a period of four subsequent years (2012-15) a total number of twelve cultivars had been cultivated in the same area, located in central Greece. The under studied cultivars had been imported from: a) Israel (DGG, RAZ, E2, GG1, Sunshine, GG3, GG4, GGMN, GGM, EF1, and CHW), b) USA (Tainung 2, G4 and Whitten) and c) China (H328 & H368). The two late Chinese cultivars (H328 & H368) gave the highest yields among the late-maturity tested cultivars which were 23.3 Mg/ha for H328 and 24.5 Mg/ha for H368. The corresponding mean dry matter yields for the two late-maturing cultivars imported from USA were 21.3 Mg/ha (Tainung 2) and 19.9 Mg/ha (Whitten). Averaged, overall years it should be pointed out that the early cultivars gave 20-25% lower dry matter yields compared to late ones. Currently, kenaf is one of the under study biomass crops BECOOL project (HORIZON 2020; www.becoolproject.eu). Field trials had been established in three Mediterranean countries (Greece, Italy and Spain) and the tested cultivar is H328 (developed by IBFC in China) since it has been proved as a high yielding one (23.3 Mg/ha$^-$ over the period 2012-15). Kenaf yields are being compared with hemp (*Cannabis sativa* L.), sunn hemp (*Crotalaria juncea* L.), and fiber sorghum [*Sorghum bicolor* (L.) Moench] in rotation systems with corn (*Zea mays* L.) and wheat (*Triticum aestivum* L.). For the field trials had been established so far in Greece it has been proved that high yields (20 Mg/ha) should be anticipated for late maturity cultivars and at high plant densities (20-40 plants per m^2). The sowing should be done as early as possible when the soil temperature is higher than 12°C. Irrigation is necessary for high biomass yields and the nitrogen fertilization should be at least 75 kg N/ha.

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SCREENING OF KENAF (*HIBISCUS CANNABINUS* L.) CULTIVARS FOR PHYTOREMEDIATION OF HEAVY METALS CONTAMINATED SOILS

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Heavy metals significantly contribute for the disruption, degradation, contamination, and pollution of the ecosystems, inducing a serious threat to the environment and public health. In particular, they might cause marginality of soils through the degradation of their quality inducing the reduction of crop yields and the quality of agricultural products, desertification, and the loss of ecosystem services. In order to remove heavy metals from soils and prevent their risks to the environment, animals, and human health, different physical, chemical, and biological approaches have been employed. Phytoremediation, the use of plants and their associated microbes for soil decontamination, is a solar driven and environmentally suitable technology that can be employed for the restoration of soils contaminated with heavy metals, without compromising the other physical, structural, and chemical characteristics of the soil. Therefore, the aim of this work was to study the effects of different heavy metals (Cd, Cu, Zn, Hg and Cr) on growth, productivity and biomass quality of different kenaf cultivars: Dowling, Everglades 41, G4, Gregg, SF 459 and Tainung 2. Plants were tested under one level of contamination. The level of contamination tested was chosen based on the remediation criteria for agricultural land use defined for contaminated sites in Ontario (Cd: 3 mg/kg, Cr (VI): 8 mg/kg, Cu: 150 mg/kg, Hg: 10 mg/kg, Zn: 600 mg/kg). The soils were artificially contaminated with salts of heavy metals, diluted in the irrigation water. Zinc was the element that more negatively affected the productivities obtained. In contrast, all kenaf cultivars showed high tolerance to Hg, Cd, Cu and Cr soil contamination. Mineral matter accumulation was also influenced by heavy metals soils contamination. Overall, kenaf was able to remove and accumulate heavy metals from contaminated soils, but the highest proportion of the heavy metals taken up by plants was present in the shoots. This fact limits the number of possible utilizations of the biomass obtained in contaminated fields. On average, Tainung 2 and Everglades 41 were the most productive cultivars in contaminated soils and G4 and Everglades 41, the ones that showed higher phytoremediation capacity.

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ABSTRACTS

GENERAL CROPS & PRODUCTS DIVISION

ORAL PRESENTATIONES

CHAIR

ANA LUISA FERNANDO, NOVA UNIVERSITY OF LISBON, LISBON, PORTUGAL

CROPSYS-CAP- A NOVEL MANAGEMENT APPROACH TO INCREASE PRODUCTIVITY, RESILIENCE, AND LONG-TERM SUSTAINABILITY OF CROPPING SYSTEMS IN THE NORTHERN GREAT PLAINS- RESEARCH UPDATE

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The use of cover crops, common in the eastern and central Corn Belt, are uncommon in corn (*Zea mays* L.)-soybean [*Glycine max* (L.) Merr.] systems in the northern Great Plains (NGP) due to the short growing season and extreme fluctuations in temperature and precipitation within and across growing seasons. Lack of winter soil cover increases soil organic matter and nutrient losses, resulting in decreased crop productivity and resiliency. This Coordinated Agricultural Program (CAP) was funded by the USDA NIFA on April 2017 to improve the productivity, resilience, and long term sustainability of cropping systems in this region. Our objectives included: i) to improve land use efficiency in corn-soybean cropping systems by temporal intensification through the inclusion of winter camelina [*Camelina sativa* (L.) Crantz.] and field pennycress (*Thlaspi arvense* L.) as cover crops and/or cash oilseed crops, ii) to determine their impact on over-all system productivity and ecosystem services and iii) to improve land use efficiency by intercropping alfalfa (*Medicago sativa* L.) with corn. The results of the first two years of this project indicate that available soil water during the three weeks following interseeding is critical for the cover crop establishment and survival. Photosynthetically active radiation under both corn and soybean leaf canopies is the main driver of interseeded cover crop growth, Winter rye (*Secale cereale* L.), radish (*Raphanus sativus* L.), and winter camelina interseeded into standing corn at V6-V8 stage had good establishment and it did not affect corn performance. Soybean interseeded at V6-V8 with winter rye did not affect soybean yield, but the addition of radish and winter camelina reduced soybean yield in the first growing season. The final results from data collected over two growing seasons from seven locations indicates that a distinct latitudinal gradient exists for optimum times to interseed winter annual cover crops into standing corn and soybean. Establishing winter annual cover crops into standing corn was more difficult than in soybean; establishment into standing soybean achieved greater success. Winter pea (*Pisum sativum* L.) provided the most soil cover compared with any other interseeded cover crops into soybean. Fall soil residual NO_3-N was significantly higher in the check treatment compared with the plots with interseeded cover crops into soybean. When cover crops were interseeded into the early maturing soybean cultivar at stage R6, the cover crops coverage was nearly half compared with the cover crops interseeded at R6 in the late maturing cultivar. Seasonal forage yield of alfalfa established in 2016 in intercropping with corn was significantly greater than the 2017 spring-seeded alfalfa. In conclusion, interseeding of winter annuals into corn and soybean and alfalfa into standing corn is possible in the NGP and Upper Midwest.

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MAXIMIZING COVER CROP PERFOMANCE BY INTERSEEDING COVER CROPS INTO STANDING SOYBEAN

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In order to reduce nutrient losses and soil erosion in the northern Great Plains following soybean [*Glycine max* (L.) Merr.], cover crops can be interseeded into standing soybean, since after soybean harvest there is not enough time for a cover crop to grow. If the cover crops cannot provide adequate growth and cover, the soil is exposed to the degradation throughout the winter months and loss of crop productivity in following years. The objective of this study was to determine the establishment and green cover of interseeded cover crops and their impact on soybean yield and quality. This experiment was conducted at two locations, Fargo and Prosper, ND, in 2016 and 2017. The experimental design was a RCBD with four replicates, in a split-plot arrangement where soybean reproductive stages R4 and R6 were the main plot and cover crops were the sub-plot. Four cover crops, winter camelina [*Camelina sativa* (L.) Crantz] cv. Joelle, Austrian winter pea [*Pisum sativum ssp.* arvense (L.) Poir], winter rye (*Secale cereale* L.) cv. Rhymin, and forage radish (*Raphanus sativus* L.) cv. Daikon, were sown into the ground at the R4 and R6 stage of soybean. Cover crop biomass yield in the fall was highest in radish and winter pea, 2 Mg/ha and 1.85 Mg/ha respectively. Winter pea provided the most soil cover. Cover crop above-ground biomass nitrogen accumulation ranged from 28.7 to 73.2 kg/ha. Results indicate interseeding cover crops have no impact on soybean yield and quality. Fall soil residual NO_3-N levels were lowest in the plots with cover crops ranging from 25 to 27.7 kg/ha and highest in check plots without cover crops at 47 kg/ha. Spring NO_3-N levels were lowest in winter rye plots at 44 kg/ha. This is due to the spring growth from winter rye surviving over winter. Interseeding cover crops at later soybean reproductive stages shows to have potential to mitigate soil nitrate losses and soil erosion in areas that grow soybean as a cash crop. Further research is needed to find which cover crops that maximize growth while growing under the soybean canopy.

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INFLUENCE OF HERBACEOUS BIOMASS CROPS ON SOIL ORGANIC CARBON CONTENTS IN ONTARIO SOILS

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Nineteen farms growing herbaceous biomass crops, switchgrass (*Panicum virgatum* L.) and miscanthus (*Miscanthus* spp.), were sampled for soil organic carbon (SOC) across Ontario, Canada in 2016. Switchgrass and miscanthus fields were sampled in addition to nearby agricultural fields and woodlots to compare SOC in herbaceous biomass systems relative to alternative land-uses. The mean SOC concentration of the woodlots was 4.26 ± 0.29 % and was significantly higher (p<0.05) than in any other types of land-use. The mean SOC concentration in agricultural fields was 2.21 ± 0.31 %, while switchgrass and miscanthus had a mean SOC concentration of 2.50 ± 0.29 % and 2.50 ± 0.36 %, respectively. The mean SOC stock in 0-30 cm was highest in woodlots at 103.55 ± 7.40 Mg C ha^{-1}. This was significantly higher than stocks quantified in agricultural and miscanthus land-uses which contained 80.51 ± 7.74 and 83.36 ± 8.97 Mg C ha^{-1}, respectively. The mean SOC stock calculated for switchgrass was 85.30 ± 7.14 Mg C ha^{-1} and was not significantly higher (p<0.05) than the SOC stocks quantified for the woodlot. The study recorded numerically higher SOC concentrations and stocks in biomass fields compared to agricultural reference fields. Therefore, it could be interpreted that biomass fields may have the potential to contribute to higher SOC sequestration in grower fields. However, challenges associated with this study such as accurate bulk density measures and lack of baseline data need to be resolved in order to improve quantification of SOC sequestration.

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INFLUENCE OF BIOMASS CROP SPECIES AND AGE ON SOIL ORGANIC CARBON SEQUESTRATION, AND PLANT GROWTH PROMOTING RHIZOBACTERIA ENHANCEMENT OF BIOMASS CROP YIELDS IN ONTARIO

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Ontario is committed to reducing greenhouse gas emissions to 37% below the 1990 levels by 2030 and 80% by 2050. Biomass crops have previously shown the ability to sequester significant amounts of atmospheric carbon dioxide into the soil, this is a possible way to reducing greenhouse gas emissions. However, it is uncertain how biomass crops can sequester carbon in different eco-climates and soil types of Ontario. This research will evaluate the use of plant growth promoting rhizobacteria to increase biomass crop yields, as well as an assessment of carbon sequestration rates under biomass crops. Currently in Ontario, there are approximately 1400 ha of land devoted to purpose grown biomass crops. The biomass crops commonly grown are switchgrass (*Panicum virgatum* L.) and miscanthus (*Miscanthus* × *giganteus* Greef et Deu), chosen for their proven ability to grow on marginal land under current climate conditions. Biomass crops can successfully store carbon in the soil but the use of fertilizer may outweigh these benefits due to increased nitrous oxide emissions. Two studies were completed to assess carbon sequestration and the use of plant growth promoting rhizobacteria to reduce nitrous oxide emissions. In the experiment investigating carbon sequestration, soil samples were taken from 5 on-farm locations in Ontario over two sampling years, 2016 and 2017. Although sampling in back to back years did not show statistically significant differences there are trends suggesting that if more time is given between sampling periods there could be significant differences. In the experiment investigating plant growth promoting rhizobacteria, will look at the potential for yield increases in biomass crops by known plant growth promoting rhizobacteria. Switchgrass crops that were inoculated with *Variovorax paradoxus* JM63 will be compared with yields derived under inorganic fertilizer application rates. Other treatments included are Monsanto JumpStart and a zero control. Zero control is used to validate the plant response is from the applied treatment. Preliminary results show that *Variovorax paradoxus* JM63 yields 1.85 Mg ha^{-1}, this is a 104% increase compared to the zero- control. These two experiments will encourage producers to allocate less productive cropland to value-added crops such as switchgrass and/or miscanthus, as these crops can be used to produce biofuels, animal bedding, animal feed, and other non-food bioproducts as well as sequester carbon from the atmosphere. Additionally, results from this study could enhance the scaling up of biomass crop acreage in Ontario, given the indicated benefits listed above.

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WHICH INDUSTRIAL CROPS COULD BE CULTIVATED ON MARGINAL LANDS?

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Industrial crops can provide abundant renewable biomass feedstocks for the production of high added-value bio-based commodities and bioenergy. They can be broadly categorized as oil, lignocellulosic, carbohydrate or specialty crops. Most of them are multipurpose crops offering the opportunity to follow a cascade bio refinery concept to produce a number of value added bio products and bioenergy, thus feeding the bio based economy. Prospectively, industrial crops can increase and diversify farmers' income through access to novel bio-based markets, and the possibility to exploit marginal land with limited value for conventional agriculture. In recent years, a debate has emerged regarding food security and land use for bioenergy/industrial non-food crops. Cultivating industrial crops on marginal land unsuitable for food production is consistently proposed as a viable alternative to minimize land-use competition for food production, and its adverse effects (direct or indirect) on food security, land based GHG emissions and biodiversity loss. The term 'marginal land' has entered the wider political debates, and today biofuel crops are generally promoted and supported on marginal land; nonetheless, marginal land has been not yet unequivocally defined, and there is not a clear information on where, when and how much genuine marginal land is available. In the framework of MAGIC project (HORIZON 2020; www.magic-h2020.eu) a number of selected industrial crops will be grown on marginal land facing natural constrains, while contaminated and degraded land will be also included. MAGIC aims to promote the sustainable development of resource-efficient and economically profitable industrial crops grown on marginal land. During the first year of the project a total number of 20 industrial crops had been selected to be grown on marginal lands in several sites in Europe. The selected industrial crops include: a) oilseeds and specialty crops; camelina [*Camelina sativa* (L.) Crantz], crambe (*Crambe abyssinica* L.), castor bean (*Ricinus communis* L.), Ethiopian mustard (*Brassica carinata* L.), safflower (*Carthamus tinctorius* L.), lupin (*Lupinus* spp.), hemp (*Cannabis sativa* L.), and cardoon (*Cynara cardunculus* L.), b) lignocellulosic crops: perennial herbaceous crops, switchgrass (*Panicum virgatum* L.), miscanthus (*Miscanthus x giganteus* Greef et Deu), giant reed (*Arundo donax* L.), reed canary grass (*Phalaris arundinaceae* L.), cardoon, tall wheatgrass [*Thynopirum ponticum* (Podp.) Z.W. Liu & R.R.-C. Wang], wild sugarcane (*Saccharum* spp.), c) fiber crops and woody species, industrial hemp, fiber sorghum [*Sorghum bicolo*r (L.) Moench], willow (*Salix* spp.), poplar (*Populus* spp.), Siberian elm (*Ulmus pumila* L.), black locust (*Robinia pseudoacacia* L.) and d) carbohydrate crops, sweet sorghum [*Sorghum bicolor* (L.) Moench], and lupin (*Lupinus albus* L.). Three types of field trials will be carried out: a) continuation of already established long-term field trials on perennial herbaceous and woody species, b) new field trials under different types of marginal lands either on small plots or on strip trials, and c) trials on pots testing marginality factors such as heavy metals and salinity. In the trials that will be established in the framework of MAGIC, the appropriate agronomic practices with limited input requirements will be investigated. In addition, new cultivars/hybrids developed in the project will be tested. A database on industrial crops will soon be available in the project website, where it could be found not only information for the selected industrial crops mentioned above but for a total number of 60 industrial crops with factsheets per crop. During the project guidelines for farmers for the successful cultivation of the selected industrial crops will be prepared and will be distributed and discussed in dedicated project's events.

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CAN INDUSTRIAL CROPS BE PRODUCED IN HEAVY METAL CONTAMINATED SOILS?

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The production of industrial crops has been presented as a promising alternative to partially replace fossil fuels and products of fossil origin. Among the various species which can be grown to generate energy, perennial crops are promising because of their high productivity and energy content. Oil crops, as sources for medium-chain fatty acids and medium-chain polymer building blocks, can be used for the production of plastics, surfactants, detergents, lubricants, plasticizers and other products, replacing fossil feedstock's. Yet, the increasing demand for biomass for the production of bioenergy and/or biomaterials and bioproducts is generating land-use conflicts which might be avoided through the establishment of dedicated industrial crops on marginal land, e.g. heavy-metal contaminated land. In this context, perennial and oil crop production under heavy metals contaminated soils was reviewed, with the aim to identify the concentration thresholds for the production of those crops with minor toxic effects. Pilot and field studies were reviewed towards different parameters namely: contaminant and its concentration in the soil; contaminant concentration bioavailable to the plant; effects of contamination on biomass production and characteristics; bioaccumulation of the contaminant in the several fractions of the biomass (aerial part, roots, seeds); bioconcentration factor (aerial part, roots, seeds); translocation factor; among others. A preliminary evaluation of the data indicates that both perennial grasses and oil crops are species potentially useful for phytoremediation of heavy metal contaminated soils. Most of the plants exhibited considerable tolerance to most of the metals and biomass was hardly affected by the potentially toxic concentrations of metals. Concentrations that affected most significantly the productivity of the plants are those that surpass four times the concentration limits accepted in soils (according to EU regulations) and when the fraction bioavailable to plants is high (exceeding 50% of the total). Most of the metals are preferentially accumulated in the belowground system or in the leaves. Cadmium and zinc are the most mobilized elements, presenting higher translocation to the above ground fraction. Biomass obtained in contaminated soils presented higher ash content which can be a constraint for its processing and use. Below the concentration thresholds for the production of those crops with minor toxic effects, those crops show potential to simultaneously deliver high yields, restore soil properties and promote ground water protection by preventing heavy metals leaching. Their production in contaminated soils could provide environmental benefits and social and economic opportunities.

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PHYTOREMEDIATION OF CADMIUM CONTAMINATED AGRICULTURAL LAND AND BIOMASS PRODUCTION FOR INDUSTRIAL USES

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Plants absorb a number of elements from soil, some of which are known to be toxic even at low concentrations. Cadmium is considered among the most toxic metals and its presence in increased concentrations in the agricultural soils is a major environmental and health concern due to potential risk of food chain contamination. Chronic exposure to Cd has been reported to be associated with kidney and cardiovascular diseases, osteoporosis, diabetes, and cancer. The major food groups that contribute to the most Cd exposure are grains, rice, potatoes, and vegetables, and they are considered to account for more than 50% of total cadmium intake by people in most countries. The development of economically viable alternative crop choices for farmers is of great importance. The worldwide increasing need for feedstock to supply the bio-based industries makes the successful penetration of non-food crops in agriculture necessary. The cultivation of high biomass yielding non-food industrial crops in Cd contaminated agricultural lands seems an interesting alternative, offer an important tool to tackle the problem of decontamination / exploitation of polluted agricultural soils, while, if economically feasible, it might ensure an income for farmers. Moreover, the produced renewable biomass can be used for the manufacture of high added-value biobased commodities (*e.g.* bio-plastics, bio-lubricants, bio-composites, etc.) and bioenergy. Promising non-food plant species suitable for phytoremediation are those possessing a series of characteristics, namely: (i) tolerance to accumulated Cd concentration, (ii) ability to uptake Cd and/or stabilize it in soil fractions in relatively high levels, (iii) fast growth and high biomass, (iv) widespread highly branched root system, (v) easy harvest ability, and (vi) non consumable by humans and animals. Examples of crops and their Cd concentrations in aerial plant parts reported in the literature are: miscanthus (*Miscanthus* spp.) 2.3–5.3 mg/kg, cardoon (*Cynara cardunculus* L.) 13.6-169.3 mg/kg, castor (*Ricinus communis* L.) 1.22-235.82 mg/kg, flax (*Linum usitatissimum* L.) 0.13-7.27 mg/kg and hemp (*Cannabis sativa* L.) 0.15-1.22 mg/kg, and giant reed (*Arundo donax* L.) 1.6-8.9 mg kg^{-1}. In conclusion, the production of bio-based raw material for industrial uses exploiting land that should not be given for food production will mitigate the exposure route for the intake of cadmium by humans, while at the same time will feed the circular economy. Furthermore, new job opportunities will be created and the local economies will be boosted.

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POTENTIAL YIELD OF DEDICATED ENERGY CROPS ACROSS THE USA: RESULTS AND OUTCOMES OF THE MULTI-YEAR SUN GRANT REGIONAL FEEDSTOCK PARTNERSHIP

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The Sun Grant Regional Feedstock Partnership commenced in 2007 with the goal of supporting the realization of the biomass potential envisioned in DOE's 2005 Billion Ton Report. Concluding in 2016, the partnership sought to increase the knowledge of bioenergy through coordinated feedstock research across the lower 48 states and Hawaii with partners in academia, government, and private industry. The core of the research includes over 130 field trials and regional resource assessment activities focused on agricultural residues [maize (*Zea mays* L.), and small grains], a suite of likely dedicated energy crops [switchgrass (*Panicum virgatum* L)., energy cane (*Saccharum spontaneum* L.), giant miscanthus (*Miscanthus* x *giganteus* Greef et Deu), energy sorghum – [*Sorghum bicolor* (L.) Moench], and mixed grasses, and woody crops (poplar (*Populus* spp.) - and willow (*Salix* spp.)]. In 2013, a series of meetings was held across the US with each of the crop teams and the resource assessment team, led by the Oregon State University and Oak Ridge National Laboratory, to review, standardize, and verify yield trial data and assimilate their outcomes into a national model of biomass yield suitability. The meetings provided a way to "ground truth" yield estimates in order to accurately capture interactions of climate and soils for dedicated energy crops, including switchgrass, energy cane, biomass sorghum, CRP mixtures, *Miscanthus* x *giganteus*, hybrid poplar, and willow. From these sets of funded trials and historical data, yield was estimated across spatial gradients according to soil characteristics and climate history. The resulting spatial grids provide critical information for policymakers and planners of the potential productivity of these pre-commercial crops. National yield estimates, as well as overall yield across the continental USA, demonstrated potential for these diverse feedstock resources. Production and management data, as well as biomass composition characteristics, provide empirical support of logistic design and feedstock supply systems. These data and maps are vital for policy makers, producers, end-users, and others in the bioeconomy.

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ENERGY EFFICIENCY OF BIOMASS PRODUCTION: SHORT ROTATION COPPICES VERSUS GRASSES AND OTHER HERBACEOUS CROPS

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Energy from renewable sources accounts for over 25% of the production of primary energy in the EU–28. The proportion of RES in energy production can be increased further, but all of its potential sources must be taken into account: sun, water, wind, geothermal energy and biomass. Solid biomass is still the dominant renewable energy source in the EU, and it plays a particularly important role in Poland. It accounted for 44.3% and 72.2%, respectively, in the structure of primary energy from renewable sources. Biomass is significant feedstock in production of solid, liquid and gaseous biofuels and in the generation of heat, cool, electricity and bioproducts. Solid biomass is mainly obtained from forests, wood processing, roadside and urban green care. Considerable amounts of solid biomass are obtained from agricultural residues and plantations of perennial industrial crops. Perennial crops include three groups: short rotation coppices (SRC) (woody biomass); herbaceous crops (semi-woody biomass); and grasses (straw). The diversity of perennial industrial crops requires proper selection of genotypes with high energy efficiency ratio of biomass production. Therefore, the objective of the study was to determine the yield energy value, energy input and the energy efficiency of biomass production of 26 genotypes of perennial crops (15 SRC; 6 herbaceous; 5 grasses) harvested in three successive annual harvest cycles. Yield energy value varied widely depending on the genotype and year of cultivation. The highest yield energy value was obtained from three new willow cultivars (*Salix viminalis* L.). On the other hand, the highest yield energy value among herbaceous plants was obtained from *Helianthus salicifolius* A. Dietr, and among grasses from *Miscanthus sacchariflorus* (Maxim.) Franch. The best energy efficiency ratio of solid biomass production in one year harvest rotation was obtained for new willow *Salix viminalis* cultivars.

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LIFE CYCLE ASSESSMENT OF VIRGINIA MALLOW (*SIDA HERMAPHRODITA* RUSBY L.) PRODUCTION WITH DIFFERENT FERTILIZATION OPTIONS

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Lignocellulosic crops can be a significant feedstock for the chemical and energy industry. Their biomass can be converted into bioproducts with various methods, e.g. thermochemical, chemical or biochemical. They can be grown on poor or marginal soils, but fertilization should be applied to achieve a good yield. The aim of the study was to determine the environmental impact of the cultivation of Virginia mallow (*Sida hermaphrodita* Rusby L.) fertilized with digestate: wet (WD), dried (DD) and torrefied (TD), obtained from a biogas plant, and fertilized with mineral fertilizers (MF) and non-fertilized (C). All the fertilizers were applied at a rate equivalent to 85 and 170 kg ha^{-1} N. The system boundaries covered the production and use of digestate and mineral fertilizers, field works, growing Virginia mallow, biomass harvest and transport from the field to the farm. The life cycle impact assessment of cultivation was done using the ReCiPe Midpoint method. The lowest greenhouse gases emission (GHG) was observed for utilization of dried and torrefied digestate. The most adverse effect on human toxicity was observed when the TD was applied at both fertilization rates. High particulate matter formation for all the growing options than for non-fertilized option resulted from production of fertilizers and use of machines. The lowest impact on terrestrial acidification was observed in the MF 85 option and the highest was in TD 170, which resulted mainly from high field emission. The use of mineral fertilizers and digestates resulted in an increased of freshwater eutrophication (30-56-fold). Torrefaction of digestate had the largest impact on terrestrial ecotoxicity. The greatest impact on fossil depletion was found for MF 170. The production of Virginia mallow intended for bioproducts can fulfil the condition of low GHG emission. The application of fertilization affected the environment more in the other impact categories than the non-fertilized option. The application of WD 85, WD 170 and DD 85 could be recommended for Virginia mallow instead of mineral fertilizers, whereas DD 170 and TD at both rates had the most adverse environmental effects.

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AN OLD CROP INDUSTRIAL HEMP BECOMES A NEW CROP AGAIN IN THE USA

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After a 70-plus year absence in production, industrial hemp (*Cannabis sativa* L.) has been grown in university trials and state pilot programs across the United States since 2015. This begins the process of defining basic production guidelines that will aid in crop commercialization in regions across the USA. The objectives of these studies were to screen cultivars from various sources for crop performance and adaptation in North Dakota. Experiments (RCBD) have been conducted at the Langdon Research Extension center since 2015. Treatment factors are associated with cultivar, seeding date, and seed treatment. Traits evaluated include emergence, stand establishment, growth staging, plant height, flowering, and grain and fiber yield. Emergence results indicate industrial hemp seedling mortality ranging from 25 to 90% depending on field conditions. This is considerably higher than for wheat (*Triticum aestivum* L.), corn (*Zea mays* L.), and soybean (*Glycine max* (L.) Merr.) where seedling mortality commonly ranges from 10 to 15%. Industrial hemp grain yield is influenced by genotype and stand density. Grain yield ranged from 1190 to 1525 kg/ha for four Canadian industrial hemp cultivars, in 2015, where stand densities ranged from 32 to 67 plants/m^2. In 2017 these same cultivars yielded from 2120 to 2300 kg/ha with stand densities from 102 to 138 plants/m^2. Fungicide seed treatments reduced seedling mortality 37% compared to the untreated control. Although stand densities were lower, 126 plants/m^2, for the control treatment compared to the fungicide seed treatment, 143 plants/m^2, grain yield was not affected indicating yield component compensation for seeds per plant. Grain yield was reduced 18% for the 12 June planting date compared to earlier planting dates 20 May and 1 June which produced similar yields of 2012 and 2170 kg/ha, respectively. Performance of industrial hemp in North Dakota is comparable to bordering Canadian provinces where production has been ongoing since 1998. Industrial hemp production, in North Dakota, increased from 5 to 35 growers and 28 to 1336 ha from 2016 to 2017, respectively, primarily due to a high grain value of $2.20/kg in 2016. Production decreased in 2018 to 27 growers and 1154 ha when grain value decreased to $0.90/kg. Declining grain value is associated with regulations that prevent and/or complicate accessing out of state markets. Such is the plight of a new crop where success is faced with defining agronomics and creating markets.

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SUPERCRITICAL CARBON DIOXIDE EXPLOSION AS A PRE-TREATMENT OF LIGNOCELLULOSIC BIOMASS TO IMPROVE BIOGAS YIELD

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The unstable price and high environmental impact of fossil fuels has stimulated the research of alternative renewable energy sources. Second generation bioenergy, produced from lignocellulosic biomass (LCB), does not compete with food or feed and is an approach to make use of underutilized and low value materials. However, the recalcitrance of LCB to degradation is an obstacle to the feasibility of many bioprocesses. When LCB is used as a substrate for anaerobic digestion, conversion to biogas is often both low-yielding and slow. As such, there is great interest in pretreatments for LCB to will improve conversion rates and yield. Supercritical carbon dioxide ($SCCO_2$) is an environmentally friendly pretreatment for LCB that has both physical (explosive depressurization breaking LCB structure) and chemical (acidic attack of LCB by carbonic acid) modes of action. Supercritical carbon dioxide is an attractive pretreatment because it is non-toxic, readily available, and can reach supercritical state under mild conditions (31°C; 7,400 kPa). While $SCCO_2$ has been used extensively in the food industry, little is known about its efficacy as a pretreatment for LCB. In this study, a three factor Box-Behnken design using process temperature (50, 115, and 180 °C), CO_2 mass (0, 75, and 150 g), and LCB moisture content (11, 35.5, and 60 %) as parameters was used to optimize biogas yield from corn (*Zea mays* L.) stover. Pretreated stover biomass was used as substrate in a biochemical methane potential assay. For comparison, pretreated stover was also enzymatically hydrolyzed to evaluate the impact of $SSCO_2$ on sugar yield from LCB.

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BIOCHAR PRODUCED FROM ANAEROBICALLY-DIGESTED SUGAR BEET (*BETA VULGARIS* L.) SLUDGE AS A SLOW-RELEASE ORGANIC FERTILIZER

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During the processing of sugar beets (*Beta vulgaris* L.) at Minn-Dak Farmers Cooperative to produce sugar, several waste streams are generated which are anaerobically-digested to produce a sludge. The sludge is applied directly to agricultural fields as pond bottom solids. However, there is a significant expense involved with land application and there are increasing environmental concerns that may restrict land application even more in the future. Our research group at NCAUR has been studying the production of biochars from a variety of feedstocks for use in horticultural applications to retain water and nutrients in soils and in nursery substrates while simultaneously sequestering carbon. Sludge as obtained from Minn-Dak was dried at 90 °C for 72 h to produce a tan-colored solid. The dried sludge was thermally treated in an oxygen-free (nitrogen atmosphere) retort oven at 500 °C to produce a biochar. The objectives of this research were to determine the chemical and physical properties of the biochar and its use as a slow-release organic fertilizer for use in greenhouse/nursery potting substrates. Surface area analysis found a value of 8 m^2/g, which was significantly lower than biochars that we had previously produced at this temperature from other feedstocks such as various woody plants and biosolids. However, this value is higher than several commercial biochars we have tested. Nutrient analysis found 1.17% total nitrogen, 5.18% P_2O_5, and 1.66 K_2O in the biochar. Calcium levels in the biochar were extremely high (29.4%), due to the use of $CaCO_3$ during processing to precipitate non-sugar contaminants. Iron levels were also high (9550 ppm) with adequate levels of other essential plant micronutrients. Tomato seedlings grown in a substrate containing 5% (v/v) biochar had dry weights similar to a chemical fertilizer control after three weeks. These results indicate that biochar produced from sugar beet sludge would have excellent potential as an organic fertilizer for container crops.

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UTILIZATION OF EGGSHELL AS A CO_2 SORBENT IN THE CALCIUM LOOPING GASIFICATION OF BIOMASS

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Carbon dioxide capture in the gasification of biomass enhances the production of hydrogen-enriched synthesis gas, and promotes carbon negativity. Therefore, the potential of chicken (*Gallus gallus domesticus*) eggshell as a sorbent for carbon capture in the calcium looping gasification of biomass is investigated in the present work. This is aimed at adding value to a perceived waste resource (eggshell). Calcination and carbonation reactions were studied with a quartz wool matrix reactor, and a thermogravimetric analyzer coupled with a Fourier transform infrared spectroscopy. To understand the morphology and characteristics of the resulting calcium oxide sorbent, characterizations with a scanning electron microscope, nitrogen sorption analyzer, colorimeter and energy dispersive X-ray were performed. Calcination of the sorbent was separately performed in an atmosphere of nitrogen and CO_2. Results showed that calcination in a CO_2 environment is less effective due to the increased CO_2 partial pressure unlike the case of nitrogen environment. Furthermore, an enhancement in the sample decomposition, and improvements in the calcium content and specific surface area of the sorbent were observed with an increase in the calcination temperature. In addition, carbonation conversion was improved with a reduction in sample particle size. Multicyclic performance of the sorbent was also investigated. An encouraging value was observed after the first cycle, with a carbonation conversion of 76.41%, which is close to the theoretical value (78.5%). However, the conversion reduced with increasing calcination-carbonation cycle. The sorbent exhibited a low conversion of 18% after the seventh cycle and this corresponds to a decay extent of 76.65%, indicating a need for sorbent modification to enhance its performance in the calcium looping gasification of biomass.

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INDUSTRIAL HEMP SEED INVESTIGATIONS

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Investigations of industrial hemp (*Cannabis sativa* L) as a fiber and grain crop in New York State began in 2017 by a team of faculty and extension staff at Cornell University. Due to regulatory restrictions in the US, there are no labelled conventional or organic pesticides, including seed treatments. Seed quality issues and poor field stand establishment are commonly encountered in commercial seed lots. Research was initiated in the Taylor lab to examine factors limiting hemp seed quality and stand establishment. Characterization of seed-borne fungi on hemp seeds and seed treatment efficacy were performed in cooperation with the Bergstrom lab. Hemp is botanically an achene with a hard pericarp that surrounds the true seed with seed coat, embryo and endosperm. The seed is medium sized with the thousand seed weight of approximately 16 grams. The seed/grain is rich in nutrients and contains approximately 26 and 35 percent protein and oil content, respectively. For seed storage, it is recommended that the seed moisture be maintained at 50% relative humidity or less, which corresponds to <8 percent seed moisture content (fresh wt. basis). Seventeen seed lots were obtained from multiple international sources including Canada, eastern and western Europe in 2017. The percent germination of the 17 lots ranged from 14 to 91%. The percent pure seed was >98% for 16 lots. In 2018, 23 lots were tested and the percent germination ranged from 29 to 94%, and purity from 39 to +99%. A series of lab studies were performed to investigate abiotic and biotic stress on hemp seed germination. For abiotic studies, one seed lot of 'Anka' was sown in plastic containers filled with a builder's sand in which the seeds were sown at 1 cm sowing depth. The effect of soil temperature was examined at 10/15˚C, 15/25˚C and 20/30 ˚C with a 14-hour photoperiod in germinators. The alternating temperatures were selected to simulate early, mid and late season plantings. The lowest temperature delayed seedling emergence compared to other temperatures, while 15/25˚C was optimal. The effect of soil moisture was examined at 15/25˚C and the percent soil moisture ranged from 2 to 26% (dry weight basis). Germination was recorded across the range of soil moisture levels. Seedling growth was reduced at lowest soil moisture levels. At high soil moisture levels approaching field capacity, root growth was reduced and thickened compared to the 20% soil moisture check. Simulated soil compaction/crusting dramatically impaired seedling emergence and early seedling growth. Seed pathology investigations were conducted on 'Anka' and 'Piccolo' seed produced in 2017, characterized by a wet growing season. Both lots were infested with *Phoma*, *Fusarium*, and *Penicillium* species, among other microbes. Treating seeds contaminated with seed-borne fungi with a combination of thiram and metalaxyl reduced but did not eliminate the pathogens. The average percent germination for the two non-treated lots was 67% and increased to 80% after treatment with fungicides. In summary, several factors impact hemp seed quality and good stand establishment in the field. A systematic approach has revealed many seed and environmental conditions that set the upper limit of field stand establishment potential.

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ABSTRACTS

NATURAL RUBBER & RESINS DIVISION

ORAL PRESENTATIONES

CHAIR

HUSSEIN ABDEL-HALEEM, USDA-ARS, MARICOPA, AZ

ALTERNATE RUBBER RESEARCH, DEVELOPMENT AND COMMERCIALIZATION – WHERE ARE WE NOW?

Katrina Cornish

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As demand for natural rubber continues to increase, in the face of a global deforestation moratorium, the hand-tapped tropical rubber tree (*Hevea brasiliensis* Müll.Arg.) is unable to keep up, even without the constant risk of crop failure and labor shortages seriously impacting production. Additional rubber sources, produced using mechanized agriculture, are needed, and two species, guayule (*Parthenium argentatum* A. Gray) and rubber dandelion (*Taraxacum kok-saghyz* L.E. Rodin) are under development in several different countries. In this overview, an update of global scientific progress, breakthroughs and commercialization efforts will be presented and discussed.

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FIELD EVALUATION OF GUAYULE (*PARTHENIUM ARGENTATUM* A. GRAY) PLANTS VARYING IN ALLENE OXIDE SYNTHASE GENE EXPRESSION

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Development of guayule (*Parthenium argentatum* A. Gray) as a 21st century industrial commodity is driven by the need for low water use crops and by market demand for biobased products, including the natural rubber, resin, and bioenergy feedstock produced by the plant. The primary goal of guayule crop improvement continues to be higher natural rubber yield. Biotechnological improvement, though pathway metabolic engineering or carbon flux diversion, has shown the potential to impact rubber content in guayule, especially in controlled environments. We previously reported remarkable changes in plant architecture, photosynthetic rate, and rubber content for guayule plants following downregulation of an allene oxide synthase gene (*AOS*). Guayule rubber particles contain unusually high levels of AOS protein, although its role in rubber biosynthesis is unclear. The objective of this study was to characterize the phenotypes of field-grown guayule plants varying in *AOS* gene expression. Plants with downregulated *AOS (AOSi),* overexpressed *AOS* (*AOSoe),* wild type *(G7-11)* and empty vector (*pND6)* from tissue culture were transferred to soil, acclimated in the greenhouse for four weeks, then transplanted in replicated plots located at the Bridgestone Guayule Research Farm in Eloy, Arizona, in May 2016 and October 2016. Plants were irrigated using a subsurface drip system throughout the trial. Phenotypes including plant size, biomass, architecture, and rubber and resin content were measured at 6 month intervals during 2 years of field growth. Constitutive expression of the *AOS* gene in stembark tissues was remarkably consistent with genotype, even after 2 years in the field environment. *AOSi* plants grew larger and exhibited higher photosynthetic rates. Surprisingly, the *AOSoe* plants showed higher rubber content at the 18 month time point compared to *G7-11* and *pND6* controls.

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IN-VIVO DETERMINATION OF POLYISOPRENE AND RESINS CONTENTS OF GUAYULE PLANTS BY NEAR INFRARED SPECTROSCOPY

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Rubber is omnipresent in our daily lives. This elastomer is used to make more than 40,000 products including tires and medical gloves. Because of its exceptional properties, natural rubber is essential for the industry. Furthermore, it is a raw material renewable and environmentally friendly (contrary to synthetic rubber). Today the only commercial source of natural rubber comes from the culture of hevea (*Hevea brasiliensis* Müll. Arg.). However, the hevea plantations will no longer be sufficient to meet the growing demand of natural rubber in ten years. Guayule (*Parthenium argentatum* A.Gray) is an alternative source for the production of natural rubber. Global warming favors the development of new crops suited to semi-arid areas and adapted to poor soils as guayule. Current issues of the culture of guayule carry on farming practices, genetic improvement, and the effectiveness of the methods of extraction and synthesis of rubber. This study is carried out under the GuayulSim project, which covers the two first issues. GuayulSim is financially supported by the Labex Agro (ID-1605-026). Direct determinations of polyisoprene and resin contents require a destructive methodology that is very long to be implemented in the laboratory. To make a very large number of measures, it is necessary to determine the contents in a quick way, in a non-destructive way, and directly in the field. The objective of this study is to improve the laboratory method by near infrared spectroscopy developed at Cirad, powerful but requesting time for the biomass collection, drying and grinding, and therefore destructive. The new method will allow making measurements directly on the plant in vivo, saving significant time and without altering the plantation since the picking of plants or branches will be no longer necessary. More specifically, the aim is to: (a) establish a model of determination of polyisoprene and resins in-vivo. (b) To test the reliability of the model. (c) To compare and interpret differences in spectral responses between the field and the laboratory. (d) Finally to determine the optimal number of measures and their locations from the analysis of the variability of contents in the field and on whole plant.

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ENDURANCE AND SUSTAINABILITY OF GUAYULE (*PARTHENIUM ARGENTATUM*, GRAY) NATURAL RUBBER COMPOSITES ARE IMPROVED SYNERGISTICALLY BY EGGSHELL AND SILICA REINFORCING FILLERS

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Fatigue, aging and ozone attack are the three main causes of deteriorating performance and service life of rubber products. Long life is important to save cost, raw materials, and because rubber composites are difficult to recycle because of their crosslinked structure. In order to develop environmentally-sound and durable rubber products, sustainable natural rubber and fillers are both necessary. In this research, guayule natural rubber (GNR) was used as the rubber matrix and compounded with different fractions of precipitated silica (PS) (surface area 195 m^2/g) and micro-eggshell (ES) (surface area 1 m^2/g) fillers at 50, 60 and 70 parts per hundred rubber (phr) loadings. ES significantly increased tensile properties and reduced energy consumption as it replaced PS in GNR composites. At 50 phr filler loading, fatigue treatment did not significantly affect the tensile strength of any GNR composites, but did reduce composite tensile strength when loaded with 60 and 70 phr, perhaps due to the lower mobility of guayule natural molecules at the higher loadings. Modulus was increased by fatigue possibly due to construction of a more extensive PS-PS filler network. After oven and real-time aging, all composites containing ES had comparable tensile strength to 100% PS ones. Elongation at break increased with ES fraction but decreased with filler loading. Modulus and hardness were increased by both oven- and real-time aging, which was related to increased crosslink density, when ES fraction was less than 50%, but not at higher ES fractions. Ozone resistance was maximal in composites containing blends of both fillers. Increased resistance was partially due to increasing PS-GNR covalent bonds which concomitantly reduced the number of GNR double bonds susceptible to ozone attack. In addition, the improved PS filler particle dispersion induced by micro-ES also increased the ozone resistance of PS filled GNR composites. In conclusion, ES-PS filled GNR composites have excellent durability, improved sustainability and add value to a food processing industrial waste. Such composites will expand the uses of guayule rubber and support expansion of guayule farming and processing facilities.

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MPROVEMENT OF RUBBER DANDELION (*TARAXACUM KOK-SAGHYZ*- L.E. RODIN) BY MANIPULATING THE INULIN BIOSYNTHESIS PATHWAY

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Natural rubber (NR), consisting of polymers of the organic compound isoprene, is used in many different products essential to modern life. Increasing global demand requires novel alternative sustainable sources. T*araxacum kok-saghyz* (TK, also called rubber dandelion) is a potential crop, which produces NR in its root system, but higher rubber yields are needed. In TK`s roots, inulin, which is a storage carbohydrate, may be antagonist of rubber biosynthesis, because they both compartmentalized photosynthetic carbon. In TK`s inulin metabolism, *fructan: fructan 1-fructosyltransferase* (1-FFT) is an important enzyme directly catalyzing the fructose polymerization into inulin. CRISPR/ Cas9 has been used to mutate and inactivate the *1-FFT* gene, using *Agrobacterium rhizogenes*, with hairy roots being used as a visual marker. The confirmed mutated plants were bred with wild type TK to segregate out the hairy root phenotype, and PCR is being used to identify normal root mutant and wildtype progeny. We will report the concentrations of rubber, soluble sugars, and inulin content and the root and shoot growth in 3 and 6 month old plants. It is expected that mutant plants will have significantly lower inulin concentration than controls. It is possible that the soluble sugar content will increase or that the sugars will be shunted to other metabolites, and higher rubber concentrations or larger plants may result. Both outcomes would result in increased rubber yield and would suggest that *1-FFT* may be a useful genetic selectable marker for high rubber yield TK in molecular breeding approaches. The CRISPR/Cas9 system may help accelerate domestication of TK.

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ALKALINE PRETREATMENT OF *TARAXACUM KOK-SAGHYZ* (TK) ROOTS TO IMPROVE YIELD AND PURITY OF NATURAL RUBBER (NR)

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Natural rubber (NR) is a pivotal biological material vital for the modern economy, the supply of which is insecure due to burgeoning demand, labor shortages, and disease. *Taraxacum kok-saghyz* (TK), a rubber-producing dandelion, is currently being investigated as an alternative source of NR. Field-grown TK roots were pretreated at temperatures between 25 and 160 ˚C, and NaOH doses from 33 to 132 mg NaOH/g TK roots. Pretreated roots were hydrolyzed by commercial enzymes. Rubber yield and dirt content (ASTM D1278-91) were measured. In addition, rubber was characterized by GPC, TGA, DSC, FTIR and SEM. Elevated sodium hydroxide concentration and temperature increased rubber yield, while reducing rubber gel, molecular weight and increasing polydispersity. Rubber dirt content and rubber thermal properties were not affected by alkaline pretreatment. FTIR analysis indicated that alkaline pretreatment modified non-rubber components. SEM images revealed the dramatic structural changes in root tissue as a function of reaction temperature. Alkaline pretreatment at 120 ˚C and 66 mg NaOH/g TK roots extracted 20% more rubber than control (non-pretreated roots) without significantly affecting the rubber quality, and therefore it forms a foundation that could be further developed for efficient extraction of high quality TK rubber.

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ABSTRACTS

POSTER PRESENTATIONES

FIBER AND CELLULOSICS

A NUMERICAL MODEL APPROACH TO PREDICT MOISTURE ABSORPTION IN DENSIFIED SOLID BIOMASS DURING STORAGE

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Bioenergy from wood pellets has aggressively grown due to its potential to reduce fossil fuel consumption and carbon emissions. Wood pellets demand is on rise as a result a large volume of pellets are manufactured and stored before consumption. Wood pellets are inherently hygroscopic and readily absorb moisture during storage. Increased moisture content (MC) can reduce the heating value, energy efficiency and mechanical durability of wood pellets. Although the moisture absorption behavior of wood pellets is well documented, no predictive model is available to simulate the moisture content in wood pellets. In this research, the kinetics of moisture absorption in wood pellets was analyzed using Fick's law of diffusion. A numerical model was developed to predict the moisture content in wood pellets for different storage conditions. The moisture absorption by wood pellets conditioned in a humidity chamber under two temperatures (20°C and 30°C) and two relative humidity's (RH) of 60% and 80% was studied over a period of 45 days. The moisture absorption pattern in wood pellets followed Fick's law model with a linear initial part and an equilibrium plateau. Considering the principles of moisture absorption in porous media, an exponential equation was employed to model the moisture absorption in wood pellets and a good agreement was observed between numerical model and the experimental data. The high values of coefficient of determination (R^2) and low values of root mean square demonstrated the suitability of the proposed numerical model to predict moisture content in wood pellets. This model can help the densified biomass processors to estimate the moisture uptake during storage conditions.

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VALORIZATION OF LIGNOCELLULOSIC RESIDUES AS A SOURCE FOR NANOCELLULOSE PRODUCTION

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Countless years of industrialization have led to the continuous depletion of nonrenewable resources and high levels of pollution. The overuse of nonrenewable resources, has served as a motivation for an intensive search and development of new types of green bio-based and degradable feedstocks derived from natural sources. Lignocellulosic biomass, is one of the least utilized bio-resources in the world, consisting mainly of lignin, cellulose and hemicelluloses. This type of biomass is plentiful in biopolymers in nature, and can be obtained from several sources, among which are the residues from agricultural and industrial lignocellulosic crops. The cellulose extracted from the biomass can be depolymerized giving rise to an extraordinary nanometer scale biobased material. Abundance, biodegradability, renewability and low cost, coupled with excellent mechanical properties appoint nanocellulose (NC) as one of the most promising nanometric biomaterials. In recent years, the improvement of the production processes as well as the properties of the nanocellulose has been extensively studied, thus exploring a wide range of applicability's in diverse technological areas. Due to its mechanical properties, the reinforcement in polymeric bio-nanocomposites has been pointed out as one of the most promising applications of the NC. This work focuses on the recent developments about the valorization of lignocellulosic biomass obtained from different lignocellulosic industrial crops, as a source of NP, by discussing (i) how the characteristics of different crops residues influence the nanocellulose properties, (ii) pre-treatments and extraction procedures, (iii) new technological applications. Ultimately, the critical assessment of the current knowledge will allow the identification of prospects, limitations and future opportunities of bio-nanocomposites reinforced with NC.

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KENAF TOLERANCE TO POLLUTANTS AND THEIR BIOACCUMULATION TO THE ABOVE GROUND PLANT BIOMASS

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Kenaf (*Hibiscus cannabinus* L., Malvaceae) is an annual fiber crop having great potential for fiber, energy, and feedstock. Its stem fibers are an excellent source for textile, paper pulp, and cordage industries, building and bedding materials, oil absorbents, biofuel production, etc. Kenaf young plants can be used in livestock feeding, due to their palatability and high protein content. Furthermore, kenaf seed meal is a rich source of protein and energy and can be successfully used as a supplement in various animal rations. A quite new application of this crop is its use as food additive, while its leaves can also be used as hot beverage. Taking under consideration the above mentioned, and knowing that food consumption is identified as the major pathway of human exposure to contaminants, it was decided to investigate the kenaf tolerance to several pollutants and their possible bioaccumulation in the plants aerial biomass. A greenhouse pot experiment was conducted using surface soil (top 20 cm) taken from two sites (A and B) of the multi-contaminated area of Lavreotiki peninsula, Attica, Greece. Ancient (3000-200 B.C.) and more recent (1864-1982 A.D.) mining and metallurgical activities resulted in a heavy soil contamination of the area. The most important minerals extracted were galena (AgPbS), smithsonite ($ZnCO_3$), arsenopyrite (FeAsS), and fluorite (CaF_2). Site A was a metallurgical and smelting area, while Site B was a mining, washing and ore enrichment area. The trace element (TE) total soil concentrations in both sites were determined using aqua regia and quantified by ICP-MS. Extremely high contents were measured for As, Cd, Cu, Pb, Sb. Zn; Mn and Ni were also higher than the common concentrations in soils, while Co was within the normal values. Soil from each site was mixed with uncontaminated soil: 0% (control), 10%, 50%, and 100%. Each soil mixture was used to fill three pots, and five kenaf seeds were sown in each pot. Twenty days later, the plantlets were manually thinned to one seedling per pot. The plant height and the number of leaves were recorded every 7 d and the plants were observed, at regular intervals, in order to detect visible injuries. Three months later, the above ground plant parts were harvested, dried and analyzed with ICP-MS for their TE concentrations. The results showed that -in all treatments- plant growth was not affected. The concentrations of heavy metals and metalloids measured in kenaf aerial biomass were higher than in the control plants but within the normal limits, apart from Cd, Pb, and Sb. Cadmium concentration was up to 11.0 mg/kg, Pb was up to 59.18 mg/kg and Sb was up to 3.4 mg/kg. Cadmium contents in plants were 55-fold higher than in the control plants. In conclusion, this work indicate that kenaf grown on soils bearing Cd, Pb, and Sb could be dangerous as a carrier of these trace elements in the food chain.

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PHYTOMANAGEMENT OF SERPENTINE SOILS BY GIANT REED (*ARUNDO DONAX L.)*

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Serpentine soils derived from the weathering of ultramafic rocks (such as peridotite and serpentinite) are found worldwide covering approximately 1% of Earth's land surface. There are outcroppings of serpentine soils in the circum-Pacific Margin, Mediterranean region, North America, Europe, and Australia. These soils are naturally metal-enriched, having elevated concentrations of Ni as well as of other heavy metals such as: Co, Cr, Fe, Mn, Cu, Pb, and Zn. These soils are characterized by high pH values, deficiency in essential nutrients (N-P-K), and low Ca:Mg ratio. They have low fertility and not-suitable for food crops production. However, under the global need for new areas to be cultivated with non-food crops in order to reduce the food vs. fuel controversy, the phyto-management of the ultramafic agricultural soils represent an ecological option for the re-valorization of these low-productivity landscapes. Plants suitable to be used for the phyto-management of serpentine soils should be fast-growing, deep-rooted, easily propagated, and able to produce high biomass yields with an economic or ecological value. The plants should additionally mitigate the risk originating from that soil, by, e.g. stabilizing the soil, reducing leaching, etc. Their cultivation must be feasible and economically attractive under the given site and land use conditions. Perennial grasses are promising candidates since they are harsh and fast growing crops, they display a good adaptability to different ecological conditions and they produce lignocellulosic biomass that can be used for the production of bio-based commodities and/or bioenergy. *Arundo donax* L. is a lignocellulosic perennial crop selected for this study due to its tolerance to high-Ni soil content and its phytoremediation potential. A 2-year pot experiment was conducted using surface soil artificially contaminated with $Ni(NO_3)_2 \cdot 6H_2O$ through a continuous addition of the metal via the irrigation water. Sixty plastic pots of 50 x 50 cm were used and each one was filled with 60 kg of soil and planted with one rhizome. At the end of the experiment, the total (HNO_3 + H_2O_2 extracted) Ni concentrations in soil were up to 2543.3 mg/kg, the KNO_3 extracted were up to 34.3 mg/kg, while the DTPA and EDTA extracted concentrations reached the 438.2 mg/kg and 869.2 mg/kg, respectively. All measured plant growth and physiological parameters were not affected by the treatments, showing the important tolerance ability of *A. donax* to increased Ni soil contents. Nickel concentration in the aerial biomass of plants was 16.0 mg/kg, while the bio-concentration and translocation factors were 0.01 and 0.3, respectively. In conclusion, *A. donax* was proved to be extremely tolerant to increased concentrations of Ni in its rhizosphere. In addition, plants could accumulate Ni in their aerial biomass in concentrations exceeding the normal values (0.02-5 mg/kg). This result should be taken under consideration when designing the phyto-management of serpentine soils by *A. donax* in order to ensure the safe and permissible uses of the produced biomass.

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CORN DISTILLERS DRIED GRAINS WITH SOLUBLES (DDGS) – A VALUE ADDED FUNCTIONAL MATERIAL FOR WOOD COMPOSITES

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In the U.S., the corn (*Zea mays* L.) dry-grind process contributes to 70% of ethanol production. Nearly 1 kg of distiller's dried grains with solubles (DDGS) is produced per kg of ethanol. DDGS contain roughly 30% proteins, 13% fat and 39% fibers. DDGS proteins can be exploited for adhesive properties if their protein structure are uncoiled from existing globular structures into more linear chains. Currently DDGS is utilized locally as feed and protein supplement for ruminant animals. In 2017 DDGS production was 20.8 x 10^6 Mg with selling price of $0.08-0.12 per kg which is below quality wood fiber price of $0.20-0.22 per kg. As predicted by U.S. Grains Council, the availability of DDGS will jump from 10 million Mg in 2006 to 70 million Mg by 2020. With increasing DDGS volume, price fluctuations, geopolitical instability, and risk of tariffs it is paramount to identify new avenues to utilize DDGS locally for long term growth and viability of ethanol industry. The main objective of this project is to promote the use of DDGS as a novel functional filler for commercial wood composites. The use of DDGS in wood composites (particleboards, hardboards, fiberboards, etc.) will reduce the use of synthetic resin and wax and help develop safe, reliable, and formaldehyde free composites for wood products industry. The two objectives of this project are: 1) Identify how DDGS proteins can be functionalized to act as natural adhesives in particleboards without compromising their physical and mechanical properties. 2) Determine the economic saving associated with the use of DDGS in the particleboards. In this research first the DDGS were characterized for their composition using nitrogen and amino acid analyzer and then they mechanically micronized into three particle sizes (100 micron, 175 micron and 250 microns). Micronized DDGS were treated with alkali (NaOH), acetic acid or formic acid to functionalize their proteins. The treated DDGS were blended with 50% pine wood flour and pressed into particleboards using hot press. The boards were tested for their physical and mechanical properties using ASTM D1037 standard. Preliminary results showed that DDGS can be directly blended with wood particles in particleboards. Low density particleboards with 5% DDGS performed superior to melamine urea formaldehyde resin. Micronized DDGS exhibited better compatibility due to increased surface area. Both the alkali (PH-14) and acid treatment (PH-1.8) helped to uncoil DDGS proteins to bond with hydroxyl groups of cellulosic fibers. The physico-mechanical properties of formic acid treated DDGS:pine (50:50 blend) particleboards exhibited flexural modulus of 416 MPa and strength of 2.29 MPa. The water absorption and internal bond strength meet or exceeded the ANSI A208.1 particleboard standards.

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PRELIMINARY TRIALS FOR SUNN HEMP IN GREECE

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Sunn hemp (*Crotalaria juncea* L.) is a legume (Fabaceae family) originated from India. It can be grown in soil with moderately low pH levels, ranging from 5.0 to 8.4. Although it is considered as a drought tolerance annual crop that tolerates low soil fertility it increases productivity when grown on fertile soils. As cover crop sunn hemp can improve soil properties, reduce soil erosion, conserve soil water, and recycle plant nutrients. It is considered as non-wood fiber crop but it is cultivated as forage and/or biomass crop. Sunn hemp could also be cultivated in rotations with kenaf (*Hibiscus cannabinus* L.) for non-wood fiber production, since it is resistant to root-knot nematodes whereas kenaf is susceptible. Currently, sun hemp is one of the under-studied biomass crops in the EU research BECOOL project (HORIZON 2020; www.becoolproject.eu), where it is being tested, among others, in rotation with wheat and maize. The research started in spring 2017 in three Mediterranean countries (Greece, Italy, and Spain). In Greece, the growth and yields of sunn hemp had been tested in three plant densities (5, 10, and 15 cm with the rows; the distances between the rows were 50 cm) in three replicates. The sowing had been done in May 2017 (20 May) and the emergence four days later. During the growing period phenological observations had been taken, while at the end of the growing period (27 October 2017) the final plant height and stem diameter had been measured on five marked plants per plot. Moreover, a final harvest had been carried out in a marked area located in the middle of each plot and harvested biomass had been weighted. Then, the leaves and the pots had been separated from the stems. The weight of the stems had been recorded. Samples from both leaves and stems had been taken for dry content determinations. The mean final plant height was 334 cm, while the corresponding value for stem diameter was 11.28 mm. The biomass yields did not statistically affected by the plant density and the dry biomass yields varied from 29.2 to 29.7 Mg/ha. The moisture content at the final harvest was 65%. A large amount of pots had been produced (45% of the total biomass as harvested and 42% on oven-dried biomass) but the seeds were not fully matured. The same trial has been established in the beginning of May 2018 and the results will be compared with the ones recorded in 2017.

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REDISCOVER INDUSTRIAL HEMP

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Industrial hemp (*Cannabis sativa* L.) is a short-day bast-fiber crop with a rapid growth that can reach a height of 4 m in 100 days and its moderate biomass yield can be 10 Mg/ha. Due to its rapid growth, hemp requires substantial available nutrients (N-P-K) to produce high biomass yields (> 100 kg N/ha). It is considered a good fore crop for cereals cultivation. Hemp absorbs heavy metals such as Cd, Pb, Zn, Cu, contribute to the re-cultivation of contaminated soils. Industrial hemp is considered as multi-purpose crop since a wide range of products can be produced from it fiber stems (paper and pulp, construction materials, etc.) as well as from its seeds and CBD from the upper part of the stems. In 2017, the cultivation area of industrial hemp in Europe was greatly increased and came up to 43,000 ha (33,000 ha in 2017; at world level the cultivation area in 2016 was 120,000 ha). In Greece, industrial hemp used to be cultivated for both its fiber stems and its seeds but in late 1950's the cultivation area started to decline and final in 1970s the cultivation of the crop had been forbidden. In 2016, with the introduction of a new law, the cultivation of industrial hemp had been allowed (for those cultivars THC was less than 0.02%) and the first field trials had been established (2.6 ha) in order to monitor which of the EU registered industrial hemp cultivars fit best to the Greek climatic conditions. In 2017, the cultivation area of the crop was increased and came up to 25 ha. A wide range of industrial hemp cultivars have been tested (Fibranova, Finola, Future 75, etc.) and in 2018 the majority of the established fields had the target to produce seeds and Finola cultivar had been selected.

Currently, industrial hemp is one of the under study biomass crops in the EU research BECOOL project (HORIZON 2020; www.becoolproject.eu), where it is being tested, among others, in rotation with wheat and maize. The research started in spring 2018 in three Mediterranean countries (Greece, Italy, and Spain). In Greece, the growth and yields of industrial hemp had been tested in three plant densities (5, 10 and 15 cm with the rows; the distances between the rows were 50 cm) in three replicates. The tested cultivar was Futura 75. Moreover, industrial hemp had been also included in MAGIC project (HORIZON 2020, www.magic-h2020.eu) as an industrial crop that can been successfully cultivated on marginal lands facing natural constraints and will be tested in in several sites in Europe.

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ABSTRACTS

POSTER PRESENTATIONS

GENERAL CROPS AND PRODUCTS

SUGARCANE (*SACCHARUM* SPP.) JUICE POTENTIAL IN A BIOREFINERY CONTEXT

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Sugarcane (*Saccharum* spp.) is one of the main crops in the world, grown in more than 100 countries. World sugarcane production totalizes about 1.9 billion tones, and Brazil is the world leader in this crop production. This significant production may be justified by technological improvements in both the sugarcane agricultural production process and in the sugar and ethanol production processes. Besides its use as feedstock for sugar and ethanol production, sugarcane juice *in natura* is very appreciated in the whole world. It is an energetic drink, not alcoholic, whose taste is pleasant, due to its characteristics of refreshment and sweet flavor, allowing people from all ages to consume this drink. However, the juice quality is also one of the main factors that can affect the quality of the final products. It relates with the crop maturity, crop cultivar and type of soil but also to degrading processes occurring during storage and processing. In fact, sugarcane juice has to be treated and clarified, because minutes after its extraction, it gets a dark color which may negatively influence its composition. There are at least four mechanisms that contribute to color formation, namely: (a) melanoidins formed during reactions of the reducing sugars-amino acids by the Maillard reaction; (b) thermal degradation and condensation reaction of sugar by caramelization; (c) alkaline degradation and condensation reactions of reducing sugar; (d) oxidative reaction of phenolic compounds. The first three are non-enzymatic reactions, while the oxidative reaction of phenolic compounds to chemically reactive quinones is an enzymatic reaction and occurs prior to the milling process, when sugarcane is milled to extract juice. Compounds that most affect juice color are those naturally found in sugarcane, that is, phenolic compounds and flavonoids, responsible for 60–75% of juice color. But those compounds represent also an added value in a biorefinery context. Therefore, this work aims to make a revision on the actual knowledge on the composition of sugarcane juice obtained from different cultivars cultivated in different edaphoclimatic conditions and also, the variation in the juice composition introduced by storage and processing conditions. The knowledge acquired will help to identify options for valorization of the compounds that most affect juice color and that can improve the quality of the juice for sugar and ethanol production.

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INDUSTRIAL HEMP PLANT POPULATION AFFECT ON CROP PERFORMANCE IN NORTH DAKOTA

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As production of industrial hemp (*Cannabis sativa* L.) increases so follows the importance of developing management practices for attaining high crop performance. Industrial hemp stands often exhibit higher seedling mortality than commonly grown crops and consequently plant densities/populations are lower than optimum for maximum grain yield. The objective of this study was to quantify the effect of reduced plant densities on industrial hemp grain and fiber yield and other traits. A RCBD 2x5x6 factorial study was conducted at Fort Ransom, ND, in 2018. Factors were two cultivars, five plant densities (PD), and six dates (D) for trait determinations. Cultivars Grandi and CRS-1 were seeded on 31 May in six-row plots, two meters in length, with a row spacing of 30.5 cm; this produced a bordered 1.39 m^2 area for trait determinations. Plant densities were oversown and hand-thinned to 130, 104, 78, 52, and 26 plants/m^2 at the 1006 growth stage. Traits evaluated included leaf canopy ground cover (LCGC) determined with the Canopeo app, plant height, stem diameter, stem branching, inflorescence length (IFL), and grain and fiber yield. The PD x D interaction for LCGC indicated values increased as plant density increased and date advanced for D1 and D2. The LCGC reached 99% on D3 and D4 for all PD levels and declined at D5 and D6 due to senescence of lower leaves. Rapidly reaching 90% or greater LCGC levels is important since there are no labeled herbicides for weed control and ground shading is relied on for weed suppression. Greater than 90% LCGC was attained 28 days after planting for PDs 130, 104, and 78 plants/m^2, but not until 49 days after planting for PDs 52 and 26 plants/m^2. Stem diameter, stem branching, and IFL tended to increase as PD decreased and were 9.6 mm, 22, and 87 cm, respectively, at 26 plants/m^2. Increased IFL at lower PDs indicates potentially greater grain production per plant at lower PDs, but this may not be sufficient to prevent grain yield loss from a low PD. The primary yield component for producing high grain yield is having the proper plant density/plant population established at the beginning of the growing season.

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SEEDING DATE AND GENOTYPE MATURITY AFFECT ON GRAIN SORGHUM PERFORMANCE IN NORTH DAKOTA

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Grain sorghum [*Sorghum bicolor* (L.) Moench] is an important warm-season, drought-tolerant crop used worldwide as food for human consumption and feed for livestock. Most of the Great Plains states from Texas to South Dakota currently produce grain sorghum. However, commercial cultivars are not adapted to North Dakota's shorter growing season and cooler temperatures. The study objectives are to evaluate early-maturing, high-yielding self-pollinated sorghum genotypes in seeding date studies at several North Dakota locations to maximize crop performance. Field research studies are in progress at the Carrington, Oakes, and Prosper, ND, locations during the 2018 season. The experimental design is a RCBD split-plot arrangement with three seeding dates (22 May, 30 May, and 7 June at Prosper) as the main plot and six genotypes as the subplot. Genotypes include two commercial hybrids and four self-pollinated genotypes previously screened from national germplasm sources from 2015 to 2017. Traits evaluated include seedling emergence and mortality, established and harvested stands, tillering, leaf canopy cover, plant height, plant lodging, phenology dates (heading, 1st anthesis, end anthesis, and physiological maturity), grain yield, biomass yield, harvest index, test weight, and seed weight. Results from the Prosper 2018 location indicated pure live seedling emergence (PLSE) ranged from 71% to 81% among five of the genotypes with SARE17's PLSE at 87%. The seeding date by genotype interaction indicated PLSE ranking differences among genotypes as seeding date advanced at the Prosper 2018 location. PLSE was generally lower at Date 1 and higher at Date 3 for all genotypes, but PLSE response at Date 2 varied among genotypes. Analysis, at Prosper, for seeding dates 1 and 2 indicated genotype differences for days from planting to heading. Genotypes SARE 14, SARE 17, SARE10, PI574595, RS320W, and AG1401 days from planting to heading were 56, 56, 58, 60, 66, and 69, respectively. Sorghum seedling emergence and mortality results from this study, except for SARE14's, were lower and higher, respectively, than commonly grown crops such as corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), and soybean (*Glycine max* (L.) Merr.). Since the open-pollinated sorghum genotypes were previously screened for earliness and high grain yield they could out-perform the hybrids at later seeding dates.

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ABSTRACTS

POSTER PRESENTATIONS

MEDICINAL AND NUTRACEUTICAL PLANTS

IN VITRO BIOACTIVITY OF NOVEL CHITOSAN BIONANOCOMPOSITE INCORPORATED WITH DIFFERENT ESSENTIAL OILS

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Essential oils (EOs) are extracted from a variety of crops, e.g. rosemary (*Rosmarinus officinalis* L.), ginger (*Zingiber officinale* Roscoe), thyme (*Thymus zygis* Loefl. ex L.ct. Linolol), to mention a few, and are rich in active compounds, such as phenolic acids and terpenes, which confer them biological activities (antimicrobial and antioxidant). Thus, EOs have the potential to substitute synthetic additives in the preservation of foodstuff, and when incorporated into polymers, may enhance packaging activity. Therefore, the aims of this work were to develop bionanocomposites based on chitosan/montmorillonite incorporated with two different essential oils (rosemary and ginger) and, to evaluate its bioactivity via *in vitro* assays. Films were produced by casting, from the chitosan film form solution (FFS) (1.5% w/v). Sodium montmorillonite (MMTNa) was incorporated at the level of 0% or 2.5% (w/w chitosan) for mechanical reinforcement. Rosemary EO (REO) or ginger EO (GEO) were incorporated in the proportion of 0%, 0.5%, 1% and 2% (v/v FFS). Films were casted in glass molds and naturally dried. Films without EO and MMTNa were used as control. The release process of the active compounds present in the film was monitored by a migration assay in a food simulant (ethanol 50%). Total phenolic compounds and their antioxidant activity were measured at the simulant over time. The diffusion coefficient was also calculated. The films were tested in terms of their antimicrobial activity by agar diffusion and viable cell colony count (CFU) methods against gram-positive (*Bacillus cereus, Enterococcus faecalis, Listeria monocytogenes, Staphylococcus aureus*) and gram-negative (*Escherichia coli, Pseudomonas aeruginosa, Salmonella enterica*) foodborne bacteria. The diffusion of phenolic compounds to the simulant media was correlated to the amount of EOs incorporated in the films. The antioxidant activity of the active compounds was maintained even after the diffusion process. The diffusion coefficient of ginger EO was higher than the rosemary EO, and the nanoclay entrapped the phenolic compounds, retarding its release. The films presented only antimicrobial activity underneath the disk specimens by the agar diffusion method. In the CFU method, the films showed high antimicrobial activity against the gram-positive bacteria (reduction around 7 log CFU for *B. cereus* and of 5 log CFU for *S. enterica*). The incorporation of the MMTNa and the EO blocked the amide group of chitosan, reducing its antimicrobial effect. In conclusion, the incorporation of EOs conferred antioxidant activity to the chitosan films, although diminished its antimicrobial performance.

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SENNOSIDES IN *SENNA* GENETIC RESOURCES

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The USDA, ARS, Plant Genetic Resources Conservation Unit, curates several *Senna* species including *S. alexandrina* Mill. *S. covesii* (A. Gray) H.S. Irwin & Barneby, *S. hirsute* var. *hirta* H.S. Irwin & Barneby, and *S. uniflora* (Mill.) H.S. Irwin & Barneby. The natural products including sennosides A and B are the primary laxative ingredients in many medicinal products. However, it is unknown if sennosides A and B are found in many of these *Senna* species and at what concentrations. The objective of this study was to evaluate sennosides A and B content from leaves of these four *Senna* species over 2 years and locations. Each *Senna* species were transplanted from about 30 days old seedlings to the fields in Griffin and Byron, GA each year (2015, 2016), during May in a greenhouse at a temperature range of 21-26°C. At 50% maturity, leaves were collected from the 4 *Senna* species and stored at -18°C, until sennosides measurements. Leaves from all of the *Senna* species were ground to a powder, using a mixer mill or coffee grinder. The powder was placed in 15 mL tubes and each sample was defatted twice with 5 mL of hexane for 15 min, followed by centrifugation and hexane removal. Sennosides were extracted twice with 5 mL of 70:30 methanol: 0.2% sodium bicarbonate and then, the tubes containing the sennosides were shaken for extraction. They were then centrifuged and the supernatants from each one, were combined. A third 5 mL extraction proceeded overnight and the supernatant was combined with the first two. The final volume yielded up to 15 mL with a portion, for injection into the HPLC. Sample analysis were performed by HPLC on an Agilent 1100 with an auto-sampler and diode array detector. A 3 x 150 mm, 5µm phenyl column at 40°C was used for separations. The mobile phase consisted of 0.5% formic acid in water (A) and 0.5% formic acid in a 2:1 mixture of methanol and acetonitrile (B). The flow rate was 0.75 mL/min at the following gradient: 15% B at zero time, increasing to 40% B at 20:00. The column was washed with 95% B and equilibrated between sample injections. Peaks were detected at 270 nm. Calibration curves were generated using sennosides pure standards for sample quantitation. Significant genotype effects were observed for sennosides A and B. Mean separations revealed that leaves from *S. alexandrina* produced significantly more sennoside A (6.14 mg/g) and B (16.19 mg/g) than all other species (0 mg/g). A significant correlation was observed for both sennosides A and B. While this is a preliminary analysis, it provides evidence for higher levels of sennosides A and B in *S. alexandrina* than in *S. covesii*, *S. hirsute* var. *hirta*, and *S. uniflora*. In conclusion, sennosides A and B are found in the leaves of *S. alexandrina.* However, additional studies are required to verify sennoside content in other *Senna* species and organs including *Senna* pods.

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MEXICAN SEMIDESERT PLANTS INHIBIT CELL PROLIFERATION AND INDUCE APOPTOSIS IN FOUR HUMAN CANCER CELLS

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Recently, the research in semi-desert plants as a natural alternative on carcinogenesis chemoprevention, has received great interest. This is due to plant extracts contain a wide number of polyphenols, type of compounds with antioxidant activity that have been related to carcinogenesis modulation. Besides, these products do not cause negative collateral effects. Therefore, the aims of this study were to determine the total phenolic content (TPC) and antioxidant activity of leaves ethanol extracts from seven semi-desert plants: *Flourensia cernua, F. microphylla, F. retinophylla, Rhus muelleri, R. virens, Juglans mollis*, and *Toxicodendron radicans*, and branches ethanol extracts from three plants: *J. microcarpa, T. radicans* and *Jatropha dioica*; and to evaluate its effect in the proliferation and apoptosis induction in 2 prostate cancer cell lines (PC-3, DU-145), a breast cancer cell line (MCF-7), and a colorectal cancer line(HT-29). The plant samples were collected randomly in wild sites located at Coahuila and Nuevo Leon States. The TPC, antioxidant activity and chemical composition were determined in extracts. Antiproliferative activity and apoptosis induction were determined in the four cell lines. Results showed that all extracts are a great source of polyphenolic compounds with antioxidant activity. The best antiproliferative effects were observed with the extracts of *Flourensia* spp., *Juglans* spp. and both *T. radicans* tissues. Also, these extracts showed the highest apoptosis ratio. The treatment with the lowest activity was *J. dioica*, as showed doses above 500 µg/mL for antiproliferative effect. Thus, these findings suggest that the semi-desert plant extracts, mainly the ones from *Flourensia*, *Juglans* and *T. radicans*, could be considered as potential natural alternatives for chemopreventive treatments.

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IN VITRO GASTROINTESTINAL DIGESTION ASSESSMENT OF *FLOURENSIA* SPP. ENCAPSULATED EXTRACTS

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Recently, the research in the bioactive agents of the Mexican semi-desert plants has acquired a great interest, due to the diverse biological activities that its extracts have reported. This has given rise to the search of new technologies, such as the encapsulation, in order to develop new products that allow an adequate dosage administration, as well as to protect bioactive compounds and improve its controlled release in the gastrointestinal system. Therefore, the aims of this research were: to encapsulate *Flourensia cernua, F. microphylla* and *F. retinophylla* ethanol extracts; and to evaluate its controlled release in a gastrointestinal model, *in vitro*; as well as to determinate its phenolic content and antioxidant activity. Branches with leaves of *Flourensia* spp. were collected in wild sites of Coahuila State, and the leaves extracts were obtained by the Soxhlet method. For encapsulation, the gelation technique was conducted, using alginate. The controlled release assays were performed in a gastrointestinal system, *in vitro*. The total phenolic content and antioxidant activity were determined by the Folin-Ciocalteu and DPPH methods, respectively. For extracts, results showed that *F. retinophylla* had the highest TPC, and the best antioxidant activity was obtained with *F. cernua*. For capsules, *F. microphylla* showed the highest TPC and *F. retinophylla* the highest antioxidant activity. The analyses of controlled release of *Flourensia* spp. Encapsulated showed that in the gastric system the extracts of fresh capsules were released from 12.70% to 18.50%; whilst, values of 26.46% to 53.28%were observed for the dried ones. On the other hand, in the intestinal system, the release of *Flourensia* spp. Extracts in fresh capsules ranged from 26.25% to 30.24%; and for the dried ones were 59.89% to 78.35%. Thus, it was observed that the encapsulation allows a controlled release of the extracts in the target site, in the gastrointestinal model. The best release of the encapsulated extracts of *Flourensia* species was obtained with the dried capsules.

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CONCEPTUALIZATION OF A BIOREFINERY TO REVALORIZE THE BYPRODUCT OF IXTLE FROM *AGAVE LECHUGUILLA* TORREY

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The extraction of ixtle from *Agave lechuguilla* Torrey is the main economic activity in rural communities of some semi-arid regions of Mexico. The ixtle is a valuable fiber which is used to make ropes, mats for luxury cars, bags, brushes and many other articles. The content of ixtle represents only 15% of the plant, the other 85% corresponds to a pulp known as guishe. Currently, the guishe has not commercial value, it is opencast disposed causing soil erosion; also, it becomes available for animals, such as goat (*Capra aegagrus hircus*), which could ingest it reaching dehydration and even death. However, the guishe is composed of several phytochemicals which could be used as raw material for the synthesis of high added value products such as saponins, antifungals and hormones, among others. The objective of this work was to evaluate the integration of a biorefinery scheme, through a mass balance analysis, in order to identify the opportunity areas in the revalorization of guishe. The processing of 1 ton (1000 kg) of guishe is employed as computing unit. Three fundamental transformation processes were considered: physicochemical treatment, alternative chemical extraction and thermochemical processing. The information for the assessment is obtained from ixtle producers and from implemented process at lab scale by the authors. The information is parameterized to evaluate different operating conditions and determine the optimal distribution of guishe in the evaluated processes. The by product could be used, through physicochemical processing, to obtain handcraft products for personal use such as shampooing, detergent and anti-inflammatory. From alternative chemical extraction the obtained products have been thymol, carvacrol and saponins, the last ones have been evaluated as surfactants, and as raw material for the synthesis of brassinosteroids type compounds. After the extraction of phytochemicals, a fiber residue is available for thermochemical processing. Combustion has been employed to produce heat (as energy source) and ashes, which are being used for recovery of soils with calcium deficit. Besides, pyrolysis is utilized to obtain biochar, which is functionalized as adsorbent for water purification and as catalyst for biodiesel production. Some other processes such as hydrolysis, fermentation, anaerobic digestion and gasification are also identified to be incorporated in the biorefinery of guishe. These results allow to conclude about the potential and feasibility to integrate processes for revalorization of guishe. Deeper studies, such as sustainability analysis through life cycle assessment, are required to quantify environmental economic and social impacts.

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ANTIBACTERIAL ACTIVITY OF *RHUS MUELLERI* STANDL ET BARKLEY AGAINST MULTIDRUG RESISTANT BACTERIA CAUSING URINARY TRACT INFECTIONS.

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The bacteria causing urinary tract infections (UTI) are classified as multidrug resistant (MDR), and as consequence it has produced a public health problem. Due to this, the research has focused on develop new alternatives to control the bacteria, based on natural plant products with antibacterial activity. By the above, the aims of this study were to determinate the phenolic content, antioxidant activity and chemical composition of *Rhus muelleri* Standl et Barkley ethanol extract, and to evaluate its antibacterial activity in six bacteria causing UTI: *Enterobacter aerogenes*, *Escherichia coli*, *Proteus hauseri*, *P. mirabilis*, *P. vulgaris*, and *Staphylococcus epidermidis*. Plants samples were collected randomly in the limits of Coahuila and Nuevo Leon States, Mexico. Ethanol extract of the leaves were obtained by Soxhlet, and its chemical composition by GC-MS, antioxidant activity and phenolic content were determined. Antibacterial assay *in vitro* was carried out by two tests: Test 1, was performed at 125, 250, 500, 1000 mg/L for *E. aerogenes*, *E. coli*, *P. hauseri*, *P. mirabilis*, *P. vulgaris*, and *S. epidermidis*; and Test 2, was conducted at 1500 and 2000 mg/L for *E. coli*, *P. vulgaris* and *S. epidermidis*. Results showed the presence of eight compounds in *R. muelleri* leaves extract. The extract demonstrated a high phenolic content and antioxidant activity. *R. muelleri* extract reduced significantly the colony forming units (CFU/mL) of all bacteria tested. The best antibacterial effect was observed on *P. hauseri*, with the lowest MIC_{50} and MIC_{90} of 3.67 and 63.15, respectively. However, the extract presented interesting antibacterial effects on all bacteria evaluated. Therefore, *R. muelleri* represents a natural alternative in the control of MDR bacteria causing UTI.

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ABSTRACTS

POSTER PRESENTATIONS

NATURAL RUBBER AND RESINS

GROWTH AND PERFORMANCE OF *TARAXACUM KOK-SAGHYZ* (RODIN) IN DIFFERENT SOIL TYPES

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Taraxacum kok-saghyz (L.E. Rodin) (TK) is a natural rubber-producing root crop. These low growing plants were grown and harvested in the United States for their high quality rubber during WWII when the natural rubber supply grown from the rubber tree (*Hevea brasiliensis* Müll. Arg.) in Southeast Asia was interrupted. There is little known about optimum TK field growing conditions in Ohio. Studying which soil types TK plants prefer is beneficial in our efforts to domesticate this crop for Ohio farmers and bring more jobs to the state. In this study, a randomized complete block design was employed and TK was seeded into tree pots filled with one of three different Ohio field soil types and compared with common greenhouse peat mix, Pro-mix. Plants were grown in the greenhouse for three months, then transferred outside, and kept in their pots, for six more months. We hypothesized that the plants grown in field soil would be larger than those grown in Pro-mix, and that the rubber concentrations would also be higher in the soil grown plants. As expected the plants grown in field soil were significantly larger than those in Pro-mix, and rubber contents will be reported. This study will determine which of the tested soil types provides the best growing medium for TK and, although this study was performed under greenhouse conditions, it will inform future field trials.

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COMPARATIVE GENOMIC ANALYSIS OF A PUTATIVE RUBBER TRANSFERASE SUBUNIT IN RUBBER TREE (*HEVEA BRASILIENSIS* MÜLL.ARG.) (HEVEA), GUAYULE (*PARTHENIUM ARGENTATUM* GRAY) AND RUBBER DANDELION (*TARAXACUM KOK-SAGHYZ* RODIN)

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Natural rubber is a high molecular weight polymer that cannot be replaced by synthetics in most applications. Natural rubber is currently harvested from the Para rubber tree (*Hevea brasiliensis* Müll. Arg.) (Hevea), but is faced with serious challenges, such as supply shortages and pathogen threats. Two plant species have gained considerable attention as potential alternative sources of natural rubber: guayule (*Parthenium argentatu* Gray) and rubber dandelion (*Taraxacum kok-saghyz* Rodin). Rubber transferase (RTase) (EC 2.5.1.20) is the most crucial biosynthetic step in the formation of rubber which occurs in over 2,500 plant species. In Hevea, two *HRT* genes have been isolated, and the HRT1 protein (but not HRT-2) restored rubber transferase activity in detergent-inactivated Hevea rubber particles, indicating a role in rubber transferase (RTase) activity. Neither had RTase activity when reconstituted in micelles, demonstrating that HRT1 is probably a member of the RTase complex but is not RTase itself. Here, two guayule HRT homologs (*PaRT1* and *PaRT2*) and five rubber dandelion HRT homologs (*TkRT1-5*) were identified by comparative genomic analysis using the published guayule genome and our lab-assembled rubber dandelion genome. Amino acid sequence analysis revealed that all 9 HRTs from rubber tree, guayule, and rubber dandelion, belong to cis-IPPS super family. The sequence similarity between *HRT* genes ranges from 52.04% to 82.78%. Phylogenetic analysis shows that *PaRT2* from guayule and *TkRT5* from rubber dandelion were classified into a same group with *HRT1* and *HRT2* according to their genetic distance; TkRT1 (273 aa) and TkRT2 (281 aa) exhibited 100% similarity on their matched area, indicating that they are probably gene duplicates pair of duplicated genes. Further studies needed to reveal the functions of these HRTs.

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PHENOTYPIC AND GENETIC CHARACTERIZATION OF *TARAXACUM KOK-SAGHYZ* (RODIN) POLYPLOIDS

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Taraxacum kok-saghyz (Rodin) (TK) is a sexually outcrossing diploid dandelion species which produces high quality natural rubber. While TK is reliably grown in greenhouse conditions in soft soils, experimental TK field plantings in the United States, Canada and Europe often produce less than optimal stands of slow growing plants that are out-competed by weeds. In many plant species, increased ploidy level increases plant size and the production of secondary metabolites. We optimized a colchicine induction method for diploid TK seeds to develop generation 0 (G0) tetraploids (4nG0). Although roots were stunted, 4nG0 plants had up to 47% higher root rubber concentration than diploids. Here, we crossed 4nG0 plants to determine the stability of the tetraploid phenotype and to see if the resultant G1 plants, not poisoned by colchicine, still had stunted roots. Flow cytometry revealed that both triploid (3nG1) and tetraploid (4nG1) progeny result from 4nG0 crosses. These plants were grown to maturity and we found that both 3nG1 and 4nG1 plants were no longer stunted, and instead were significantly larger than the diploid controls. Also, rubber concentration of the polyploids was up to double that of the controls. Since triploids were unexpected, and did not appear to be apomictic, we also interbred triploids, and crossed triploids with tetraploids, and characterized both sets of progeny. Cropping with polyploid TK may allow for improved stand establishment as these plants are quicker to grow and are larger and more robust than diploid TK. Increased field survival rate coupled with large plants and high rubber concentrations would increase overall rubber yield, advancing this species towards domestication.

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DEVELOPMENT OF AN IN-VITRO PHENOTYPING ASSAY FOR RUBBER AND RESIN CONTENT IN GUAYULE (*PARTHENIUM ARGENTATUM*) GERMPLASM – PRELIMINARY RESULTS AND PROGRESS

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Guayule (*Parthenium argentatum* A. Gray) is under commercial development in the southwestern U.S. as a source of natural rubber, organic resins, and biomass for fuel and energy. The ARS-NPGS guayule collection is the only publicly available source of germplasm and serves as the basis for most guayule breeding worldwide, yet the collection lacks basic characterization for rubber and resin production. Many factors have contributed to this gap in critical knowledge: the rubber and resin production phenotype is highly variable based on changes in environment, time of year, and developmental stage; some of the accessions in the collection have a high genetic variability within the same seed lot; and different rubber and resin extraction techniques can produce variable results. Our goal is to develop a precise, repeatable, and rapid phenotyping assay to compare relative rubber and resin production in guayule plants. In a preliminary experiment, individual guayule seedlings were grown in a controlled environment in tissue culture to minimize environmental variance. Average rubber content was determined through a novel procedure using small amounts of tissue and an Accelerated Solvent Extraction method, and clear distinctions among different accessions were observed. These initial results will be presented, in addition to progress in developing methods to rapidly propagate multiple clones of single seedlings to allow for evaluation of variation within a single accession. In the future, the relative rubber and resin production of *in-vitro* grown plants will be compared with results from the current SBAR project field trials.

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ABSTRACTS

POSTER PRESENTATIONS

OILSEEDS

ANALYSIS OF FATTY ACID PROFILES AND PERCENT OIL AND PROTEIN CONTENT IN SEEDS OF SUMMER- AND WINTER-BIOTYPES OF *CAMELINA SATIVA* USING NEAR INFRARED SPECTROSCOPY

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Camelina sativa, (L.) Crantz is a marketable oilseed feedstock for biofuels and bioproducts. In addition to being an oilseed commodity, summer- and winter-annual biotypes of camelina are also being evaluated in northern climates of the USA for ecosystem benefits associated with improving soil health, suppressing weeds and soybean cyst nematode (*Heterodera glycines*) egg populations, and providing early-season nutritional sources for pollinators. Although crosses between summer- and winter-genotypes of camelina have been developed to determine genomic regions associated with important agronomic traits, the fatty acid profiles and percent (%) oil and protein from seeds of many existing summer- and winter-annual genotypes have not been determined. In this study, cluster analysis of Near Infrared Spectroscopy (NIRS) data helped identify seed from 72 genotypes (39 summer- and 33 winter-annual genotypes) with differential characteristics. Fatty acid profiles for these 72 genotypes were determined using Gas Chromatography (GC), whereas % oil and protein of seeds was determined by established wet chemistry methodology. The raw GC and wet chemistry data was further used to calibrate the NIRS for development of a non-destructive, high-throughput screening method to determine fatty acid profiles, and % oil and protein content of intact seeds. Based on the averages for % of individual fatty acids obtained by GC for both summer- and winter-annual genotypes, the most abundant fatty acid was linolenic acid (18:3) at 30-32% followed by linoleic (18:2) at 18-19%, eicosenoic (20:1) at 15-17%, and oleic (18:1) at 15-16%. Among the individual summer- and winter-genotypes, as the abundance of linolenic acid increased the abundance of linoleic and oleic acid decreased and vice versa. Although greater variability in % fatty acid profiles were observed for winter- compared with summer-genotypes of camelina, on average, overall differences were relatively similar. The % mean oil was greater in seeds of summer- (36.5%) than that of winter-biotypes (33.8%), while the % of protein was similar. Variability observed for both % oil and protein also was greater in winter biotypes. Comparisons of fatty acid profiles determined by GC and NIRS, and conclusions for using NIRS as a non-destructive, high-throughput method for capturing fatty acid profiles, and % oil and protein content from intact seed of summer- and winter-biotypes of camelina will be presented.

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NEW BITING FLY REPELLENT FROM A COCONUT OIL SOURCE

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Many blood-suck insects are capable of transmitting human and animal pathogens worldwide. Repellants are a primary tool for reducing the impact of biting insects on humans and animals. A new inexpensive derivative from coconut oil (fatty acids) was found to be excellent insect repellent. N,N-Diethyl-meta-toluamide (DEET), developed by Samuel Gertler of the United States Department of Agriculture in 1944, is considered to be the standard insect repellent and these new materials have comparable repellency. Although DEET has claimed to be the most extensively used personal arthropod repellent for six decades, it has been frequently associated with human health issues, particularly for infants and pregnant women. Plant derivatives acting as insect repellents or insecticides are nothing new. The first successful plant-based insect repellent was citronella oil that contains the active ingredient citronellal, but with a limit to its effectiveness. These new coconut (*Cocos nucifera* L.) based compounds are active against a broad array of blood-feeding arthropods. The medium-chain, C_8 to C_{12} fatty acids were found to be the dominant repellent compounds and they are also listed as GRAS (generally recognized as safe) substances. The fatty acid composition of hydrolyzed coconut oil shows it to contain a series of C_8 to C_{12} medium-chain fatty acids that represent >65% of total fatty acids present. In laboratory bioassays, these compounds repelled biting flies for two weeks after application. Repellency was stronger and with longer residual activity than that of DEET, the most effective and long-lasting repellent currently available commercially. In conclusion, the fatty acids derived from coconut oil displayed better repellency against several blood-suck insects, compared to the most commonly used repellent, DEET. Cattle (*Bos Taurus*) treated with the coconut oil fatty acid formulation had significant protection against biting flies which may be the longest lasting repellent reported to date. The cost of applying a coconut fatty acid repellent to cattle is estimated to be extremely cost effective, less than 0.1 US $ for animals of 363 to 454 kg in weight. Such an economically sound practical tool could be easily adopted for livestock animal producers as well as other public health applications for preventative measures (repellent barriers).

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DEVELOPMENT OF A *FAD2*B/*FAE* CARINATA-TURNIP ADDITION LINE WITH ULTRA-HIGH ERUCIC ACID CONTENT

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Ethiopian mustard (*Brassica carinata* [A.] Braun) (BBCC, 2n = 34), also known as carinata, is a drought- and heat-tolerant oilseed, which has recently been developed in Canada as a dedicated industrial feedstock crop. Its seed oil contains a relatively high content of erucic acid (> 40%), which renders it well-suited for the production of bio-fuels or bio-lubricants. In addition, erucic acid as a mono-unsaturated very long chain fatty acid (VLCFA) is an interesting feedstock for the oleochemical industry with more than 1,000 potential or patented industrial applications. In order to enhance the marketability of carinata, the objective of our work was to create a breeding line with ultra-high erucic acid content through interspecific hybridization. To this end, firstly, a mutated *fad2*B allele from *Brassica juncea* (AABB, 2n = 36) was introgressed into *B. carinata*, yielding in the stable *B. carinata fad2*B mutant VR10-183 with increased levels of erucic acid from just over 40% in generic carinata material to approximately 50%. Subsequently, in a second round of interspecific hybridization, the *FAE* allele from *B. rapa* spp. yellow sarson cv. R500 (AA, 2n = 20) was transferred to the *fad2*B *carinata* line, resulting in breeding line VR13-156 with an erucic acid content of close to 60%. Molecular analysis using the 90K Brassica Illumina Infinium SNP array revealed that VR13-156 is a disomic alien chromosome addition line with an extra A chromosome (A08) containing the *FAE* gene. To examine the stability and transferability of the chromosome insertion, doubled haploid plants were produced from the *fad2*B/*FAE* carinata-turnip addition line. These showed that the pollen transfer rate of the A08 chromosome is over 98%, which is extremely high. In conclusion, we have shown that the development of ultra-high erucic acid Ethiopian mustard is possible through traditional interspecific hybridization. In order to achieve a 100% stability of the *FAE* introgression, work will continue to optimize the second gene insertion. For this, we are currently attempting to introgress the *FAE* gene into the C genome through non-homologous recombination between A08 and a C chromosome using intraspecific hybridization between the *fad2*B/*FAE* carinata-turnip addition line and resynthesized *B. carinata*.

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PRELIMINARY EVALUATION OF NEW CAMELINA GENOTYPES SUITABLE FOR SOUTHERN EUROPE

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Camelina [*Camelina sativa* (L.) Crantz] is a native species of Europe where it was widely cultivated until the beginning of the 19th century, afterward replaced by more productive species such as oilseed rape (*Brassica napus* L.). The recent renaissance of this species is mainly due to its wide environmental suitability, low input requirements and good tolerance to pests and diseases. The majority of breeding programs for this species is located to northern America and northern Europe, while a real evaluation of new camelina genotypes suitable for southern Europe is just recently started within a common research program enclosing two breeding groups (IFVCNS and BOKU) and one group focusing on the agronomy (DISTAL). In spring 2018a twinned experiment comparing 2 camelina lines selected by IFVCNS (NS Slatka and NS Zlatka) and 6 lines selected by BOKU (CA13X_1S-21, CJ6X-78, CK1X-129, BGRC-51558, CU005 and CJ13X-115) was set up at Bologna (Italy, 44°30' N, 11°21' E, 28 m a.s.l) and Rimski Šančevi (Serbia, 45°20' N, 19°51' E, 84 m a.s.l). The trial was arranged as a randomized complete block design with three replicates. The experimental protocol in terms of plot size, seeding rate and agronomic management was the same in the two locations, while sowing date was optimized according to local environmental conditions. Different earliness among tested spring camelina lines was highlighted in Bologna, with line CJ13X-115 showing a significant delay both in flowering and maturity stage compared to all the other lines. Due to sub-optimal weather conditions in Bologna (i.e. high temperature and exceptional wetness during spring) disease pressure resulted quite high and some camelina lines were more susceptible to downy mildew (*Hyaloperonospora camelinae*) than others, this trait needs to be better investigated with future specific experiments. The high susceptibility of camelina to dodder (*Cuscuta* sp.) has been confirmed with a massive infestation of this parasitic plant in Bologna trial this year. White rust (*Albugo candida*) and *Hyaloperonospora camelinae* were dominant diseases in Serbia affecting all genotypes by mid-June, which clearly impaired plant growth and yield formation. The full characterization of tested camelina lines in terms of seed and biomass yield, plant height at harvest and seed quality will be also presented aiming at an exhaustive characterization of these new spring camelina genotypes.

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PHYTOREMEDIATION POTENTIAL OF HEAVY METAL CONTAMINATED SOILS BY *CRAMBE* SPP. UNDER IRRIGATION WITH WASTEWATERS

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The European oleochemical industry currently relies on imported coconut and palm kernel oils, and castor oil as sources for medium-chain fatty acids and medium-chain polymer building blocks. These are used for the production of plastics, surfactants, detergents, lubricants, plasticisers and other products. Oil crops, such as crambe (*Crambe abyssinica* R.E.Fr.), and camelina [*Camelina sativa* (L.) Crantz.] are being considered as new options as feedstock for the oleochemical industry. Yet, the increasing demand for biomass for the production of bioenergy is generating land-use conflicts which might be avoided through the establishment of dedicated energy crops on marginal land, e.g. heavy-metal contaminated land. Moreover, the need to irrigate biomass during cultivation can cause the depletion of water resources, an environmental constraint in the Mediterranean region, due to water scarcity. In this context, this research work aims to study the potentiality of the oil crop crambe grown in heavy metal contaminated soils and irrigated with wastewaters. Two different heavy metals were tested (Zn and Pb) at three different contamination levels (0, 450, and 900 $mg.kg^{-1}$) under different irrigation regimes (tap water and wastewater). Throughout the experiment, in pots, percolated waters were analyzed in terms of ammonium and nitrate ions, as well as pH, conductivity and chemical oxygen demand in order to evaluate if the "soil-biomass system" was capable to prevent contamination of the ground and surface waters due to irrigation with wastewaters. Crambe biomass production was not affected either by the Zn contamination and the Pb contamination. Irrigation with wastewaters did not affect either the yields obtained. Biomass obtained in heavy metals contaminated soils presented higher ash content and higher Zn/Pb content then biomass from non-contaminated soils, thus showing phytoextraction and accumulation capacity. An average seed yield of 0.51 g (dry matter)/pot was obtained with crambe. Nevertheless, it will be mandatory to quantify and characterize the oil content obtained from the seeds to evaluate if heavy metals contamination and irrigation with wastewaters have an effect. Crambe showed capacity to trap the nitrogen of the wastewaters. Nitrates and ammonium ion analyzed monthly in the percolates showed that the "soil-biomass" system was able to remove more than 90% of the incoming nitrogen pollutant compounds. The soil-biomass system also showed phytostabilization of the heavy metals contamination as the leaching of heavy metals to groundwater contamination from the contaminated soils was prevented.

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EFFECT OF SEEDING RATE ON PENNYCRESS AGRONOMIC PERFORMANCES ACROSS CONTRASTING ENVIRONMENTS

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Among emerging non-food oilseed species, pennycress (*Thlaspi arvense* L.) has attracted considerable attention in the scientific community since it possesses many traits that can easily support its integration in existing rotation systems. Pennycress is highly cold-tolerant and provides a living cover over winter, reducing soil erosion and nutrient leaching, furthermore the shortness of its cycle easily allow double cropping. Due to the presence of seed dormancy accompanied by a very slow growth during winter months, the definition of an effective seeding rate allowing an optimal stand establishment and guarantying good competition against weeds still remain an open question for pennycress. At this scope similar field experiments to identify the optimal seeding rate for pennycress were established under contrasting environmental conditions, at Bologna (Italy, 44°30' N, 11°21' E) and at Morris, Minnesota (USA, 45°35' N, 95°54' W). Despite similar latitudes the two locations are characterized by diverging climatic conditions: the mean annual temperature is 5.6 °C in Morris and more than double in Bologna (13.4 °C). Annual precipitation is similar (~ 650 mm $year^{-1}$) but in Italy the majority of rainfall occurs during winter, while in Minnesota it occurs during the summer months. Five different seeding rates (250, 500, 750, 1000 and 1500 seeds m^{-2}) were tested in Bologna during 2017-18 growing season. In Morris three increasing seeding rates corresponding to about 300, 600 and 900 seeds m^{-2} were tested during 2014-16. In Italy the pennycress line Elisabeth, supplied by ARS-USDA, were tested while in Minnesota the lines MN-106 and Beecher were compared under the different seeding rate. Sowing was performed in September in both locations. Winter survival was satisfactory in both environments, generally better stand establishment was associated to increased seeding rate. Plants in Bologna were much taller at harvest than those in Morris (91 vs. 57 cm), probably in relation to milder temperature allowing unhindered growth to pennycress during the whole winter. Pennycress seed yield in Morris was highly influenced by environmental conditions reaching on average of all treatments 0.6 Mg DM ha^{-1} in the 2014-15 and just 0.2 Mg DM ha^{-1} in 2015-16. In Bologna seed yield was on average of all treatments slightly higher (0.7 Mg DM ha^{-1}), but differences among seeding rates became evident at densities >1000 seeds m^{-2} which had significantly higher seed yields. The full characterization of seeds in terms of oil content and fatty acid composition will also be performed with respect to the effect of seeding rate and environment on pennycress potential productivity.

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RICINUS COMMUNIS L. GROWTH UNDER WATER STRESS CONDITIONS

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Marginal land unsuitable for food production is consistently proposed as a viable alternative to minimize land-use competition for food production. One of the main natural constrains for marginality is dryness, i.e. the imbalance in the water availability for a normal rainfed crop. This imbalance consists of low total precipitation and high evapotranspiration demand, resulting in a low soil water content and low carrying capacity of the agro-ecosystem. The cultivation of selected industrial crops in such areas could support the production of resource-efficient feedstock for a growing bio-based industry, and could contribute to increase farmers' incomes through access to new markets and the revalorization of the marginal land. Castor bean (*Ricinus communis* L.) is a major industrial oil-yielding crop belonging to the Euphorbiaceae family. It is indigenous to Africa and India, but currently is being cultivated in not less than 30 countries in the world. Its seed oil is an important commodity for a number of industries, ranging from pharmaceuticals to renewable energy resources. The global castor oil seed production amounted to 1.8 x 10^6 Mg in 2015, with India being the largest producer (1.5 x 10^6 Mg), accounting for 86% of global production. Castor bean is predominantly grown in arid and semiarid regions worldwide and can be considered a sustainable alternative crop for cultivation in marginal lands because it has considerable ability to survive under stressful conditions, such as little available nutrition and water. The aim of this work was to investigate the morphological and physiological reactions of castor bean when subjected to water stress conditions and to assess its adaptability to dryness. A greenhouse pot experiment was accomplished using castor been seedlings exposed to three different water stress treatments: 70%, 55% and 45% of the available soil moisture. During the growing period morphometric and physiological parameters were measured, namely plant height, number of leaves, stem diameter, leaf water potential and stomatal resistance. After harvest, fresh and dry weights of the aerial biomass were determined. The results showed that the growth of the plants suffered the highest water stress treatment (45%) was significantly decreased. More specific, the plant height, stem diameter, number of leaves and the produced biomass (fresh and dry weights) were not affected by the treatments of 70% and 55% of the available soil moisture, while in high stress conditions (45%) they were significantly decreased. Under the high water stress conditions the leaf water potential (negatively) and the leaf stomata resistance were significantly higher (stomata closure). On the contrary, plants of intermediate and of low water stress were not significantly affected, indicating a possible tolerance of the crop to relatively low soil moisture content. The leaf water potential showed that there was a graduation in the water status of the plants depending to the stress levels. The highly stressed plants showed the worst water status (higher negative values of leaf water potential), while in the lower stressed plants the water potential values were less negative and closer to zero (turgor point). Stomatal resistance values were higher in high water stress (45%), suggesting the corresponding closure of the leaf stomata. In small and medium water stress, the stomata remained open, indicating that the castor bean plants are resistant to relatively low soil moisture values.

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COULD *JATROPHA CURCAS* L. BE A PROFITABLE CROP FOR CULTIVATION IN MOROCCO?

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JatroMed project was a 5-year demonstration project involving five countries from the Mediterranean region: Greece (coordinator), Italy, Egypt, Morocco and Algeria. The main scope of the project was to reinforce and upgrade the natural and socioeconomic conditions of depressed rural areas of the North African partner countries, and to give local farmers and population the opportunity to produce sustainable energy to cover their needs by establishing *Jatropha curcas* L. plantations of even few hectares. The JatroMed project was finalized in 2016, with the results and conclusions presented here for the case of Morocco, were a demonstration field (4 ha) has been established in the commune Had Draa of the Essaouira Region. An economic analysis supported the main project objective by identifying the cost figures relevant to such small plantations and the related benefits to the local population. This analysis has been conducted by applying the Activity Based Costing (ABC) software, following the Discounted Cash Flow (DCF) method, with the aim to calculate the annual equivalent production cost of jatropha, divided into the main cultivation activities. The plants of four genotypes (from Mexico, Mali and two from India) were treated with different fertilization (Urea or NPK 20-20-20), irrigation (4 L/8 L) and pruning (tree- or cup-shaped) combinations. The field data were divided into labor, machinery, energy, and raw materials. The analysis showed that the annual equivalent production costs was high, in the range of 1623-2086 $/ha, since many activities have been considered that are not always necessary, such as the pre-cultivation in nurseries and the installation of an irrigation system. Land rent, mechanical weed control, land preparation, and fertilization have the higher contribution on this with about 232-290 $/ha each. However, for the cases of small family farms, this production cost can be greatly reduced, since many activities could be avoided, and in case the farmer owns the land and has no labor costs, the annual production cost is reduced by about 1159 $/ha (464-927 $/ha), with the remaining costs mostly for fertilizers and energy/fuel. Even though the plantation in Morocco was very well established and the plants were growing very well, the harvested quantities of seeds were extremely low. The best-performing genotype was Mali that gave a maximum yield of 58 kg/ha, with very similar quantities for all treatments. These quantities have been extrapolated in future years, leading to a steady production of 0.2 Mg/ha after the fifth harvesting year, which is much lower than the reported maximum yields of 5-12 Mg/ha. Using an approximate jatropha seed price equal to 232 $/Mg, the annual income is just 46 $/ha. It becomes clear that the net income is always negative, making this plantation not financially sustainable. Even if the wastes (biomass by-products) are further utilized as fertilizers, still the net income remains below zero. In conclusion, it becomes clear that it is not possible for the *J. curcas* plantations to become cost-effective and bring some income to local farmers in Morocco. Similar conclusions have been also reached in Egypt. Further research is needed on genetic improvement of this crop, so as to have genotypes more productive, more tolerant to cold and non-toxic.

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SAFFLOWER AND CASTOR TWO PROMISING INDUSTRIAL CROPS TO BE GROWN ON MARGINAL LANDS

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Safflower (*Carthamus tinctorius* L., Asteraceae) is an annual oilseed crop that can be found in Asia, Africa and Europe and it is mainly cultivated for its seeds (birdseed or edible oil production). It was also grown for its flowers used for coloring and flavoring foods and making dyes, especially before cheaper aniline dyes became available, and in medicines. Safflower is a highly branched, herbaceous, and thistle-like, usually with many long sharp spines on the leaves. Plants are 30 to 150 cm tall with globular flower heads (capitula) and, commonly, brilliant yellow, orange or red flowers. It can be cultivated both as winter or spring crop. It has a strong taproot and thus thrives in dry climates. When it is cultivated as winter crop irrigation could be avoided. Castor (*Ricinus communis* L., Euphorbiaceae) is annual spring oilseed crop native of the Mediterranean region. Its seeds are source of ricin oleic acid with numerous chemical and medicinal applications. Its oil it is largely worldwide and the growth of its consumption is limited by insufficient and unreliable feedstock supply rather than the industry demands. The majority of the castor seeds are being produced on small-scale farms in four countries, India, China, Brazil, and Mozambique. It is a crop that cannot tolerate low temperatures and it can be grown on marginal lands (grows best on moderately fertile), which are not competitive with food (economic viable solution for non-productive lands). It can tolerate pH 5.5-6.5 and saline soils. In the framework of the European research project namely MAGIC (www.magic-h2020.eu, H2020) both of the aforementioned crops has been selected as promising industrial crops to be cultivated on marginal lands as feedstock for biobased products and bioenergy. In Greece, a marginal area had been selected in central Greece (Aliartos; Viotia) that had been left fallow for almost a decade due its low productivity. The field area had unfavorable soil texture, low organic matter (less than 1%) and it had a shallow soil depth. Two field trials had been established; one for each crop. In the safflower trial, two cultivars (one high-linoleic one imported from France and one high-linoleic imported from Chile). In castor trial four castor hybrids (C854, C855, C1008, C1016) produced by KAIIMA company (from Israel) was compared in three blocks. Both trials had been established as spring annual crops; safflower was established by hand on 19 March 2018 and castor on 2 April 2018. The distances between the rows were 50 cm for safflower and 70 cm for castor, while within the rows was 25 cm for both of them. It is anticipated that the final harvest for safflower to take place in the first part August 2018, while for castor a month later. At the final harvest the plant height will be measured. An area of 4 m^2 per plot will be harvested and the total biomass will be weighted and then the seeds will be separated and will be weighted. Samples from the residual biomass will be taken for dry content determinations, for proximate and elementary analysis as well as for the determination of the calorific value (net and fixed). Oil analyses on the collected seeds for each tested cultivar/hybrid will be collected and the oil content and the oil profile will be measured. Finally, the yields for both crops on the marginal area will be compared with the achieved ones on previous years in a nearby agricultural area with reduced soil fertility and the results will be further discussed.

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