AAIC 2023, ASSOCIATION FOR THE ADVANCEMENT OF INDUSTRIAL CROPS

2023 Conference Host

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President's Welcome

Welcome to the 34th Annual Meeting of the Association for the Advancement of Industrial Crops (AAIC 2023). This year's conference has a full slate of presentations distributed across the societies five Divisions: Fibers and Cellulosic Crops, General Crops and Products, Medicinal and Nutraceutical Plants, Natural Rubber and Resin, and Oilseeds. A host of internationally recognized experts will provide the six invited plenary, 54 oral - including 5 invited keynote speakers, and 24 poster presentations covering a wide range of topics associated with the advancement of industrial crops and products. The half-day field tour and excursion will allow in person participants to visit sites growing and processing industrial crops in Oregon, and the closing awards banquet will provide an opportunity to honor our deserving colleagues. On behalf of the AAIC board of directors and division chairs, thank you for participating at AAIC 2023.

AAIC BOARD OF DIRECTORS

President:	James V. Anderson, USDA-ARS, ETSARC, Fargo, ND, USA
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Division Chairs

Fibers & Cellulosic Crops	Marisol Berti, North Dakota State University, Fargo, ND, USA
General Crops & Products	Efthymia Alexopoulou, CRES, Athens, Greece
Medicinal & Nutraceutical Plants	Diana Jasso De Rodríguez, Universidad Autónoma Agraria Antonio Narro, Saltillo, México
Natural Rubber & Resin	Guangyao (Sam) Wang, Bridgestone Americas, Inc., Eloy, AZ, USA
Oilseeds	Hussein Abdel-Haleem, USDA-ARS, Maricopa, AZ, USA

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CONFERENCE PROGRAM

Sunday, August 27

1:00-3:00 PM	New Crops CGC Meeting	CH2M HILL Alumni Center – Ballroom 110A
3:00-5:00 PM	AAIC Board of Directors Meeting	CH2M HILL Alumni Center – Ballroom 110B
3:00-6:00 PM	Registration Desk Open & Poster Set Up	CH2M HILL Alumni Center – Foyer
6:00-8:00 PM	**Welcome Reception**	**CH2M HILL Alumni Center – Ballroom 110C**

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CONCURRENT SESSION
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Moderator: *Diana Jasso de Rodríguez*
Room: CH2M HILL Alumni Center – Ballroom 110A

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CONCURRENT SESSION
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Wednesday, August 30

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CONCURRENT SESSION
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Moderator: *Hussein Abdel-Haleem*
Room: CH2M HILL Alumni Center – Ballroom 110A

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5:30-8:00 PM	**AAIC Awards Banquet - CH2M HILL Alumni Center – Ballroom 110C**		

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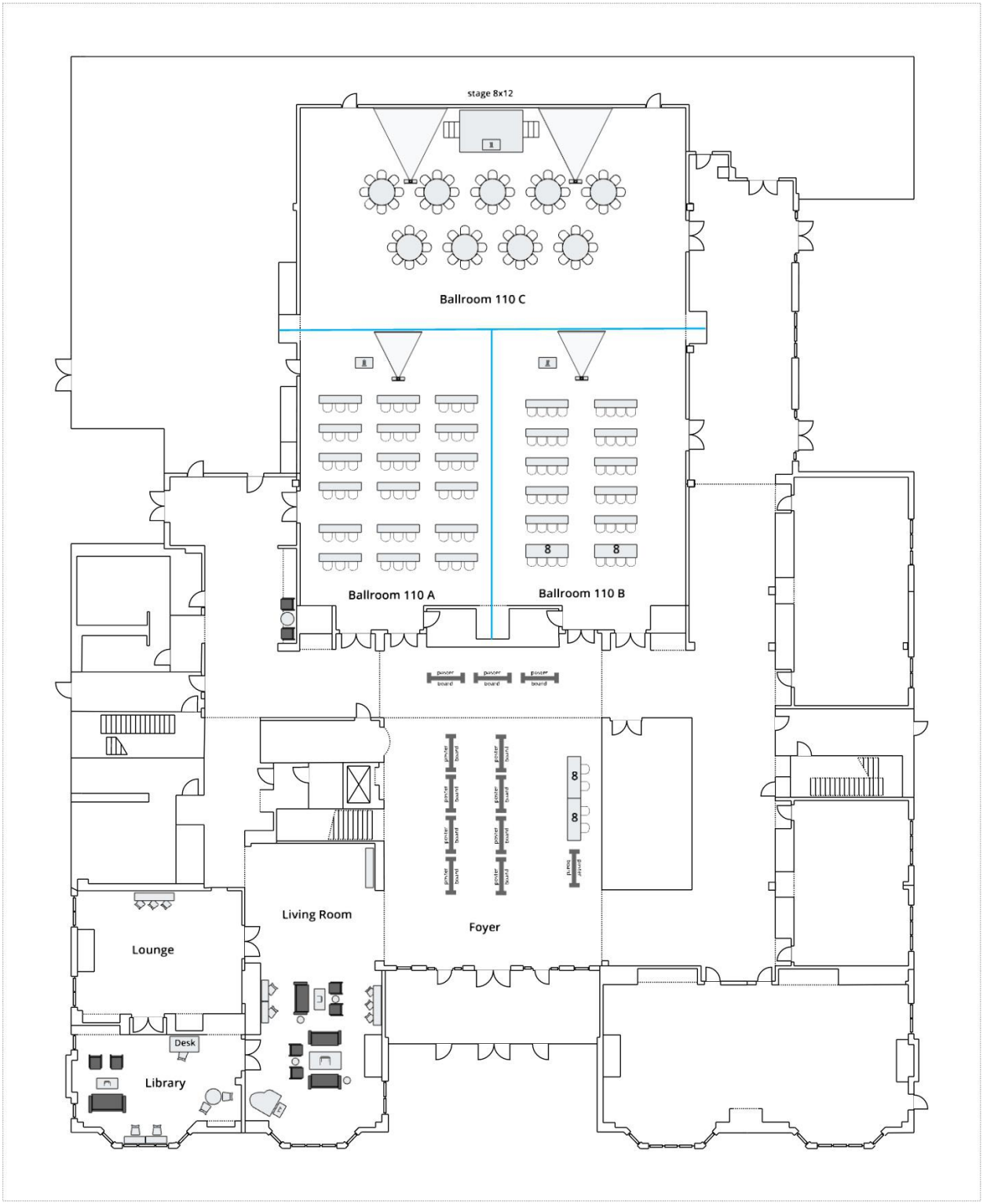
CH2M HILL Alumni Center



ABSTRACTS

PLENARY SESSION PRESENTATIONS

Moderator: Valtcho D. Jeliazkov (Zheljazkov)

ARE THERE DOWNSIDES TO CROPPING HEMP?

Jay S. Noller

GHIC, Oregon State University, Corvallis, OR, USA

Hemp (*Cannabis sativa* L.) is a puzzling crop for farmers in the United States as shown by the number of licensed hemp growers: from just a few hundred in 2014 to over 20,000 in 2020 and back down to a couple thousand in 2023. Proponents declare "Unlock the potential of hemp farming! With its adaptability to diverse climates and soils, growing hemp is a breeze. This low-maintenance crop is gaining momentum as the demand for hemp products skyrockets. Brace yourself for the booming global market, projected to hit a staggering $75 billion by 2025. Join the wave fueled by the rise of cannabidiol (CBD) and Dx-THC products and the quest for sustainable materials. Embrace the future of farming with hemp!" While there are known and potential benefits to cropping hemp, there are downsides that need to be considered; (1) Market Volatility: While the demand for hemp and hemp-derived products is growing, the market can be volatile and unpredictable. Prices for hemp products, such as CBD oil or bast fibers, can fluctuate due to factors like oversupply, changes in consumer preferences, regulatory changes, and competition. Volatility in the USA is due to the hemp industry's ever-evolving production and synthesis of minor cannabinoids to meeting shifting consumer tastes and corresponding legal enforcement of evolving laws and regulations. This volatility poses challenges for farmers trying to establish a stable and profitable market for their hemp crops, be that for production of cannabinoids, grain, or fiber. (2) Limited Infrastructure: The infrastructure for processing hemp crops can be limited in some regions. Farmers need access to facilities for drying, processing, and extracting various components of the plant. Without adequate infrastructure nearby, transportation costs and logistical challenges can arise, impacting the profitability and efficiency of hemp production. (3) Regulatory Challenges and Risk of THC Non-Compliance: Hemp is legally required to contain a low THC concentration (below 0.2-0.3%) to be considered industrial hemp. However, hemp plants can sometimes exceed this threshold due to genetics, environmental factors, or cultivation practices. If a hemp crop surpasses the legal THC limit, it may be deemed illegal, leading to crop destruction and legal consequences. Scholars can help dampen the volatility and uncertainty in hemp cropping systems through agronomic research. Attention must be paid to the alignment of hemp production with processing and end-use product development in their specific region as well as approachable distant markets.

Contact: Jay "Strat" Noller, Department of Crop and Soil Science, Oregon State University, Strand Agriculture Hall 258, 170 SW Waldo Place, Corvallis, OR 97331 (USA), Email: jay.noller@oregonstate.edu

OREGON HEMP REGULATIONS: A COMPREHENSIVE OVERVIEW

Sunny Summers

Oregon Department of Agriculture, Salem, OR, USA

The hemp (*Cannabis sativa* L.) industry has gained significant momentum in recent years, with Oregon emerging as a key player in this rapidly evolving market. However, understanding and complying with the complex web of regulations surrounding hemp cultivation, processing, and distribution can be challenging. This presentation aims to provide a comprehensive overview of the current hemp regulations in Oregon, exploring key aspects such as licensing requirements and testing protocols - testing hemp and hemp-derived products, focusing on THC content, pesticide residue, and microbial contaminants. This includes the use of third-party testing, and the specific requirements to meet compliance standards. Furthermore, this presentation includes the Oregon Liquor Control Commission's regulations for hemp-derived products. Participants will gain valuable insights into the regulatory landscape of hemp in Oregon.

Contact: Sunny Summers, Senior policy advisor, Oregon Department of Agriculture – Directors Office, 635, Capitol St NE, Salem, OR 97301-2532; Phone:503.986.4565, Email: sunny.summers@oda.oregon.gov

CARLINA ACAULIS ESSENTIAL OIL: A POTENTIAL PHYTOTOXIC AGENT FOR WEED MANAGEMENT

Eleonora Spinozzi[1], Marta Ferrati[1], Sara Álvarez-Rodríguez[2], Adela M. Sánchez-Moreiras[2], Fabrizio Araniti[3], Loredana Cappellacci[1], Riccardo Petrelli1, Filippo Maggi[1]

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Weeds are plants causing severe constraints in agricultural production, competing with crops for water, gases, nutrients, space, light, and other growth resources. Consequently, weed management is a key agronomic practice, and synthetic pesticides represent a common approach. However, their constant use led to the onset of herbicide resistance, residue in crops, ecological imbalance between harmful and beneficial organisms, and environmental pollution. For this reason, research has focused on developing more sustainable and environmentally friendly weed control alternatives. In this context, essential oils (EOs) are natural products that are gaining increasing attention for their industrial employment as eco-friendly herbicides for weed management. *Carlina acaulis* L. (Apiaceae) is a traditional European medicinal plant whose root EO was reported as a promising tool against insect pests and vectors. This work investigated for the first time the phytotoxic potential of the EO against the weed *Bidens pilosa* L. revealing a strong phytotoxic effect on the plant metabolism, such as leaf necrosis, reduction of relative water content, and an increase in the dry weight/fresh weight ratio. The EO also damaged the photosynthetic system, with a substantial reduction of the effective quantum yield of photosystem II (Φ_{II}) and the maximum quantum yield of photosystem II (F_v/F_m). The damage to photosystem II was further proved through the reduction of manganese and calcium concentrations, possibly due to an alteration in the correct functionality of the Mn_4Ca cluster of the PSII. This work was accompanied by a metabolomic analysis that revealed an accumulation of branched-chain amino acids. This is normally related to osmotic alterations under drought stress situations and a general reduction in sugar content, suggesting a reduction of the photosynthetic efficiency too. In conclusion, these results indicate *C. acaulis* EO as a promising natural phytotoxic agent against weeds.

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EXTRACTS OF *ACMELLA OLERACEA* R.K. JANSEN AS PROMISING CANDIDATES FOR STORED-PRODUCT INSECT PEST MANAGEMENT

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The infestation of stored products by noxious insects has represented a big issue causing the extent of loss in commodities, variation in their nutritional quality, dissemination of toxins by microorganisms, and associated health complaints. However, the increasing environmental concerns provide for the reduction of chemical pesticides. In this regard, botanicals are gaining great attention, and *Acmella oleracea* R.K. Jansen, a widely cultivated industrial plant, has recently shown a high efficacy against several insects. The interest in this plant mainly depends on its biologically active constituent, spilanthol belonging to the class of *N*-alkylamides. In this context, the aims of the work were the optimization of an extraction protocol to obtain *N*-alkylamides rich-extracts and the evaluation of their efficacy against noxious stored products-attacking arthropods of different species and developmental stages. The Soxhlet apparatus led to the highest extraction yield, and it was selected to prepare methanol and hexane extracts. Methanol is the most efficient solvent for spilanthol recovery, whereas *n*-hexane is able to extract the highest concentration of *N*-alkylamides. Both extracts were effective against most of the tested species, e.g., *Cryptolestes ferrugineus, Tenebrio molitor, Oryzaephilus surinamesis, Trogoderma granarium, Tribolium castaneum, Tribolium confusum, Alphitobius diaperinus,* and *Acarus siro.* Moreover, the *n*-hexane extract showed higher efficacy with respect to methanol extract against most insect species. Our study, together with the already established large-scale cultivation of the plant, provides new perspectives for the industrial employment of this plant for the development of novel eco-friendly botanical pesticides.

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PRACTICAL APPROACHES TO UNLOCKING MEADOWFOAM SEED YIELD POTENTIAL IN THE WILLAMETTE VALLEY OF OREGON

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Maximizing seed yields of meadowfoam (*Limnanthes alba* Benth.) production in the Willamette Valley to allow for expanded production acreage. Meadowfoam is a crop that is very suitable for sustainable no-till production systems in the Willamette Valley and for rotating key grass species to maintain standards for certification. There are currently 4047 ha (10,000 acres) of meadowfoam grown in the Willamette Valley each year; there is very likely rotational capacity and demand for twice that amount. The key is its economic competitiveness. Meadowfoam seed oil is a vegetable oil, and it finds its primary market in the personal care and cosmetic industry where it competes with many other natural oils and botanicals for market share. One key to unlocking expanded acreage and greater price point competitiveness in the end use markets is to tap into a greater share of its seed yield potential. It is commonly thought that commercial seed yields of meadowfoam should be able to achieve a level near 2690 kg/ha (2400 pounds per acre) or more. To date while the occasional yield of 1682-2017 kg/ha (1500-1800 pounds per acre) can be achieved, typical yields tend to average 1065-1177 kg/ha (950-1050 pound per acre). While this is a substantial improvement from the 673-785 kg (600-700 pound) yields observed in the late 1990's and early 2000's ongoing agronomy work is being pursued to unlock this yield potential of meadowfoam to enhance its utility as a key component of Willamette Valley cropping systems. This has taken a multi-level approach utilizing plant breeding, analysis of disease impacts, the impacts of different crop production methodologies, and manufacturing strategies to accomplish this goal. This presentation will take an in-depth view of the continuing pursuit of these strategies.

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ALTERNATIVE AND SPECIALTY CROPS FOR PRODUCTION OF BIOACTIVE PHYTOCHEMICALS

Charles L. Cantrell

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The use of specialty and alternative crops to produce bioactive and high value phytochemicals has been well established and documented with classical examples including the production of morphine from opium poppy or the production of pyrethrum extract which is isolated from *Chrysanthemum cinerariifolium* flowers. More modern examples include the production of steviol glycosides, which are isolated from the leaves of *Stevia rebaudiana,* to produce an artificial sweetener or the isolation of podophyllotoxin from *Sinopodophyllum hexandrum* to serve as a starting synthon to synthesize the anticancer drug etoposide. Summarized in this talk will be the efforts underway within the Natural Products Utilization Research Unit (NPURU) to generate specialty and alternative crop opportunities, with medicinal, nutraceutical, and pesticide applications for isolated bioactive constituents and their preparations. Highlighted examples will be the production of capsinoids, the non-pungent analogs of capsaicinoids, from *Capsicum* species and genotypes. Also discussed will be opportunities for production of mosquito (*Culicidae* family) repellents from breadfruit (*Artocarpus altilis*) male inflorescences as well as the production of a triketone enriched herbicide from manuka (*Leptospermum scoparium*) oil.

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TURMERIC (*CURCUMA SPP.*): A POTENTIAL INDUSTRIAL CROP FOR NORTH ALABAMA

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Turmeric (*Curcuma* spp.), used in Indian medicine for over 4000 years, is now gaining popularity in the US as a health supplement to combat inflammatory diseases, memory loss, and immune deficiency, among many others. A lack of high curcumin turmeric varieties adapted to the southeastern US is a major limitation to its production in the US. Therefore, field trials were conducted between 2007 and 2022 at Alabama A&M University to assess a wide range of turmeric genotypes obtained from Vietnam and other sources for identifying genotypes best suited for commercial production. In the first phase (2007 - 2012), 15 genotypes were evaluated for adaptation, yield, and curcumin content; in the second phase (2015 - 2019), 52 varieties of Vietnamese origin were assessed for developing high-curcumin varieties to cater to the medicinal plants industry; and in the third phase (2019 – 2022) season extension methods (high tunnel, cold plasma, hot water, and heat pad treatments) were evaluated to extend turmeric growing season to enable higher rhizome yields and curcumin accumulation. Five genotypes were planted in single-row plots arranged in a RCBD with four replicates. Three plants from the middle row of each plot were harvested to determine fresh and dry rhizome yields and their curcumin and essential oil (EO) components. In Phase 1 trials, the fresh rhizome yield ranged from 9 to 28 MT/ha and the genotypic differences were significant. The curcumin content varied from 0% in *C. zedoaria* genotypes to 2.5% in *C. longa* genotype (CL6). The yield of Vietnamese genotypes ranged from 0 to 18.1 MT/ha. The total curcumin content was zero for all black and white turmeric and 6.8% for red turmeric varieties. Rhizomes subjected to cold plasma, hot water, or heat mats sprouted a week to 4 weeks earlier and produced higher rhizome yields than the control. Production in high tunnels extended the growing season by 4 to 6 weeks, resulting in 8 to 26% higher yield and curcumin content compared to those grown in open fields. The essential oil content varied between 0.204% and 0.695%. The major components in the essential oils were α-phellandrene (3.7-11.8%), 1,8-cineole (2.6-11.7%), α-zingiberene (0.8-12.5%), β-sesquiphellandrene (0.7-8.0%), *ar*-turmerone (6.8-32.5%), α-turmerone (13.6-31.5%), and β-turmerone (4.8-18.4%). In another study, the dominant EO components were curzerone (14.7-18.6%), germacrene (10.7-14.7%), 1,8-cineole (5.2-11.7%), *ar*-turmerone (8.3-36.1%), α-turmerone (12.7-15.2%), β-turmerone (5.0-15.4%), α-zingiberene (4.6-13.9%), and β-sesquiphellandrene (4.6-10.0%). The distinctly different oil components in turmeric varieties studied could be potent against different diseases, particularly cancers.

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ABSTRACTS

MEDICINAL AND NUTRACEUTICAL PLANTS DIVISION

ORAL PRESENTATIONS

CHAIR

DIANA JASSO DE RODRÍGUEZ

UNIVERSIDAD AUTÓNOMA AGRARIA ANTONIO NARRO, SALTILLO, COAHUILA, MÉXICO

RESEARCH OVERVIEW ON HEMP (*CANNABIS SATIVA* L.) AGRONOMY, CANNABINOIDS AND ESSENTIAL OIL

Valtcho D. Jeliazkov (Zheljazkov)

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Industrial hemp (*Cannabis sativa* L.) is one of the oldest crops cultivated and wildcrafted for fiber and grain food. It was extensively grown in the U.S. until the 1930s. With its numerous properties including nutritional, industrial, medicinal, and psychotropic, hemp offers a wide range of uses and applications. The "Farm Bill," officially known as the US Congress Agricultural Act of 2014, granted authorization for the cultivation of hemp. According to this bill, hemp is defined as "the plant *Cannabis sativa* L. and any part of such plant, with a delta-9 tetrahydrocannabinol (THC) concentration of not more than 0.3 percent on a dry weight basis. "Under the 2014 Farm Bill, "Institutions of higher education" and state agriculture departments were permitted to grow hemp as part of a pilot program, provided it was allowed under state law. However, certain aspects of production still fell under the oversight of the Drug Enforcement Administration. In 2018, the Farm Bill legalized hemp production as an agricultural commodity and categorizing it as a covered commodity crop eligible for crop insurance. This presentation will provide an overview of hemp plant secondary metabolites, focusing on cannabinoids and essential oils. It will also touch upon some agronomical aspects of different types of hemp. Our research has focused on analyzing the differences in cannabinoids and terpenes among industrial, wild, and cannabinoid-type hemp varieties. We have also investigated the effects of postharvest preparation, such as grinding and fractionation during distillation, on hemp essential oil and its antimicrobial activity. Additionally, we have explored the valorization of cannabidiol (CBD)-hemp through distillation to obtain essential oil and enhance the cannabinoids profile. Furthermore, we have examined changes in terpene and cannabinoid yield and profile in relation to direct-seeded non-feminized and transplanted feminized plants from the same genotype, as well as explored green extraction methods for hemp. In addition, an update will be provided on our project “Hemp Education Initiative: Development of an online undergraduate and graduate certificates in hemp”.

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WINTER SAVORY (*SATUREJA MONTANA* L.) ESSENTIAL OIL PROFILE IS INFLUENCED BY CLIMATE IN THE BALKANS?

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Aromatic and medicinal plants are well known for and used in treating different illnesses. Increased awareness of antibiotic overuse and super strains of microorganisms has increased the search for alternative compounds from natural sources. *Satureja montana* is used in the traditional medicine and flavoring industry due to its high essential oil (EO) content. Previous studies of this species have shown high variability in EO composition and, thus, the medicinal properties of the source plant. Our research aimed to resolve the question of this high variability. For this purpose, samples of three *S. montana* subspecies were collected from fourteen wild-growing populations from the Balkans. The samples were collected during the full flowering stage between 2012 and 2021. The individual EOs were extracted from air-dried material using simultaneous distillation and extraction (SDE) and analyzed using gas chromatography coupled with mass spectrometry (GC-MS). The EO composition was dominated by monoterpenes (70.3-88.2%), followed by sesquiterpenes (8.1-25.0%). Almost one-half of the individuals had phenols (carvacrol and thymol) as dominant components, while others had aromatic, linear, or circular monoterpenes (*p*-cymene, linalool, geraniol, *cis*-sabinene hydrate). This led to the identification of five chemotypes, which showed geographic-specific distribution, separating coastal from continental populations. The dominant chemotypes in coastal populations (temperate climate with hot summers) were carvacrol and thymol, while *p*-cymene, linalool, *cis*-sabinene hydrate, and geraniol were more common in continental populations (colder climate with warm summers), irrespective of infraspecific taxonomy. Univariate and multivariate statistical tests were used to study the correlation between chemotype distribution and different environmental parameters, confirming strong genetic control of chemical composition. These findings can contribute to domesticating specific chemotypes with desired EOs profiles since the above-mentioned compounds have various biological activities. Also, suggestions on different areas of protection are proposed to ensure the proper conservation of genetic diversity.

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EYSENHARDTIA TEXANA S. LEAF EXTRACTS HAVE ANTIOXIDANT AND ANTIMICROBIAL ACTIVITIES

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Bacterial infections are a serious threat to the health sector, as many of these microorganisms have developed heightened resistance to pharmacological treatments. Turning to plant extracts, particularly those of the arid zone of Mexico, proves to be an innovative solution due to their outstanding composition; known for providing antioxidant, antimicrobial and anticancer properties. *Eysenhardtia* genus plants have exhibited notable potential in controlling the development of clinical bacterial strains; although less is known about *E. texana* (common name "palo dulce"), despite it being widely found in Mexico. Therefore, the objectives of this work were to evaluate the potential antimicrobial properties of *E. texana* leaf extracts for obtaining potential antibacterial agents and to determine their phytochemical composition. The physicochemical analyses of *E. texana* leaves were carried out according to the AOAC (Association of Official Analytical Chemists) Official Methods. Subsequently, solutions of 20 g of dry leaves in 400 mL of distilled water (AE), ethanol (EE) or hydroalcohol solution (50:50, v/v, HAE) were extracted under agitation at 150 rpm for 24 h at room temperature. The extracts were characterized in terms of yield, total phenolic compounds (TPC), antioxidant activity by the FRAP (Ferric Reducing Antioxidant Power) and ABTS (2,2-azinobis-(3-ethylbenzothiazoline-6-sulphonic acid) methods, and antibacterial activity *in vitro* against *Escherichia coli* and *Staphylococcus. aureus* expressed as minimum extract concentration required to inhibit 50% of the bacterial growth (MIC_{50}). In general, the results showed the influence of the solvent on the properties of the extracts, allowing higher ($p<0.05$) TPC when water was used as solvent, with values of 85.9±8.5, 59.6±2.4, and 46.4±1.8 mg of gallic acid (GA) per gram of extract for AE, HAE, and EE, respectively. Regarding the antioxidant activity, the EE and HAE showed similar reducing power, in the range of 271-288 μM Fe(II)/g extract, while the AE had lower activity (104.8±2.0 μM Fe(II)/g extract). On the contrary, the AE presented higher antioxidant activity when the ABTS method was used. On the other hand, the HAE and EE inhibited *S. aureus* growth but not *E. coli*. This study provides information, for the first time, on the potential of *E. texana* as a new source of bioactive compounds with an interesting antioxidant and antimicrobial activity on clinical bacterial strains.

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STABILITY OF *LARREA TRIDENTATA* (DC.) COVILLE AQUEOUS EXTRACTS ENCAPSULATED IN *OPUNTIA FICUS-INDICA* (L.) MILL. MUCILAGE

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The study of phytochemicals has focused on their application in health due to their proven biological activity. However, the main problem with phytochemicals is their low availability to the organism due to their chemical nature and low absorption. That is the reason why the methods used for the extraction can control the concentration of phytochemicals. Due to their chemical composition and polarity, these substances contain different types of compounds, which can interfere with their application. However, affirming the availability or accessibility of these compounds is not guaranteed. For this reason, various materials have been developed to encapsulate and transport phytochemicals to guarantee their absorption and availability in the human organism. Among the most studied materials for this application, some emulsions, nanoparticles, and encapsulations stand out, which allow the delivery of substances of interest at a programmed speed and on a specific organ or system. Thus, this research aims to evaluate the stability of aqueous extracts of gobernadora (*Larrea tridentata*) using a nopal (*Opuntia ficus-indica*) mucilage as an encapsulant. The extracts were analyzed by liquid chromatography (LC MS-MS), the content of phenols and flavonoids was quantified, and their antioxidant capacity was determined. The chromatography analysis identified phenolic acids such as ellagic and some flavonoids such as quercetin and its derivates. Encapsulates were prepared by spray drying, and the stability of the extract was measured through the content of polyphenols and antioxidant activity over time. The obtained encapsulates were spherical particles in shape between 1.7 and 3 mm, which are thermally stable up to temperatures of 60 °C (> 90 % by weight). It was determined that the encapsulates retained functional groups that favor the interaction between the biopolymer and the extracts used. Regarding encapsulates stability, it was calculated that it maintained between 60 and 20% of phenols at the end of the experiment. This was correlated with the antioxidant activity of the encapsulated extracts, in which there was a 40-60% decrease 60 days after starting the experiment. It was concluded that nopal mucilage is a promising encapsulant for gobernadora extract.

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DO HIGH PLANT DENSITIES INCREASE HEMP (*CANNABIS SATIVA* L.) FLORAL BIOMASS AND CANNABINOID YIELD/VALUE IN FIELD PLANTINGS?

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The 2018 Federal Farm Bill allowed a dramatic increase in the legal crop production of hemp (*Cannabis sativa* L) in the US, accelerating a trend of some states that earlier legalized both hemp and marijuana for medicinal, recreational, and industrial uses. Production of hemp in Oregon and elsewhere increased rapidly in 2019-2021, mainly for production of cannabidiol (CBD) and other cannabinoids. Cannabidiol is produced in hemp's floral structures, but not in the stems and leaves. Many new hemp growers adopted methods used previously by (sometimes illegal) marijuana growers, such as growing plants on very wide spacing in the field (e.g., 150 x 200 cm plant spacing, or as few as 3400 plants ha^{-1}). Such spacing results in large, highly branched plants with multiple secondary and tertiary flower structures on the side branches. While the primary flower structure on top of the central plant axis is typically large and has high cannabinoid content, secondary and tertiary floral structures are often much smaller. Depending on the grower's market objectives, the number and size of primary flowers vs secondary/tertiary flowers per plant and per hectare can have a large impact on total cannabinoid yield and value. The objective of this study was to evaluate whether floral biomass and cannabinoid yield per hectare could be increased by increasing plant density, and secondarily to evaluate how increased stand density altered plant morphology and structure to determine if machine-harvest methods could be used instead of the traditional hand harvest of flowers. Over two seasons, a full-season hemp variety was direct-seeded into irrigated, sandy loam soil at the Southern Oregon Research & Extension Center, near Medford, OR. Seeding rates and row spacing were adjusted to result in a range of plant stand densities from about 8000 to 80,000 ha^{-1}. Each year, the densest stands had about eight times as many plants per hectare as the least dense plantings. Over the eight-fold increase in stand density, the stem + leaf biomass per plant decreased by about 4-fold, expressed as smaller plants having fewer side branches. Over the eight-fold increase in stand density, the biomass of secondary floral structures decreased by about 5-fold per plant, and the tertiary floral structures essentially disappeared at the higher densities. The concentration of CBD in primary or secondary floral structures remained almost constant at all stand densities. The net result of the changes in plant morphology with stand density resulted in a maximum CBD yield per hectare occurring at a stand density of between 45,000 - 60,000 plants per hectare. This is eight to twelve times the density commonly seen in production fields in southern Oregon. Implications for machine vs hand-harvesting, in-season crop management, market objectives, and related considerations will be discussed.

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BIOACTIVE COMPOUNDS OF SEMIDESERT PLANTS ON THE GROWTH AND YIELD OF TOMATO (*SOLANUM LYCOPERSICUM* L.)

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Recently, research has focused on the search for natural products applied to agriculture. In particular "Green chemistry", focus on the use of plant extracts containing biologically active compounds. In the semi-arid areas of northeastern Mexico, wild plants grow, with high concentrations of polyphenols and other secondary metabolites with important potential applications. In this context, the objectives of this research were: 1) to analyze phytochemically the extracts of three species from northeastern Mexico: *Rhus muelleri* Standl et Barkley (RM); *Flourensia microphylla* (A.Gray) S.F.Blake (FM), and *Cucurbita foetidissima* Kunt (CF) and 2) To evaluate the impact of the bioactive compounds of the extracts on the growth and yield of tomato (*Solanum lycopersicum* L.) plants. The methanolic extracts of the leaves of the three species were obtained and the content of total phenols (TFC) and the antioxidant activity were determined, and the identification of polyphenols by high performance liquid chromatography (UHPLC), in addition the extracts were analyzed by GC-MS. In the greenhouse, the extracts were evaluated in tomato plants in a completely random design with seven treatments: three species (RM, FM, CF), three phytohormones (IAA, 6BAP, GA) and one control, and each treatment with seven repetitions. The extracts were applied in three stages of plant development at 75 mg/L. The results from the chromatographical analyses confirm the presence of seven compounds on RM, six on FM and five on CF. Among these compounds were found phenolic acids and flavones. The vanillic acid, an hydroxybenzoic acid, was identified on the three extracts, and has been reported as a compound able to increase the plant growth on tomato plants. Furthermore, the phenolic acids; gallic, chlorogenic and caffeic acids were identified on RM and CF, and these compounds are known by their antioxidant property, as well as the ability to improve the development and growth of the roots in plants. The identification of compounds by GC-MS showed for RM, FM, and CF, ten, six and eight compounds, respectively. In RM, shikimic acid, which acts as a growth inducer, was identified. In the greenhouse, the RM treatment presented the highest number of fruits and yield per plant. In general, the phenolic compounds identified in the extracts show antioxidant activity and have bioregulator and biostimulant properties in crops. These activities could be due the structure of antioxidant compounds, and the hydroxyl configuration of each compound. This could demonstrate the potential of extracts as biostimulants to enhance plant growth for sustainable agriculture.

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ESSENTIAL OILS FOR POTATO (*SOLANUM TUBEROSUM* L.) SPROUT SUPPRESSION AT ROOM TEMPERATURE

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Potatoes (*Solanum tuberosum* L.) are a staple food worldwide but storing them effectively and for an extended period is necessary to ensure their availability throughout the year. Sprouting is a significant problem during potato storage, which, if not controlled in time, can lead to significant yield loss. Chemical sprout inhibitors like chlorpropham (CIPC) have been traditionally used to suppress potato sprouting successfully. However, the excessive and repeated use of these chemicals can adversely impact the environment and non-targeted vegetation, leading to health concerns if it reaches the food chain. The use of essential oils (EOs) has emerged as a safe and effective alternative to chemical sprout inhibitors for potato sprout suppression. Several EOs products, including Biox-M, Biox-C, Talent®, and ARGOS®, are being used in organic potatoes storage. This study aimed to evaluate the effect of several EOs on potato sprout suppression and identify the most effective ones. The study screened 20 EOs to identify the ones with the highest potato sprout suppression in three potato cultivars; Ranger Russet, Terra Rosa, and mini tubers of Trail Blazer. The results showed that EO 194 and EO 207 were the best treatments, preventing sprouting during the 60-day storage duration in all potato cultivars. Additionally, EO 205 and EO 206 can also limit and decrease the sprouts' number and length, making it a potential option for growers who want to reduce sprouting without completely inhibiting it. The most effective EOs were analyzed on GC/MS for chemical profile. The study highlights the importance of finding sustainable and safe solutions for potato sprout suppression and the potential of EOs in this regard. Essential oils can be an effective and eco-friendly alternative to chemical sprout inhibitors for potato sprout suppression. Further research needs to be conducted to explore the suitability of other EOs and their combinations for potato storage.

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VIRGINIA MOUNTAIN MINT [*PYCNANTHEMUM VIRGINIANUM* (L.)]: A POTENTIAL INDUSTRIAL CROP FOR NORTH ALABAMA.

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Virginia mountain mint (*Pycnanthemum virginianum* L.), a mint-flavored herb with diverse aroma profiles and high essential oil (EO) content, offers the potential for commercial applications similar to species within the *Mentha* genus. The genus is native to North America and the southeastern United States is considered as the center of diversity. However, very little is known about its production potential in North Alabama. The objective of this research was to assess adaptability, leaf biomass production, essential oil content and its composition by growing four Virginia mountain mint varieties in north Alabama. The four varieties were evaluated for their production potential as multiple year crops over three years in north Alabama. Four varieties (M1, M2, M3, & M4) were planted in field plots in 2020, and after three harvests [135 (H1), 155 (H2), and 170 (H3) days after planting], they were left to overwinter and regrow in 2021, and repeated in 2022. In each year, the varieties were compared for regrowth, above ground biomass (AGB) yield, and essential oil content and its composition. Essential oils were obtained by hydrodistillation and analyzed by gas chromatographic techniques. In Years 2 (2021) and 3 (2022), the four varieties sprouted in late March and were evaluated at two harvest times after regrowth (DAG). The seasonal total fresh AGB in Year 1 (2020) ranged from 125 g/plant to 809 g/plant. M1 and M2 produced a total fresh biomass of 699 and 561 g/plant, respectively. In Year 2 (2021), the percentage fresh AGB increased from Year 1 to Year 2 by 82, 66.5, 21.9 and 226.9% for M1, M2, M3, and M4, respectively. Similar to Year 2, the AGB of the three varieties increased further between 2021 and 2022 by 35.2, 51.9, and 71.7 for M1, M2, and M3, respectively. The increase in fresh AGB from the year of planting (2020) to the third year (2022) was 146.1, 152.9, 109.3, and 218.3%, respectively for M1, M2, M3, and M4 varieties. Thus, mountain mint regrowth in Years 2 and 3 increased between the years. At the first harvest in Year 1, the EO content of M1 was 1.15% and was higher than M2 (0.91%), M3 (0.76%), and M4 (1.03%). At first harvest in Year 2, the EO content of M1 and M3 increased to 4.91% and 1.85%, respectively, whereas the EO content of M2 and M4 decreased to 0.53 and 0.79%, respectively. In Year 1, the isomenthone concentrations increased significantly through the season, from 19.93% at H1 to 69.31% at H3 in M1 and from 18.1% at H1 to 65.83% at H3 in M3. However, it increased only slightly in M2 and M4. The thymol concentration decreased slightly but not significantly in all four varieties; the thymol in M2 and M4 was very high compared with M1 and M3. Varieties M1 and M3 with higher EO content, and plant and leaf biomass were the best performing varieties. The study showed that mountain mint offers potential for production in north Alabama, and farmers can maximize its yield and minimize production costs by growing the crop over multiple seasons.

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NATIVE, UNDERUTILIZED *ARONIA* BERRY: A NUTRACEUTICAL BOON

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Chokeberry (*Aronia* spp.) are woody shrubs of Rosaceae family which tolerate moist and dry soil conditions. The widely recognized species of *Aronia* are *A. melanocarpa* (Michx.) Ell. (black chokeberry), *A. arbutifolia* (L.) Pers. (red chokeberry), *A. prunifolia* (Marshall) Rehder (purple chokeberry), and *A. mitschurinii* A.K.Skvortsov & Maitul (Eurasian domesticated taxon, a hybrid of *A. melanocarpa* and *Sorbus* species). *Aronia* genus is of North American origin and known for its nutrient rich berries but is underutilized. *Aronia melanocarpa* is native to North America and grows up to 1 to 3 m tall with white blooms in June/July. When compared with other berries and vegetables, *Aronia* berries contain significantly higher antioxidant activity, polyphenols, and flavonoids and have anti- cancer, anti- diabetic and anti- neurodegenerative properties. *Aronia* as a nutraceutical crop has a market for its fortified food as well as personal care products such as, tea, juice, jams, low sugar bakery products, wine, herbal powder, face serum, and anti-aging cream. Demand for the *Aronia* plant is increasing and the species could be considered for north Georgia fruit growers. *In vitro* micropropagation protocols for desired cultivar of *A. melanocarpa* 'Viking' were developed in MS medium. Nodal explants were incubated at 25 ±2˚C with 16 h photoperiod for four weeks and the highest number of shoots was observed in MS+0.1µM BAP. Flow cytometry was used to test the ploidy of tissue culture raised plants that were found to be true to mother type. The plants grown in Fort Valley State University's experimental plot showed good vegetative growth, but flowering and fruiting was poor. Pollen germination and stigma structure and receptivity were studies in *in vitro* condition to ascertain reproductive barriers. Flowers at post-anthesis stage were collected and pollen grains were dusted in cavity slides with the germination medium, left in humidity chamber in dark for six hours. About 30% pollen germination was achieved. Pistils were first fixed in FAA, transferred to 70% ethanol after 24 hours, stained with safranin and then cleared in 1M NaOH for 60˚C to reveal a clear papillary layer and natural pollen germinated was observed on the surface of stigma. Results obtained on the antioxidant potential of *Aronia* berries will also be discussed.

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ABSTRACTS

NATURAL RUBBER AND RESIN DIVISION

ORAL PRESENTATIONS

CHAIR

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RESIN, RUBBER, AND OTHER CBSM: IS SELECTION FOR YIELD SHIFTING OUR PLANTS AWAY FROM THE DESIRED IDEOTYPES?

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Plants that produce essential oils, resins, rubber, or gum (generically Carbon-Based Secondary Metabolites-CBSM) invest significant amounts of energy on them (3-4 g of glucose/g of CBSM compared to 1.1-2 for starch and oils) and on building special structures for their storage. Selection for yield tends to shift the relationships between growth (biomass), CBSM, reproduction, and reserves storage for regrowth after harvest. Changes ranging from biomass allocation (partition) to physiology and anatomy have been found in several new crops such as Grindelia (*Grindelia inuloides* Willd.) -resin, Silflower (*Silphium integrifolium*)- oilseed crop, which also accumulates resins, and Guayule (*Parthenium argentatum* A. Gray)- rubber and resin, all perennial *Asteraceae*. Overall, selection for biomass and/or seed-yield can shift resource use strategy (both acquisition and use of resources such as water and Nitrogen), from a conservative to a more acquisitive strategy. Within the criteria used to choose a wild species as a candidate for domestication, those involved in low resource requirements, stress tolerance, high defense mechanisms, and perenniality (all related to a conservative strategy) are frequently cited. Still, the shift in resource-use brought about by selection may go unnoticed at the beginning against our criteria, moving plants away from our initial ideotype. These unwanted shifts may be avoided with a better understanding of the structural and functional characters involved in resource use and partition. Examples of these mechanisms and their influence on yield will be presented for the above-mentioned crops. How far can we push selection for yield maybe a matter of finding the appropriate balance between selection for productivity potential (biomass and harvest index), resource use and stress tolerance, and production costs (water and nutrients).

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ANTIFUNGAL ACTIVITY OF GUAYULE RESIN AND *SATUREJA* ESSENTIAL OILS AGAINST *FUSARIUM OXYSPORUM* IN *BORAGO OFFICINALIS* CROP

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Guayule (*Parthenium argentatum* Gray) is a shrub with many interesting potential activities, different from their actual rubber exploitation. Guayule resin has already shown activity against fungi that cause damage to wood, so the aim of this work was to test the activity of guayule resin against *Fusarium oxysporum* Schltdl., a soil-borne fungus that causes losses of up to 80% in the borage (*Borago officinalis* L.) crop. Up to know there isn´t any effective treatments and it is becoming a huge problem for farmers in northern Spain. First, guayule resin was formulated in water in three different forms: resin alone, and resin with essential oils of savory (*Satureja montana* L.) in a 1:0.25 and 1:1 ratio (resin/savory). The activity was test by a minimum inhibitory concentration (MIC) assay carried out for 10 days to determine the effective dose for mycelial growth inhibition, and by a conidial germination inhibition assay carried out with the same battery of formulations. Guayule resin formulation alone proved to be very effective in inhibiting mycelial growth of *F. oxysporum*, with a reduction rate of >70% for all concentrations lasting up to 10 days. Resin formulations with savory essential oils proved to be less active, with growth reduction rates <30% at higher concentrations, and no inhibition at lower concentrations. On the other hand, none of the guayule formulations produced inhibition of conidial germination. Results showed that guayule resin could be an effective tool for the integrated management of pathogenic fungi such as *F. oxysporum* in *B. officinalis* crop, not to prevent the infection, but to cure it or minimize its harmful effects.

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GUAYULE RESIN ANTIFEEDANT ACTIVITY AGAINST THE COLORADO POTATO BEETLE

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Among the many applications of guayule (*Parthenium argentatum* Gray), the use of its resin as a biopesticide has gained much attention in the last few years as it would allow to organically manage important agricultural pests as the Colorado potato beetle (*Leptinotarsa decemlineata* Say). It is one of the most damaging insect pests to the potato economy worldwide, difficult to control by conventional methods due to the development of resistance to chemical insecticides. Therefore, the aim of this work was to evaluate the activity of guayule resin in affecting the feeding behavior of *L. decemlineata*. To this end, a short-term feeding choice assay was designed in which the beetles could choose between solvent-treated control leaves or leaves treated with either crude guayule resin 100 µg/cm^2, crude guayule resin 50 µg/cm^2, refined guayule resin 5 µg/cm^2, or low molecular weight rubber 5 µg/cm^2. The assay was performed in duplicates and lasted six hours under controlled conditions. After, unconsumed leaf areas were measured, and the feeding inhibition index calculated (% FI). For all the treatments tested, quite a lot of variability was observed between the two replicates. Even so, it was observed that a treatment with guayule resin moderately inhibited the feeding of the beetle, showing a % FI of around 54% for crude guayule resin 100 µg/cm^2 and refined guayule resin 5 µg/cm^2, and of around 40% for crude guayule resin 50 µg/cm^2. As for the treatment with low molecular weight rubber, this showed a negative % FI, indicating not only that it does not inhibit feeding, but also that it promotes feeding. Consequently, it seems that guayule resin exerts some antifeedant effect against *L. decemlineata*, probably due to active compounds and not to a contact effect derived from the sticky texture of the rubber, which makes guayule resin a potential product in the integrated pest management programs of the Colorado leaf beetle.

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CHARACTERIZATION OF ESSENTIAL OILS FROM DIFFERENT PARTS OF THE GUAYULE HYBRID ACCESSION AZ-2 PRODUCED IN SPAIN

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Other exploitation possibility for guayule (*Parthenium argentatum* A.Gray), apart from being used mainly as an alternative to natural rubber from *Hevea brasiliensis*, could be to obtain essential oils (EOs), since it can reach up till 1% in leaves fresh weight basis. Essential oils are complex mixtures that may contain over 300 different organic volatile compounds, generally of low molecular weight below 300 Da, with biocidal properties. But knowledge about EOs in guayule is poor, being terpenes (70-83%), oxygenated terpenes (6-10%), sesquiterpenes (8-14%), and sesquiterpene alcohols (3-6%) the most abundant compounds. The purpose of this study was to know more about the composition of the essential oil from different fresh parts of AZ-2 guayule hybrid (leaf, flower, and stem) harvested during May 2022 in Santa Cruz de la Zarza (Toledo, Spain) by means of GC-TOF-MS. The EOs were obtained by steam distillation during 2 h and the sample was diluted 1:25 in hexane before injection in an Agilent 7280 for 45 min separation in a 30 m DB-5ms column. The volatile profile among the three analyzed parts of the plants, showed that the major compounds were: α-pinene (17.0-19.9%) in accordance with Haagen-Smit and Siu (1944), 2-thujene (6.2-9.5%), sabinene (7.9-10.4%), limonene (7.0-10.2%), germacrene-D (3.7-5.4%), and bicyclogermacrene (1.9-3.5%). Other volatiles were present in all parts of the plant but in different amounts, such as santolina triene, which was 11.3% in guayule stem, 1.4% in the flower, and 3.7% in the leaf. Compounds such as sabinol and *p*-cymene were only identified within the stem (1.1 and 0.3% respectively) and α-terpineol was only found in the flower and stem (0.5 and 0.3% respectively). The yields obtained, about 0.5% dry weight, and the content in the different fractions in the plant (leaf>flower>stem) were similar to those obtained by Haagen-Smit and Siu (1944), and high enough to consider its exploitation.

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PRELIMINARY STUDY OF INSECTS ASSOCIATED WITH GUAYULE IN TOLEDO (CASTILLA-LA MANCHA REGION, SPAIN)

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Guayule (*Parthenium argentatum* A. Gray) is an endemic plant of Mexico and the southern United States, which has been also successfully adapted to the edaphoclimatic conditions of Castilla-La Mancha (Central Spain). Due to the importance that this plant could have in the near future, it is necessary to verify how insects may affect the conditions for its reproduction and if the presence of certain species that can feed on its trunk or leaves can be a threat for its survival. For this, it is essential to study the entomological fauna present in these crops. For this reason, monthly frequency samplings were carried out in July, August, and September of the year 2022 in a delimited area of a crop on the outskirts of Santa Cruz de la Zarza, Toledo. Three different guayule accessions were used in three subzones to test if there was a preference of certain insects for a specific variety or another. In these samplings, all possible specimens were taken and those that could not be captured or were easily identified, were noted. The captures were carried out in three ways: on the plant to see which insects could be potential pollinators as they approached and interacted with the flowers, sweeping the middle, and nocturnal sampling using a light trap. These samplings resulted in a variety of species of different orders, mainly Diptera, Hymenoptera, Hemiptera and Coleoptera, although the presence of other orders such as Lepidoptera and Orthoptera could also be verified. The variety of potential pollinators stands out, with many species of bees and syrphid flies, as well as certain species of moths. It is also noteworthy the low presence of phytophagous and parasites of the plant, not being found in populations large enough to pose a threat to the survival of the crop. The results did not indicate a preference of the species for one accession or another of guayule. This study is a first contact with the fauna present in guayule plantations in Spain that should be continued in successive years and refined with more frequent samplings that cover the entire guayule flowering period. There is only one previous detailed characterization study in the early 1990s in Texas. While previous studies conducted in the 1980s at the University of Arizona showed that the yield and germination capacity of the seeds produced is greatly increased by the presence of honey bees (*Apis mellifera* L.) knowledge about the influence of natural pollinators is limited. In our case, it would be important to determine the implication of individuals of the order Diptera, which were the most abundant.

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FUNCTIONAL STUDIES ON A COLD-INDUCED TRANSCRIPTION FACTOR GENE FROM GUAYULE

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Natural Rubber (NR)-producing guayule (*Parthenium argentatum* Gray*)* has been developed as an alternative crop to diversify NR production. Guayule rubber synthesis is highly upregulated by cold. A well-studied transcription factor family, DREB (dehydration responsive element binding protein) regulates many cold-responsive (COR) genes. A guayule *DREB* (*PaDREB*) gene was highly expressed in cold-treated stem tissue where active rubber synthesis and accumulation occurred. To better understand the process of increasing rubber synthesis through cold-mediated signaling in guayule, we isolated a *PaDREB* gene that we hypothesized would regulate this process. We identified *PaDREB* as a member of the *DREB1D* gene family based on phylogenetic analysis of amino acid sequence similarity with other DREBs. Sequence alignments of DREBs indicated that PaDRED1D contains DNA-binding domains responsible for regulating COR gene transcription. Spatial gene expression profiling of *PaDREB1D* revealed that stems had the highest expression level among different organs examined. Under cold or freeze temperatures, *PaDREB-1D* significantly increased its expression in stem, peduncle, and root, followed by leaf and flower. We further confirmed the function of *PaDREB1D* as regulator of cold-signaling processes by expressing it in the model plant Arabidopsis under a constitutive cauliflower mosaic virus (CaMV) 35S promoter. The resulting transgenic Arabidopsis expressing *PaDREB1D* turned on expression of a set of Arabidopsis COR genes under both room temperature (24˚C) and cold (4ºC), whereas wild-type Arabidopsis expressed these COR genes only upon cold treatment. The transgenic plants also exhibited enhanced freezing tolerance under freezing temperature at -5ºC, showing a survival rate of 98–100% compared with that of wild-type at 0%. Thus, we suggest that *PaDREB1D* is a functional member of the guayule *DREB* gene family and plays a critical role in cold and freeze tolerance. Unlike many other *DREB* genes whose over-expression cause growth retardation of transgenic plants, including Arabidopsis, the *PaDREB1D*-overexpressing Arabidopsis displayed a normal growth phenotype. The knowledge gained from this study will benefit breeders and farmers through the development of more cold-hardy varieties not only for guayule but also for other crops. In addition, overexpression *PaDREB1D* may allow guayule to produce more rubber in absence of cold temperature, which could expand guayule cultivation to warmer environment and ensure higher and more consistent NR synthesis.

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TOLERANCE OF GUAYULE (*PARTHENIUM ARGENTATUM* GRAY) TO CHALLENGING CONDITIONS IN WESTERN SAN JOAQUIN VALLEY (CA) SOILS, AND IRRIGATION WATER

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Farm fields in California's San Joaquin Valley (SJV) have experienced accumulation of naturally occurring salts, and toxic trace elements such as boron (B) and selenium (Se), in cultivated soils via groundwater contamination. In some areas the toxic environment has limited agricultural production, and created interest in alternative crops that can grow well in this challenging setting. We report on a series of greenhouse and field sediment microplot experiments conducted to evaluate guayule's tolerance to soil and irrigation water typical to that found in the westside of the SJV. Guayule seeds were germinated in flats and transplanted to control or saline soils in the greenhouse, then irrigated with control or simulated poor quality WSJV drainage water. Field experiments were conducted in field microplots containing control or drainage sediment soils, and similarly irrigated. Plant tissues were analyzed for chemical content, rubber, and resin. The effect of the applied chemical stressors on plant growth varied by accession. For example, in greenhouse studies, AZ1, AZ5, and AZ6 tolerated high salinity and B levels better than AZ2, AZ3, and AZ4. Accessions N566 and R1037 showed high tolerance compared to R1093, 11600, 11604, and 11635, but plant biomass was often significantly lower. Likewise, when grown in field sediment microplots or field-located lysimeters, tolerance to poor soil, and/or high salts (Na, B, Se) in irrigation water varied significantly by accession, and lower plant biomass was found under the most challenging conditions. Under all greenhouse and field conditions tested to date, selenium and boron were absorbed by guayule stem and, primarily, leaf tissues. Uptake of both elements was reduced in the presence of salts, but accumulation was sufficient to consider guayule a gentle phytoremediator of Se. Interestingly, rubber and resin production were increased, by as much as two-fold (% dry weight basis) when plants were grown under chemical stressors in greenhouse conditions. This trend also varied by accession. Rubber and resin concentration were not affected by chemical stressors in one field sediment study reported to date. However, in an ongoing field lysimeter trial, the highest chemical stresses showed the highest rubber and resin accumulation after 14 months growth. At the molecular level, salt stress tolerance is a polygenic trait. Stress signaling induces stress-responsive genes common among various biotic stresses, including drought, cold, wounding etc. The expression level of a few selective genes known to play a role in salt tolerance in plants were investigated and compared among guayule stem tissue experiencing drought, cold and salt stress. The analysis showed that HKT1 (high affinity potassium transporter) was induced significantly under both salt and cold stressed plants, which suggests a role in maintaining the osmotic balance in salt and cold stressed guayule.

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IMPROVING GERMINATION OF RUBBER DANDELION (*TARAXACUM KOK-SAGHYZ* RODIN) FOR IMPROVED STAND ESTABLISHMENT AND ROOT RUBBER YIELD

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Developing a domestic supply of natural rubber (NR) is of economic and strategic importance because NR is required in many high-performance applications such as aircraft tires and medical devices. The current primary source of NR is the Brazilian rubber tree (*Hevea brasiliensis* Willd. Muell.-Arg.), which grows only in the tropics. Research during WWII and since 2006 in Ohio, Oregon, and Nebraska suggest that the latex in roots of rubber dandelion (*Taraxacum kok-Saghyz* Rodin), (TKS), also historically known as Russian dandelion, is chemically nearly identical to rubber tree NR, and that TKS has the potential to produce competitive rubber yields in temperate climates. One of the primary constraints in growing TKS commercially is a reliable method for direct seeding that results in high stand density, due to the uneven, unpredictable germination that has often been observed in the field with both raw and pelleted seeds. Use of transplants is not viable due to the costs of producing industrial-scale NR. The objective of this research was to determine how various seedbed factors affect TKS germination rate. Using raw and pelleted seed of improved TKS cultivars, a series of experiments were done in a germination chamber under controlled temperature, light, and adequate moisture conditions. Seedbed zone variables included seed depth, layering of high vs low organic matter soil media over/under seeds, varying ratios of uniformly mixed mineral soil with organic matter (commercial potting mix), and comparison of several natural soils having a natural range of organic matter contents. Over many runs, several distinct trends were consistently observed. Seed depth had a strong negative correlation with germination rate for every combination of the seeding media base (under seed layer), cover (over seed layer), or homogeneous soil mixture/type. For a given seed depth, seeds covered with potting mix almost always germinate better than seeds covered with mineral soil. Conversely, a mineral soil base under the seeds usually resulted in higher germination than potting mix under the seeds for a given depth. Germination in homogeneous media having a range of organic matter content (the mineral soils mixed with potting mix at various ratios or the natural soils having a range of organic matter content) were more variable, but trends will be discussed. It was clear that TKS seeds germinate best from a shallow depth (<7mm) and under conditions of consistent moisture available for the entire germination period of 7-10 days. It seems likely that the germination response to various soil organic matter contents and locations relative to the seed placement was due to organic matter's effect on moisture retention, seed-soil contact, and improved imbibition by seeds during germination. Rubber dandelion has good potential as a source of natural rubber grown in temperate climates, but improved management including dependable germination and stand establishment is necessary to facilitate a viable domestic NR industry using TKS.

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IN VITRO NATURAL RUBBER BIOSYNTHESIS ON RUBBER PARTICLES FROM *HEVEA BRASILIENSIS* AND NANODISCS

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Natural rubber (NR), mainly consists of *cis*-1,4-polyisoprene, is a natural polymer used for industrial rubber products, such as tires. The NR supply depends solely on latex from the Para rubber tree *(Hevea brasiliensis*). In the latex, NR exists as rubber particle (RP), primarily consisting of a hydrophobic rubber core enclosed by a lipid monolayer. In the past several years, we clarified that NR biosynthesis occurs by a ternary protein complex consist of *Hevea* rubber transferase (HRT1), Rubber elongation factor (REF) and HRT1-REF Bridging protein (HRBP) on RP. In this study, to produce NR on artificial membranes *in vitro*, we performed reconstitution of HRT1 and HRBP on nanodiscs (NDs) utilizing a cell-free translation system and measured polyisoprene synthesis activity. As a result, HRT1 on NDs or HRBP on NDs did not show the polyisoprene synthesis activity. However, co-expression of HRT1 and HRBP on NDs showed the activity. The products were extracted by 1-butanol and analyzed by TLC. The number of isoprene units in the products were around 16 whilst that for commercial natural rubber is usually more than 5000, indicating that the chain length of the products was much shorter than usual NR. These results suggest that the polyisoprene synthesis activity requires direct contact between HRT1 and HRBP on the surface of nanodiscs. Further, we attempt to utilize other types of artificial membrane for NR synthesis *in vitro.*

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ABSTRACTS

FIBERS AND CELLULOSIC CROPS DIVISION

ORAL PRESENTATIONS

CHAIR

MARISOL BERTI,

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BIODEGRADABLE COMPOSITE HYDROMULCHES FOR SUSTAINABLE ORGANIC HORTICULTURE

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In agriculture, mulch helps optimize soil moisture and temperature while preventing weed growth. The most common material used for commercial mulching is low-density polyethylene (LDPE). This plastic is typically landfilled, stockpiled, or even buried or burned at the end of the growing season, significantly impacting the environment. This research aims to develop an alternative mulch that is approved for organic farming and biodegradable while still providing the same benefits as LDPE mulch. The hydromulch materials evaluated in this study included a mixture of either paper pulp, wood fiber, or hemp (*Cannabis sativa* L.) hurds in combination with a tackifier. At various concentrations, the tackifiers tested were guar (*Cyamopsis tetragonoloba* [L.] Taub.) gum, psyllium (*Plantago ovata* L.) husk, and camelina (*Camelina sativa* (L.) Crantz) meal. The hydromulch treatments were tested for tensile strength, puncture resistance, rain fastness, density, soil adhesion, porosity, and C:N ratio. The treatments were also compared with control samples containing no tackifier to determine if adding a tackifier or varying its concentration resulted in enhanced mechanical properties. The results showed that the hydromulch samples containing tackifier performed better than the control samples in strength testing and porosity. It was also observed that increasing the amount of tackifier improved specific properties, and that guar gum was overall the best tackifier. Hydromulches containing paper were far superior to wood or hemp hurds in all tests. Guar gum and psyllium husk mixed with camelina meal helped to reduce overall cost. This also resulted in an interaction between the two tackifiers, significantly reducing the strength of the hydromulch. Due to the fragility of wood fiber and hemp hurd samples, they were mixed with paper at rates of 75% and 50% paper. The blended formulations did not show promising results. The study found that by adding 50% moisture to hydromulch, regardless of the tackifier used, the hydromulch lost over 70% of its initial puncture resistance. Overall, paper pulp-based hydromulch formulations containing guar gum or psyllium husk demonstrated superior physical and mechanical properties. The best-performing formulations are currently being tested in open field studies.

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PRODUCTION OF BIOCHAR USING NOVEL MOLTEN SALT TORREFACTION PROCESS

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Fossil fuels provide most of the energy in the US. Meeting part of the US energy demands with renewable energy sources would have a significant financial and environmental benefit. However, these sources require effective storage as raw biomass is susceptible to rot, has relatively low energy density, and seasonal availability. Thus, there is a need for an effective way to harness and store the energy from biomass resources. This project focused on converting biomass feedstock into biochar using a novel torrefaction process. The biomass materials evaluated included pine (*Pinus sylvestris* L.) wood flour and switchgrass (*Panicum milleaceum* L.). The material properties evaluated were their bulk density, moisture content, cellulose, hemicellulose and other sugar oligomers, lignin, and acid insoluble residue content using National Renewable Energy Laboratory (NREL) standard methods. In addition, the higher heating value (HHV) was determined via calorimetry (ASTM E711), fixed carbon content via proximate analysis. The biomass was grounded, and mixed with salt, heated to the torrefaction temperature to produce biochar. The biochar was characterized using processing variables and their effect on torrefaction, HHV, fixed carbon, ash content, pH, effluent gas and liquids and elemental ratios (O, C and N). The results demonstrated that processing variables (temperature, time) and type of salt had a substantial effect on the properties and characteristics of biochar. Addition of salt lowered the processing temperature of biochar. Variables that did not have a statistically significant effect on the resulting biomass included sweep gas, salt to biomass ratio, and particle size. Temperature increases were correlated with significant increase in % total nitrogen, slight increase in % total carbon and significant decrease in C:N ratio as well as a slight increase in pH. The long-term goal of this project is to evaluate the salt-torrefied biomass's soil amendment capabilities.

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ENVIRONMENTAL IMPACT ASSESSMENT OF BIOFUELS PRODUCTION FROM INDUSTRIAL CROPS CULTIVATED IN CONTAMINATED SOILS

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Dedicated crops represent an important feedstock to decarbonize the energy sector and to meet the no-net emissions of greenhouse gases by 2050, as set by the European Green Deal. However, the greenhouse gas performance of biomass to energy can be negatively impacted by Indirect land use change (ILUC) effects. Consequently, cultivation of industrial crops on contaminated land is repeatedly suggested as an approach to minimize land use competition with food crops and land use change controversies. The GOLD project (Bridging the gap between phytoremediation solutions on Growing energy crOps on contaminated LanDs and clean biofuel production), aims to produce clean low Indirect Land Use Change biofuels by growing selected high yielding lignocellulosic crops [miscanthus (*Miscanthus* spp.), switchgrass (*Panicum milleaceum* L.), biomass sorghum (*Sorghum bicolor* (L.) Moench), and industrial hemp (*Cannabis sativa* L.)] on contaminated land. In the long-term, polluted lands can return to agricultural production. Therefore, the objective of this work was to determine the local and site-specific environmental impacts associated with the cultivation of these lignocellulosic crops in contaminated soils. The study was developed and applied to the cultivation phase of the four different lignocellulosic crops in contaminated soils of Europe and China, using environmental impact assessment (EIA) protocols. Different categories were studied; fertilizers and pesticides related emissions, impact on soil and water resources, and biological and landscape diversity. Preliminary assessment of the results suggests that growing these lignocellulosic crops in contaminated soils provide benefits regarding soil properties and erodibility. *Miscanthus* and industrial hemp enhanced biological and landscape diversity, due to the higher density of the biomass, that provides higher coverage to wildlife. Impacts associated with water resources and N-fertilizer related emissions were higher in the annual crops; industrial hemp and sorghum, but impacts associated with pesticide related emissions were low to all the crops studied. The use of appropriate management practices (plant-associated microorganisms and a variety of bio-stimulants) penalizes the impact on the biological diversity index, but rewards the impact on the soil quality index, by greater reduction of soil contaminants.

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OPTIMIZATION OF HEMP PRODUCTION TECHNOLOGY FOR FIBER USES

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Industrial hemp (*Cannabis sativa* L.) has emerged as one of the most popular plants during the past few decades. There is a significant potential for the development of a multi-perspective approach of industrial hemp fiber as a resource in industrial applications. The hypothesis of this study was that industrial hemp properties (plant height and stem thickness), and fiber content would be affected by cultivar, seeding date, and row spacing. The objective was to evaluate the effect of cultivar, seeding date, and row spacing, and their interaction on fiber yield with the focus to develop optimal production technology for specific hemp production. The field experiments were conducted in Bački Petrovac, Serbia (45.3568° N, 19.6173° E, at 82 m) in 2020 and 2021. The study included five cultivars Helena (fiber, grain), J x USO31 (grain), Bob-1 (grain), H x USO31 (grain), and Marina (fiber). The three seeding dates were at the beginning of April, beginning of May, and beginning of June. The three between-row spacings were 12.5, 25, and 50 cm. The three two-way interaction effects (seeding date by row spacing, seeding date by cultivar, and row spacing by cultivar) had a significant effect on plant height, but only seeding date by cultivar and row spacing by cultivar had significant effect on stem thickness. The results indicate that the tallest plants were on plots seeded at 12.5-cm row spacing. The effect of row spacing and cultivar on stem thickness points out those plants with the thickest stem were sown at 50-cm, and the thinnest stem were in hemp plants sown at 12.5 cm. The Bredemann method was utilized for fiber extraction. The highest fiber content was with 12.5 cm row spacing, and cv. Marina. Our study revealed that cultivar, sowing date, and row spacing had significant effects on the plant height, and stem thickness, as well as on responses of the fiber content. The seeding date and row spacing also affected fiber quality.

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DELAYED HARVEST AFFECTS INDUSTRIAL HEMP GRAIN YIELD IN NORTH DAKOTA

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Due to the newness of industrial hemp (*Cannabis sativa* L.) as a grain/seed/fiber crop many of the best management practices essential for sustainability are in the developmental phase and require further study. Crop response to delays in harvest beyond normal harvest timing usually results in seed yield and quality losses and reduced economic value for the producer. A replicated field study was conducted at the Prosper, ND, research site during the 2020, 2021, and 2022 growing seasons to determine the effect of harvest timing on yield response of industrial hemp. The experimental design was an RCBD with a factorial arrangement of cultivars and harvest dates (HDs). Three industrial hemp cultivars Katani, Canda, and X59 were harvested at five HDs spaced at 7-to-9-day intervals depending on weather conditions. Reported traits evaluated included seed yield and seed moisture. Analysis indicated Year interactions with the main effects Cultivar and HD and the Cultivar x HD interaction primarily due to 70% greater seed yield in 2022 than for 2020 and 2021 which produced similar yields. Reduction in seed yield was observed each Year at HD 4 and 5 compared with earlier HDs 1, 2, and 3 which produced similar yields. Across years yield was reduced 20% and 35% at Harvest dates 4 and 5, respectively, compared with the earlier harvest dates and was associated with seed shatter. Yield was stable during the 16-day interval for HDs 1, 2, and 3 where seed moisture was 25.3, 20.9, and 17.2%, respectively. The study results indicate an approximate 16-day harvest period for hemp, at elevated seed moisture that requires drying, to avoid yield reductions due to delayed harvest.

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DEVELOPMENT OF THE PROCESS-BASED CSM-CROPGRO-HEMP MODEL TO SIMULATE GROWTH AND DEVELOPMENT OF INDUSTRIAL HEMP FIBER CULTIVARS IN FLORIDA AND CHINA

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Industrial hemp (*Cannabis sativa* L.) is a re-emerging crop with unique agronomic challenges that require location-specific studies and guidance. Understanding the variability and interaction of multiple genetic, environmental and management factors is a critical step during the introduction of a new crop to identify or develop locally adapted cultivars and management approaches. Systematic analysis of different growing systems (e.g., fiber vs. medicinal hemp), as well as how yield and quality parameters [e.g., fiber and cannabidiol (CBD) content] are influenced by genetics, management and environment will be of special importance. Digital farming tools, such as crop models and decision support systems (DSS), can facilitate this process by providing researchers, extension agents and farmers with a better understanding of the farming system and crop physiology. Therefore, the objective of this study was to adapt the existing process-based CSM-CROPGRO model within the Decision Support Systems for Agrotechnology Transfer (DSSAT, www.dssat.net) for the growth and development of fiber hemp. Data for model parameters and the model adaptation process was obtained through review of foundational hemp physiology and field experiments. Several fiber and seed hemp cultivars were grown across sites in Florida during the 2021 and 2022 season, with destructive and non-destructive measurements for morphology as well as for in-season and end-of-season growth and partitioning of biomass. Results show that it was feasible to include and calibrate hemp cultivars from different growing regions within the CROPGRO modeling structure. The model is well suited to predict growth and development, including flowering behavior and seed formation, across several sites and two seasons. Future work will include the addition of further sites and cultivars, in-depth evaluation with independent datasets as well as further development of the model into a more actionable decision support systems for the hemp value-chain.

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STRUCTURAL SUGAR PROFILE OF FIBER RESIDUES FROM HIGH-CANNABINOID TYPE HEMP AND POTENTIAL FOR VALUE-ADDED FERMENTATION

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U.S. production of hemp (*Cannabis sativa* L.) has been largely driven by the cannabidiol (CBD) market. Processing of high-CBD type hemp results in large amounts of unused lignocellulosic biomass. There has been substantial interest in the use of this fibrous residue for production of bio-based materials and for replacement of petroleum-based chemicals. Unlike stalks from industrial fiber or grain hemp, high-CBD hemp stalks are not well suited for decortication. Instead, this material is typically milled as a single stream, such that the bast and hurd fibers are combined. Little information is available on the composition of the structural sugars in these kinds of whole milled hemp fibers. Such information is needed to evaluate the feasibility of pretreating the fiber for enzymatic hydrolysis and downstream fermentation of the C5 and C6 sugars. Additionally, the mixed fiber biomass from high-CBD hemp is expected to closely resemble the biomass residues from the recreational and medicinal *Cannabis* industries. The goal of this research is to characterize the fiber residues from high-CBD hemp to gauge the potential for value-added fermentation of the waste streams from these growing markets.

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COMPARATIVE YIELD STUDIES AMONG THREE BAST FIBER CROPS (FLAX, HEMP, AND KENAF) IN THE MEDITERRANEAN REGION

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A large number of industrial crops could be grouped as fiber ones, namely bast fiber crops (hemp (*Cannabis sativa* L.), flax (*Linum usitatissimum* L.), and kenaf (*Hibiscus cannabinu*s L.), grasses (miscanthus (Miscanthus spp.), switchgrass (*Panicum virgatum* L.), spartina (*Sporobolus cynosuroides* (L.) P.M.Peterson & Saarela), and woody species. The majority of bast fiber crops are multipurpose crops and provide feedstock to feed biorefineries. The aim of this research work was to compare three bast fiber crops (flax, hemp, and kenaf) in an arid area in central Greece (Viotia). The field trials had been carried out for two subsequent growing years (2020-21 and 2021-22 for flax as winter crop, 2021 and 2022 for hemp and kenaf as spring crops). All crops were compared under three N rates (0, 60 and 120 kg N/ha), while the two spring crops (hemp and kenaf) were also compared under three irrigation rates (25, 50 and 100% of PET). The varieties were: Calista for flax, Future 75 and Future 83 for hemp, and CH-3 and CH-95 for kenaf. At the end of each growing period, crops were harvested (4 m^2 per plot) to estimate the biomass yields. At the same time a few plants per plot were taken and weighed, and stems, leaves and seeds separated. The stems had been further separated to bark and core. Sub-samples from all part fractions had been oven-dried to determine the moisture content. The highest stem yields were for kenaf (21.0 t/ha), following hemp (9.0 Mg/ha), and flax (4.4 Mg/ha). It can be commented that kenaf yields were more than double compared with hemp yields which were also double, compared with flax yields. Hemp and kenaf were tested under different irrigation and fertilization rates and it was found that irrigation results in higher differences among yields. When kenaf was fully irrigated it had 16% higher stem yields, compared with kenaf receiving 25% of PET. The effect of irrigation on yield was greater in hemp compared with kenaf and thus the fully irrigated crops of hemp were 40% higher yields compared with the plots that received the low irrigation rate. Flax yields were 17% higher when received 120 kg N/ha (compared with the control plots) and the corresponding increase for hemp was 21%, while for kenaf was 16%. The comparative studies carried out for two subsequent years for three bast fiber crops showed that kenaf was the most productive with more than double yields compared with hemp when grown in the same area and with the same treatments, while flax was the least productive.

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INCREASING THE VALUE OF LIGNOCELLULOSIC BIOMASSES THROUGH THE PRODUCTION OF NANOCELLULOSE

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Lignocellulosic feedstocks are rich in cellulose, hemicellulose, and lignin which, when recovered and separated, can give rise to innovative value-added products. Cellulose can be isolated from the lignocellulosic fibers and then depolymerized to give rise to nanocellulose (NC), an extraordinary nanometer-scale bio-based material with applicability in diverse technological areas. Yet, the recalcitrance of the lignocellulosic material to deconstruction requires pre-treatments as an earlier and necessary step in the process to get nanocellulose. Therefore, the aim of this work was to optimize the NC production from different lignocellulosic biomass (hemp (*Cannabis sativa* L.), coconut (*Cocus nucifera* L.) shell, and to test it as reinforcement agents in chitosan films. Nanocellulose was produced via an alkaline pre-treatment approach applied to the two different lignocellulosic biomasses, followed by acid hydrolysis. In the alkali pre-treatment process optimization, some parameters were tested, namely time of reaction and temperature. The produced nanocelluloses were incorporated in chitosan at the rate of 2.5% w/w and the bionanocomposites were characterized: mechanical properties, thickness, optical properties (opacity and transparency), surface color, and solubility and swelling degree. Commercial nanocellulose at the same rate was also tested in the chitosan films for comparison. Pristine chitosan film was the control. Taking into consideration a scale up of the process, the time of 2.5 h and temperature of 60 ºC were chosen as optimum for the process. Bionanocomposites made from hemp and coconut shell NC were slightly more saturated and opaquer than the pristine chitosan films. In terms of solubility, no differences were observed between pristine films of chitosan and films reinforced with hemp and coconut shell NC. Films reinforced with hemp NC presented a higher swelling degree than pristine chitosan films or coconut shell bio-nanocomposite. Coconut shell and hemp NC improved the strength and stiffness of the chitosan biopolymer.

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RELAY CROPPING COUPLING FOOD AND BIOENERGY FEEDSTOCK PRODUCTION

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To face the current environmental and climate challenges, innovative cropping systems are needed to provide sustainable and stable food, feed, biofuels, and bio-based feedstocks. Relay cropping is one of such innovative cropping systems where food/feed and dedicated lignocellulosic crops could be produced in the same growing season without land competition issues. However, in temperate climates of Europe relay cropping is less popular than double cropping due to the complexity of agronomical management and difficulties in its mechanization. The objective of this study was to evaluate the biomass yields and quality of a dedicated lignocellulosic legume crop and relay-planted soft winter wheat (*Triticum aestivum* L.). A commercial sunnhemp (*Crotalaria juncea* L.) variety (Ecofix) was sown in June 2019 and July 2021 and harvested at the beginning (H1), full (H2), and end of flowering (H3) stages. Relayed wheat was directly hand seeded in November when sunnhemp reached the full flowering stage, thus with variable relayed period, until H2 and H3 were done. Conversely, in H1 wheat sowing occurred about 40 days after sunnhemp was harvested. Sunnhemp yield was about three times higher in 2019 (12 Mg ha^{-1} dw) compared with 2021 (4 Mg ha^{-1} dw) mainly due to one-month anticipation in sowing and rainfall distribution. Harvest time did not influence sunnhemp yield (average of 8.1 Mg ha^{-1} dw) even though it did influence the relayed wheat. Wheat grain yield was similar across the two years experiment and treatments (H1, H2, and H3). Differences in grain bread-making quality were observed which, however, were higher compared with the reference values for the area. The grain hectoliter mass was 2% higher in H2 and H3 (77.9 kg hL^{-1}) compared with H1 (76.4 kg hL^{-1}), thus in the top rating for milling requirements (> 75 kg hL^{-1}). Similarly, the grain sedimentation index (Zeleny) in 2019, was higher in H2 compared with H1. Grain protein content in 2022 was 14.4 % compared with 12.9 % of the same variety under conventional rotation, given the same amount of fertilizer. The accumulated biomass yield (sunnhemp + wheat straw) averaged 12 Mg ha^{-1} that is potentially available for bio-based applications and comparable to the productivity of some high yielding perennial grasses [i.e., giant reed (*Arundo donax* L.) and switchgrass (*Panicum virgatum* L.)]. The relay cropping demonstrated no reduction in wheat production, but to improve some grain quality parameters in H2 compared with H1, possibly due to an increase in fixed nitrogen in soil, thus increasing the general biomass produced annually. These results suggest that relay cropping could be a sustainable cropping system to integrate food and dedicated biomass crops production in such a way that grain production is not penalized and the local availability of dedicated lignocellulosic feedstocks is greatly enhanced.

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DECORATIVE PANELS FABRICATED FROM AGRICULTURAL WASTE BY-PRODUCTS

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Agricultural production and processing generates large quantities of byproducts and waste. This has been a leading cause of concern for many places worldwide. Some of this waste is used as animal fodder or for compost, while the majority is either burned or discarded as landfill. These practices have an adverse environmental impact. Fabricating bio-composites using these agricultural wastes in various forms, from stalks to fibers to particulates, helps provide several options for generating sustainable products contributing positively to the local economy as well as long-term carbon sequestration. The process will also provide a steady source of income for the farmers from their wastes, which generally require additional funds to be discarded. One such farm is Bluebird Grains Farm (Winthrop, WA) that produces approximately 816 kg of waste every month. The current work aims to demonstrate the feasibility of producing decorative panels from agricultural waste byproducts, especially hazelnut (*Corylus avellana* L.) shells and wheat (*Triticum aestivum* L.) hulls. A novel vacuum assisted resin transfer molding (VARTM) method will be used for fabrication. The work will illustrate the influence of the different preform materials on the process while determining the limits on density, thickness, strength, and infusion time. Hazelnut shells are generally heavier and denser than the ancient emmer wheat (*Triticum dicoccum* Schrank ex Schübl.) hulls. Therefore, the variation in the inherent particulate properties will directly influence the fabrication process, which will be highlighted in the current work. The strength bearing capacities, surface roughness and dimensional stability of the panels will be compared between the two by-product types. Finally, some proof-of-concept ideas will be illustrated.

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ABSTRACTS

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OPTIMIZATION AND CHARACTERIZATION OF PECTIN EXTRACTION FROM *OPUNTIA* SPP. CLADODES

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Opuntia ficus-indica (L.) Mill. (OFI), is a xerophytic plant which is particularly adapted to arid and semiarid lands (e.g., Mediterranean and North Africa), and severely degraded soils that are unsuitable for traditional crops, thus being considered a promising crop to overcome the climate change effects in agriculture. Cladodes, the vegetative parts of the plant, have an interesting content in pectin. Pectin is a complex polysaccharide that can be used to substitute fossil-based products, e.g., plastics in food packaging. Thus, the aim of this work was to optimize the pectin extraction from OFI cladodes. For pectin extraction the procedure comprises the general steps; washing/cutting cladodes, mixture with solvents, centrifugation, precipitation in ethanol, and drying. In this study the following parameters were tested. Solvent (water, acetic, ascorbic, and citric acid), pH (1.5–7), extraction temperatures (70-90ºC), extraction time (40-60 min), and L/S (Liquid/solid ratio) (5-15). Extractions were performed in peel and pulp of cladodes. Preliminary studies indicate that the pH does not affect the extraction yield. But more pectin was extracted from peel (average of 8.5% w/w db) than from pulp (average of 6.6% w/w db). Extraction with citric acid showed a higher pectin yield (average of 9.1% w/w db) than acetic acid (average of 6.5% w/w db) or water (acidified at different pH's, average of 7.5% w/w db). The extraction yield obtained using ascorbic acid showed similarities to citric acid, when used as the solvent. Also, the first round of results indicated an extraction time and a temperature of 40 min and 70 ºC, resulting in a L/S ratio of 5. To identify an optimized procedure to extract pectin from OFI, the characteristics of the pectin should also be considered, which is also being studied so that pectin from OFI can emerge as alternative to fossil-based plastics to produce new packaging materials.

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MATHEMATICAL APPROACH FOR ASSESSMENT OF FOLIAR APPLICATION OF BIOSTIMULANTS AND FERTILIZERS TO CORIANDER VARIETIES (*CORIANDRUM SATIVUM* L.)

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The biostimulants and fertilizers have an important role in improving coriander growth by providing basic macro and micro-nutrients. This study was conducted to determine the effects of foliar application of biostimulants and fertilizers on the essential oil yield, content, and composition of coriander varieties in Central Bulgaria. The field trial was carried out on alluvial-meadow soil type in the region of the village of Voivodinovo - Central Bulgaria, during 2020-2022. The experiment was set by the method of fraction parcels in four repetitions, with size of the crop parcel - 15 m^2, after a predecessor – wheat (*Triticum aestivum*). Three foliar products were examined in the relevant doses: *Energy* 20-8-60– 25 L/ha, *Fulvin* 40-22– 80 L/ha, and *Isabon* – 30 L/ha were compared with an untreated control. The tested products were applied at the end-budding stage of five coriander varieties (Yantar, Moroccan, Mesten drebnoploden, Thüringen and Marino). The results showed that the foliar treatment products increased the yield, and essential oil content of the tested coriander varieties. *Energy* has the greatest effect on the essential oil content, and *Isabion* and *Energy* on the essential oil yield. *Isabion* increased the content of the main compound - linalool in the essential oil of the Moroccan and Mesten drebnoploden varieties compared to the control. In the Yantar and Thüringen varieties, the tested products did not affect the linalool content of the essential oil. The *Energy* fertilizer leads to a decrease in the content of linalool in the essential oil of the Marino variety. Under the influence of leaf preparations, the presence of aldehyde 2E-Tridecen-1-al was reported in all tested varieties, which was absent in the untreated variants. Based on the obtained results of the hierarchical cluster analysis, the chemical parameters were evaluated comprehensively and grouped into clusters. The classification made allows to increase the objectivity of the evaluation, which in turn will lead to a more complete characterization of the chemical indicators of individual coriander varieties.

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BIO-MORPHOLOGICAL TRAITS, CHEMICAL COMPOSITION, AND ANTIOXIDANT ACTIVITY OF TWO ACCESSIONS FROM SAINFOIN SEEDS

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The importance of some underutilized legume crops in creating sustainable bioeconomy is increasing constantly in the 21st century. Apart from the commonly used beans (*Phaseolus vulgaris* L.) and faba beans (*Vicia faba* L.), most of them are mainly utilized as animal forages. Crops such as sainfoin (*Onobrychis viciifolia* Scop.) is characterized by its ability to resist droughts, and adapt to wide range of climatic conditions, Hence, it is important to perform a detailed study on the genetic diversity of the plant as well as to be established the main components derived from the sainfoin seeds. The aim of the study was to examine of the variability of some important bio-morphological traits of two accessions of sainfoin species – *Onobrychis transcaucasica* and *Onobrychis viciifolia*, as well as revealing the chemical composition and antioxidant activity of the seeds. The field evaluations were carried out on 30 plants per accession. It was found that in both species the highest variability was with the width of the top leaflet. Seed characters such as glyceride oil content, total proteins, carbohydrates (i.e., water-soluble sugars, starch, and fibers), ash, and seed moisture were also determined. Total phenolics and flavonoids, as well as their individual content in the sainfoin seeds revealed them as a potential source of bioactive components. The antioxidant activity of the seeds was examined using four methods (ABTS, DPPH, FRAP, and CUPRAC). The results of this study contributed to *ex situ* collection of accessions of *Onobrychis transcaucasica* and *Onobrychis viciifolia*., that could be successfully used in breeding program improvements, the seeds may have possible industrial applications and/or as functional food ingredients due to their composition, i.e., high protein, carbohydrate (including starch), phenolic acid, and flavonoid content. as well as having moderate antioxidant activity.

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ZORNIA RETICULATA EXTRACTS USING ULTRASOUND: COMPOSITION AND BIOACTIVE PROPERTIES

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Mexico has an estimated 4,500 species of medicinal plants, but only 5% of their pharmacological effects have been studied. *Zornia reticulata* Sm., also known as viper's weed, commonly grows on grassy sites, roadsides, and allotments. It is distributed in the southern United States and most of Mexico, but with a greater presence in the center and south. Traditionally, this plant is used to treat infections; for example, Rarámuri is used to treat respiratory diseases. However, studies of its composition and bioactivity are still limited. The objectives of this study were to evaluate the effect of three solvents (A: aqueous, H50:50 ethanol:water 50:50%, and H70:30: ethanol:water 70:30%) on ultrasound-based recovery of bioactive compounds from *Z. reticulata*, as well as their antioxidant activity. The results showed significant differences in the extraction of total phenolic compounds, being higher for the H50:50 extract with values of 15.7±0.7 mg gallic acid equivalents (GAE)/g, followed by the H70:30 (13.4±0.6 mg GAE/g) and A (7.0±0.3 mg GAE/g) extracts. In addition, the antioxidant activity was also higher for the H50:50 extracts with values of 23.0±0.9 and 3.2±0.1 mM Trolox/g by ABTS (2,2′-Azinobis-3-ethylbenzotiazoline-6-sulfonic acid) and DPPH (2,2′-diphenyl-1-picrylhydrazyl) methods, respectively; and a reducing power of 7.3±0.3 mg ascorbic acid/g. Comparatively, the H70:30 extract had the highest content of total flavonoids, followed by the H50:50 and A extracts (29.3±0.6, 26.2±0.6, and 11.9±0.1 mg quercetin acid equivalents (QAE), respectively). Also, High Pressure Liquid Chromatography (HPLC) demonstrated the effect of the solvent on the presence of bioactive compounds, obtaining higher concentrations of syringaldehyde, epicatechin, epicatechin gallate, and catechin in the H70:30 extracts. It was interesting to find that only aqueous extracts contained chlorogenic, vanillic, and caffeic acids. This research reveals for the first time the potential of the *Z. reticulata* extracts, which contain several bioactive compounds with antioxidant, antimicrobial, antiviral properties, with potential health benefits.

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RHUS MICROPHYLLA LEAF EXTRACTS OBTAINED BY OHMIC HEATING: PHYSICOCHEMICAL COMPOSITION AND BIOACTIVE PROPERTIES

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Rhus species are plants typically used for medicinal purposes due to their bioactive compounds. There are approximately 250 species, of which only a small number have been studied. In this study, extracts of *Rhus microphylla* (common name agrito) leaves were evaluated under the following treatments: hydroalcohol (1:1) and aqueous extracts obtained by means of ohmic heating for 5 and 10 min (H5, H10, A5 and A10, respectively) at 70 V using a laboratory-built ohmic heating system. The results showed higher values of total phenolic content in both aqueous extracts (78.8-96.2 mg of gallic acid per gram of extract). According to High Pressure Liquid Chromatography (HPLC), the aqueous extracts also contained higher amounts of catechin (412.5-441.4 mg/L) when compared to hydroalcohol extracts (206.4-259.8 mg/L). Additionally, all the extracts contained various amounts of gallic acid, epicatechin gallate, and ferulic acid, which showed strong antioxidant activity by the ABTS (2,2-azinobis-(3-ethylbenzothiazoline-6-sulphonic acid) and DPPH (2,2-diphenyl-1-picrylhydrazil) methods. Regarding the antiproliferative activity, the A5, A10, and H5 extracts had similar effect to inhibit the cancer cell line A549 cell line (lung cancer), with values of IC_{50} (concentration of extract needed to reduce 50% of cell proliferation) in the range of 180.6-198.9 mg/L, while no extract showed cytotoxic effect for noncancerous ARPE-19 (human retinal pigmented epithelium) cell line. On the other hand, the best treatment to inhibit *Staphylococcus aureus* was A10, while for *Escherichia coli* there were no differences between treatments. Insecticidal effect was also observed on *Musa domestica* and *Plutella xylostella*, highlining the H5 extract. This study suggests that these extracts could be used in the development of new drugs and pesticides, providing a more sustainable and natural alternative to synthetic chemicals. Furthermore, the findings highlight the importance of exploring traditional medicinal plants for their potential therapeutic properties.

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LEAVES AND FLOWERS OF *CYNARA CARDUNCULUS* L.: A NATURAL SOURCE OF ANTIOXIDANTS AND ANTIMICROBIALS

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Cynara cardunculus L. (cardoon) is a perennial multipurpose crop that can grow in challenging environments with high yields. Its flowers are known for their coagulant properties in cheese making, and the leaves are known for their richness in bioactive compounds with interesting antioxidant and antimicrobial properties. This study evaluated the antioxidant and antimicrobial properties of cultivated cardoon and globe artichoke (*Cynara cardunculus* var. scolymus L.) leaf extracts and cardoon flower extracts. The antioxidant capacity was evaluated through DPPH free radical scavenging and the β-carotene bleaching assays. The phenolics and flavonoids content were assessed, and the individual phenolic compounds were identified and quantified through UHPLC-PDA. The extracts were tested against the main Gram-positive and Gram-negative bacteria. Overall, cultivated cardoon leaf extract presented a greater antioxidant capacity (EC_{50} = 2.1 mg/mL), followed by globe artichoke leaf extract (EC_{50} = 3.9 mg/mL) and cardoon flower extract (EC_{50} = 5.2 mg/mL). Cultivated cardoon leaf extract also presented the highest content in total phenolics (82.0 mg GAE/g) and total flavonoids (145.5 mg ECE/g). Accordingly, cultivated cardoon leaf extract showed better antibacterial activity, effective against *Staphylococcus epidermidis*, *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus* (MRSA), and *Bacillus cereus*. This study concludes that cardoon leaves are a rich source of bioactive compounds with antioxidant and antimicrobial properties, a feature that can be exploited in the context of a biorefinery approach.

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EVALUATING THE NATIONAL PLANT GERMPLASM SYSTEM *OPUNTIA* COLLECTION FOR USE AS A CLIMATE-RESILIENT BIOENERGY FEEDSTOCK FOR SEMI-ARID REGIONS OF THE U.S.

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The US National Plant Germplasm System *Opuntia* collection is maintained at the National Arid Land Plant Genetic Resources Unit in Parlier, CA. This collection contains 275 accessions of *Opuntia* (cactus pear, tuna, or nopal) from 18 different species and cultivated hybrids, although the majority are cultivated clones of *Opuntia ficus-indica*. *Opuntia* is a promising source of food, feed, and biomass feedstock for semi-arid regions of the United States due to its high productivity and water-use efficiency. As part of a collaborative effort to characterize the publicly available *Opuntia* germplasm for its many uses, the collection was genotyped through whole chloroplast genome sequencing. Genetic characterization revealed a broad range of ploidy levels in the collection from 2n = 22 to 2n = 220. A high-quality full genome sequence of one diploid accession of *O. cochenillifera* was produced with an estimated genome size of ~1.1 Gb to serve as a reference for future *Opuntia* genomics. Molecular phylogenetic tree reconstructions derived from 270 *Opuntia* accessions showed that the CP genomes were well conserved with close genetic relatedness likely due to clonal propagation and acquisition of duplicate accessions over time. This molecular genetic resource provides a strong foundation for future evolutionary studies of *Opuntia* spp. and genotypic identifiers for commercially important accessions of cactus pear. A three-year field trial in Parlier, CA evaluated the establishment and productivity (as cladode count and dry biomass) of 14 spineless accessions and identified five highly productive accessions, four of which have been advanced to ongoing field evaluation of optimal fertilization rates.

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MULTI SEED ZEA PELLETS (MSZP) SEED TECHNOLOGY TO ENHANCE BIODIVERSITY IN AGRICULTURE

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The decline of biodiversity on agricultural lands was accelerated by the adoption of herbicide-tolerant (e.g., Roundup Ready®) crops starting in the late 1990s. Herbicide-tolerant crops enabled the widespread post-emergence application of nonselective herbicides, reducing non-crop plant biodiversity and therefore biodiversity at other trophic levels. Our project focuses on restoring some of the lost density of milkweed (*Asclepias* spp.), the sole larval host plant of the monarch butterfly (*Danaus plexippus* L.). In July 2022, the migratory monarch butterfly was listed as endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Restoring the monarch population would require adding an estimated 1.6 billion milkweed plants to non-agricultural habitats; this total might be lower if plants could instead be returned to agricultural areas. Farmers who plant milkweeds may be eligible for compensation from the USDA NRCS (Natural Resources Conservation Service of the United States Department of Agriculture) or other entities. However, milkweed planting methods currently available to farmers are often inadequate for reasons including lack of access (e.g., native seed drills), unreliability (e.g., broadcasting), and/or high cost (e.g., transplants or plugs). The Cornell authors of this study formed a multi-disciplinary team to tackle the challenge of milkweed restoration. The first objective of the overall project was to develop seed technology enabling a farmer to use their existing corn (*Zea mays* L.) planter to sow milkweed seed. Milkweed seeds are small, irregularly shaped, and flat. To facilitate seed pelleting, the outer, wing-like portion of the pericarp was removed with seed conditioning equipment that reduced the seed surface area by about 50%. Milkweed seeds have physiological dormancy that was broken with moist chilling (stratification) for 14 days. Next was the development and fabrication of a protype 3D mold with the same size and shape of a field corn seed. This mold was used to produce MSZP (Multi Seed *Zea* pellets) composed of filler materials (diatomaceous earth and wood flour) and a solid particulate binder (maltodextrin). Three milkweed seeds (hence, multi seed) were placed within each MSZP before drying. The MSZP broke down rapidly when placed in water but had good mechanical strength comparable to commercial pellets of single seeds. MSZP were singulated with a lab-mounted vacuum planter, demonstrating the potential for field sowing with a commercial corn planter. Germination and seedling growth was comparable to multiple seeds without pelleting when sown at 2 cm planting depth. Results of additional indoor and outdoor pot experiments confirming good milkweed establishment from MSZP were published in *Weed Science* (doi: 10.1017/wsc.2023.5). In addition to milkweed, MSZP can be developed as a delivery system for a wide range of beneficial non-crop species such as pollinator plants.

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CHEMICAL CHANGES IN NEWLY-ESTABLISHED GOLF GREENS AMENDED WITH BIOCHAR AFTER FIVE YEARS

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Before 1960, golf putting greens were constructed primarily with either native soils or varying mixtures of sand, soil, and organic matter. These greens were often afflicted by problems such as compaction and poor drainage, leading to inconsistent playing conditions. In this year the United States Golf Association (USGA) first set recommendations for new putting green construction which have since become the standard worldwide. Due to increased research on green construction, these recommendations were updated in 1973, 1989, 1993, 2004 and most recently in 2018. In all cases, these recommendations consist of a layered design that includes: (1) underground drainage pipes; (2) a 10-cm layer of drainage gravel; (3) a variable (from 20 to 35-cm) layer of rootzone mix, which is composed of at least 80% sand (primarily sand with particle diameters from 0.25-1.00 mm) with the balance composed of organic amendments such as peat. However, peat decomposes rapidly, reducing soil organic matter, resulting in lower water and nutrient retention. Biochar, which can effectively absorb water and nutrients, is resistant to decomposition and should remain in the rootzone for an extended period. Additionally, as greens age there is frequently the formation of an impermeable iron layer at the interface of the rootzone and gravel layers. New putting greens were constructed at North Shore Country Club in 2017 using 85% calcareous sand (Thelan Materials, Antioch, IL, USA), 10% Dakota reed sedge peat (Rocky Mountain BioAg, Montrose, CO, USA), 4% biochar (Cool Planet, Greenwood Village, CO, USA) and 1% vermicompost (TerraVesco, Sonoma, CA, USA). In 2022, 2.50-cm thickness cores were sampled from these greens at depths of 20.0, 30.0, 30.0, 32.5 and 35.0-cm, respectively, and chemically analyzed for elements including iron and calcium. Compared to initial rootzone layer pH values, pH values were lower near the surface and increased until plateauing at approximately 15 cm. with the shallowest (20.0 cm) core sample having significantly higher pH values than the deeper core samples. Biochar was still visible in core samples, although larger biochar pieces were generally absent. Iron and calcium levels varied with depth with the lowest levels of both elements near the surface of the greens, with higher levels found in deeper layers. Despite this accumulation of calcium and iron, there was not a visible iron layer formed next to the gravel layer that is commonly found in older greens. Our results indicates that biochar appears to be a suitable organic amendment for new golf green construction.

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LOW INDIRECT LAND USE CHANGE (ILUC) INDUSTRIAL CROPS TO BIOENERGY, BIOFUELS, AND BIOPRODUCTS

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Industrial crops can be directed for biofuels, electricity, heat production, and bioproducts. Due to their tolerance to marginal soils, they can alleviate and ameliorate soil marginality and the risk of land-use conflicts due to competition for food, feed, and fuel are reduced, contributing positively to economic growth, and bringing additional revenue to landowners. Therefore, the main objective of this study was to present an overview of the potential of selected industrial crops for bioenergy, biofuels, and bioproducts production, when cultivated in marginal/degraded/contaminated soils (not competing with land for food and feed production), contributing to avoid Indirect Land Use Change (ILUC) burdens. The selected crops are miscanthus (*Miscanthus* × *giganteus* J.M.Greef, Deuter ex Hodk., Renvoize), hemp (*Cannabis sativa* L), crambe (*Crambe abyssinica* Hochst), and castor bean (*Ricinus communis* L.). In this context, studies on the production of these crops in marginal soils were reviewed. Globally, it was observed that yields and biomass quality can be affected by soil marginality, which may reduce environmental savings and compromise its economic exploitation. Nonetheless, the reduction in yields was, for many of the studies, less than 25%. In addition, resource use efficiency of those crops, in terms of water and nutrient use is also being evaluated across marginal soils and their water and nutrients use efficiency are being established. In the end, a critical assessment of the literature is made and opportunities and risks are pointed out.

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COMPARATIVE YIELD STUDIES AMONG THREE PERENNIAL GRASSES (MISCANTHUS, SWITCHGRASS AND GIANT REED) IN THE MEDITERRANEAN REGION

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Perennial grasses are high in resource use efficiency, and high biomass yielding crops suitable for adverse environmental conditions (e.g., marginal lands). They produce lignocellulosic feedstock that can be used for biobased products and bioenergy and are expected to play an important role in achieving long-term goals for energy policy in reducing CO_2 emissions. Several perennial grasses had been tested in Europe but most of the studies had been focused on miscanthus and secondary on switchgrass and giant reed. The aim of this research work was to compare three perennial grasses [miscanthus (*Miscanthus x giganteus* J.M.Greef & Deuter ex Hodk. & Renvoize), switchgrass (*Panicum virgatum* L.), giant reed (*Arundo donax* L.)] in an arid area in central Greece (Viotia). The field trials had been established in 2012 and are still on-going. Miscanthus and giant reed had been established by rhizomes, while switchgrass was established by seeds. The tested parameters per crop (in three plots) were the followings: a) for miscanthus four irrigation rates [0, 25, 50 & 100 of Potential Evapotranspiration (PET)] and two plant densities (1 and 2 plants/m^2), b) for switchgrass two varieties (Alamo and Kanlow), two row distances (35 and 70 cm) and three irrigation rates (0, 50 & 100% of PET) and c) for giant reed two establishment practices (by rhizomes or by stem cuttings) and two plant densities (1.1 and 1.8 plans/m^2). Since 2012, at the end of each growing period a final harvest was carried out per plot (4 m^2 had been harvested) to estimate the biomass yields. At the same time samples had been taken, separated to stems and leaves, weighed, and oven dried till constant weight. Moreover, specific growth parameters had been measured namely plant height, and tiller density per square meter. The highest (peak) yields for miscanthus and switchgrass had been recorded in the 2nd and the 3rd growing years and were 19.3 and 18.2 t/ha, respectively for miscanthus, and 24.9 and 24.4 t/ha for switchgrass. Thereafter yields for both crops (miscanthus and switchgrass) started to decline but the reductions were quite small till the 8th growing period. The yield of switchgrass in the 11th growing period was half of the peak yield, while the corresponding yield reduction for miscanthus was 30%. The peak yields for giant reed were recorded in the 3rd growing year and were 28.5 t/ha and remained high till the 10th growing period, but a yield reduction of 10% had been recorded in the 11th growing period. Among the three perennials the most productive (mean of 11 years) was giant reed (30.6 t/ha) followed by switchgrass (21.4 t/ha) and miscanthus (18.3 t/ha). Between miscanthus and switchgrass tested with different irrigation rates, miscanthus was most affected by the water deficit. Miscanthus plots that received 50% of the PET gave 32% lower yield compared to fully irrigated plots, while for switchgrass the reduction was quite small and not significant.

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CATALYTIC GASIFICATION AS A MANAGEMENT STRATEGY FOR NUT WASTES

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More than 120,000 tonnes of *Carya illinoinensis* are produced each year in Mexico. About 45 % of the total fruit weight corresponds to the external shell; also, leaves and twigs fall together with fruits in harvesting. Therefore, more than 60000 tonnes of nut waste are produced, requiring management. Usually, these wastes are either open cast disposed of or burned which cause environmental issues to the soil, air, and even water. An alternative to combustion is gasification. The gasification process transforms biomass into gaseous compounds (hydrogen, carbon monoxide, methane, carbon dioxide) and ashes. Gasification reaction takes place at high temperature in controlled oxygen atmosphere, and it requires a starting material (charcoal, diesel, etc.); the use of a catalyst can improve gasification reaction since it allows a better heat transfer in the reactor. In this research, a catalytic gasification process was evaluated as a method of nut waste management. The waste was collected from a farm located in General Cepeda, Coahuila. A fixed bed gasifier was used in batch mode with a reaction volume of 1 kg, considering charcoal as the starter. Several experiments were carried out to evaluate the effect of a catalyst (clinoptilolite) in the gasification process. In addition, environmental and economic analyses were performed to evaluate the feasibility of this management strategy. It was found that gasification with 8% zeolite presented the shortest reaction time (39.2 min) and the highest average flow of synthesis gas (0.779 m^3/5 min). The environmental impact was evaluated through life cycle assessment considering two scenarios; gasification without catalyst and gasification with catalyst at different concentrations (2, 4, 6 and 8%). In the first scenario, a greater effect was detected in the categories of freshwater ecotoxicity, global warming and human toxicity. In the second scenario, the use of 8% zeolite generates a lower effect on the global warming and human toxicity categories. Concerning the economic analysis, three cases were addressed. In the first one, gasification at laboratory level was considered. In the second case, a scaling-up was carried out with a production 100 times greater with an *in-situ* gasification plant using the gas produced to generate electricity that self-supply the process energy requirement; for the third case, the scaling up of case two was maintained, changing the synthesis gas concentration to a typical one (N_2 48%, H_2 17%, CO 21%, CH_4 1%, CO_2 13% (by volume)). From this analysis it was possible to deduce that gasification could be feasible for the management of waste nuts from technical, economic, and environmental viewpoints.

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ABSTRACTS

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ORAL PRESENTATIONS

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CARBON INTENSITY OF INDUSTRIAL AND FOOD CROP FEEDSTOCKS: ITS ALL ABOUT TRADE-OFFS

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Agricultural production in the USA accounts for 11% of the greenhouse gas emissions (GHG) among all sectors, while the transportation and industrial sectors account for 57% of the total GHG emissions. In addition, the transportation, processing, manufacturing, and disposal of all industrial bio-based products life cycle accounts for 30-40% of the GHG emissions, with 60-70% of the emissions occurring in the production phase of the agricultural feedstock. Thus, to reduce emissions in the whole life cycle of a product, significant reductions are needed during the crop production phase. Both food and fuel industries are searching for crops and cropping systems that have a low carbon intensity (CI) and reducing high fossil carbon-footprint inputs in crop production is key to accomplishing this goal. A low-input crop is not always synonymous to a low-CI crop. Carbon intensity of a product is measured in kg CO_2eq per kg of seed or in g of CO_2 per MJ of energy. Reducing inputs, especially nitrogen fertilizer, also reduces seed yield and as yield decreases the CI increases. The objective of this review was to evaluate the CI of oilseed feedstocks and determine the research needed to accurately estimate CI in diversified cropping systems that include both biofuel and food crops. Camelina [*Camelina sativa* (L.) Crantz] has been identified as a potential low CI feedstock for biofuels. However, camelina seed yield is about half or less than other oilseed crops and does not always have lower CI than other oilseed feedstocks such as canola or rapeseed (*Brassica napus* L.) and soybean [*Glycine max* (L.) Merr.]. Nitrogen fertilizer and field management (tilling, planting, spraying, and harvesting) account for the majority of the GHG emissions. Nitrogen fertilizer has a high C footprint during its production and also increases field emissions; mainly nitrous oxide emissions, a potent GHG. The global warming potential (GWP) of camelina production ranges from 0.45 and 1.8 kg CO_2eq kg^{-1} of seed. The CI of camelina oil-based fuels from "well to wheel" ranges between 11 and 45 g CO_2eq MJ^{-1} depending on seed yield and nitrogen fertilization used in the life cycle inventory. In comparison, the CI of canola and soybean renewable diesel ranges between 48 and 51 g CO_2eq MJ^{-1}. All reports included in the analysis agree that the agricultural production of camelina accounts for most of the GWP. In oilseeds production, nitrogen fertilizer production alone accounts for 8 to 30% of GWP, and field nitrous oxide emissions contribute 13 to 23% of total GWP of the agricultural phase "cradle to gate". There is a need for more research to determine how reducing nitrogen fertilizer and other inputs correlates with reducing CI of an integrated cropping system that includes food and biofuel crops.

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CAMELINA: A LOW INPUT FEEDSTOCK FOR BIOFUELS AND ITS RESPONSE TO NITROGEN FERTILIZATION

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Nowadays, there is an urgent need for identifying vegetable oil sources with low environmental footprint, for renewable fuel production. Camelina (*Camelina sativa* L. Crantz) can produce high oil yield per hectare with reduced nitrogen fertilization; this is increasing the interest towards this crop in comparison with other more widely grown *Brassicaceae*, such as oilseed rape (*Brassica napus* L.). Camelina seeds contain about 40% of oil and mean camelina seed yield is reported to vary between 1 and 3 Mg ha^{-1}, with an average of about 1.5-2.0 Mg ha^{-1}. Many studies have reported an optimal N rate in the range of 50-60 kg N ha^{-1}; however, seed yield response with rates greater than 100 kg N ha^{-1} have been reported. The objective of this study was to analyze and summarize the available literature on camelina response to N fertilization. Additionally, the aim was to determine the optimum N rate for camelina. In a three-year study (2020-2023) conducted at northern Italy (Bologna), camelina cv. 'Alba' was sown at the experimental farm of Bologna University at Cadriano (Italy). Two sowing dates, early October, and late October/beginning of November and three N rates (0, 60, and 120 kg N ha^{-1}) were evaluated. Nitrogen was applied before stem elongation. All the studied parameters were influenced by the N rates. The effect of sowing date and the interaction between the two factors affected seed yield, seed oil content and fatty acid composition. Final plant height was similar when 120 and 60 N kg ha^{-1} were applied (82 cm and 76 cm, respectively) while shorter plants were observed when no fertilization was applied (71 cm), a similar pattern was observed for total aboveground biomass where 120 and 60 kg N ha^{-1} resulted in values of 8.1 and 6.9 Mg ha^{-1} while in absence of fertilization, total above biomass was only 5 Mg ha^{-1}. An interaction between sowing date and N was observed for seed yield. In the early sowing date, N application significantly increased seed yield, with 1.58 Mg ha^{-1} and 1.20 Mg ha^{-1} with 120 and 60 kg N ha^{-1}, respectively. Seed yield with no N was 0.8 Mg ha^{-1}. In the later sowing date, a decrease in seed yield was observed only with no N application. Seed yields were 1.00, 1.55, and 1.47 Mg ha^{-1} for 0, 60, and 120 kg N ha^{-1}, respectively. Oppositely to the seed yield response, 1000-seed weight (TKW) was higher with no N fertilization (1.25 g), while with 60 N ha^{-1} and 120 N ha^{-1} TKW was 1.18 g and 1.17 g, respectively. Seed oil content (%) was influenced by N fertilization where higher N incorporation (120 kg N ha^{-1}) showed values of 31% oil content while an increase in oil was observed when lower nitrogen rates were used (0 and 60 kg N ha^{-1}): GM 33%. Results confirmed, as observed before, that camelina does not respond to increasing N rates above 60 kg N ha^{-1}, while a decrease in seed oil content can be expected when applying N rate of 120 kg N ha^{-1}. Nevertheless, research is needed to determine the lowest N rate needed to minimize greenhouse gases emissions, while maximizing oil production per hectare.

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CULTIVAR CHOICE AND HIGH TEMPERATURE DURING REPRODUCTIVE STAGE AFFECTING TOCOPHEROL CONTENT AND COMPOSITION IN CAMELINA

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High temperature and heat stress in cultivated crops are becoming major concerns, as they substantially lower seed yield. Crops grown in the Mediterranean basin are often subjected to heat stress conditions during spring. The reproductive stage of plants is the most sensitive to heat stress, diminishing seed yield. The specific effects of high temperature on tocopherol content and composition in camelina have not been investigated. The aim of this work was to test the response of two different camelina cultivars to high temperature imposed at reproductive stage. The experiment was carried out in two growth chambers located at the DISTAL, between November 2021 and February 2022. Two camelina cultivars Cypress and Omega were sown. Plants were kept in controlled conditions (25/18 °C day/night), until the imposition of heat stress. Two different high temperature treatments were applied: EF (i.e., 35/18 °C day/night for five consecutive days from the end of flowering) and SF (i.e., 40/18°C day/night for five consecutive days from silicles at final dimension). At harvest, seed production per plant was assessed by manually opening the silicles and extracting the seeds. Moreover, seed oil content, tocopherol content, and tocopherol composition were determined for the harvested seeds. Determinations were performed on five pots per treatment. In the EF treatment, cultivar significantly ($P \leq 0.05$) affected seed production per pot. In both the EF and the SF treatments, cultivar significantly ($P \leq 0.05$) influenced total tocopherols, α-tocopherol, and γ-tocopherol contents. Both treatments significantly ($P \leq 0.05$) impacted oil content and α-tocopherol. Cultivar by treatment interaction was significant ($P \leq 0.05$) only for γ:α ratio in the SF treatment. In the EF treatment, 'Omega' produced greater seed yield (0.83 g/plant) than 'Cypress' (0.70 g/plant). Omega had the highest tocopherol content both in the EF (1066 mg kg^{-1} oil) and in the SF (1029 mg kg^{-1} oil) treatments compared with 'Cypress' (893 mg kg^{-1} oil in EF and 901 mg kg^{-1} oil in SF). 'Omega' had the highest α-tocopherol and γ-tocopherol content in both high-temperature treatments reporting 15 mg kg^{-1} oil and 1042 mg kg^{-1} oil, respectively in the EF, and 14 mg kg^{-1} oil and 1006 mg kg^{-1} oil, respectively, in the SF treatment. Heat stress reduced seed oil content by 9.5% in the EF treatment, and decreased oil content up to 11.8% in the SF treatment, compared with the control. Exposure to high temperature increased α-tocopherol content from 9.2 mg kg^{-1} oil to 12 mg kg^{-1} oil in the EF treatment, and from 7.3 mg kg^{-1} oil to 13 mg kg^{-1} oil in the SF treatment. Only in the SF treatment, γ:α ratio was higher in Cypress (177.0) than in Omega (81.6), and it was higher in the control (173.5) than in SF (85.1). However, in 'Cypress' the decrease in γ:α ratio was up to 55%, while in 'Omega' the reduction was 40%. The imposed temperature conditions did not affect camelina seed yield, however they altered seed oil content and α-tocopherol. Despite reducing oil content, heat increased α-tocopherol. 'Omega' had the highest tocopherol content. The results suggest that growing camelina in environments prone to heat waves would allow to obtain acceptable seed and oil yield, with an increased nutritional value of the oil.

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SUPPRESSION CAPACITY OF *CAMELINA SATIVA* AGAINST THREE SUMMER WEED SPECIES

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Semi-arid regions, characterized by low and irregular precipitations, are expected to increase in the following decades because of the ongoing climate change. Therefore, to reduce the potential negative consequences and avoid productivity losses, irrigation is required. In semi-arid Mediterranean regions, a typical cropping system in irrigated fields is an annual double crop rotation of winter cereal-annual summer crop [maize (*Zea mays* L.)]. Despite being a rotation, it is based on simplified and specialized strategies aimed at enhancing agricultural yields. In these regions, drought-tolerant crops with a short life cycle, such as camelina (*Camelina sativa* (L.) Crantz), are interesting for their quick development and early harvesting, generally in June, allowing a summer crop to be produced and harvested before winter. Furthermore, *C. sativa* has several agronomic qualities that show a high competitive capacity against weeds. This trial aims to study the weed suppression capacity of spring sown camelina. The studied summer weed species were *Chenopodium album* L., *Polygonum aviculare* L. and *Xanthium spinosum* L. The trial was carried out in plots with sprinkler irrigation at the University of Lleida for three years (from 2019 to 2021). Each year, sowing was done in March with camelina (variety GP204) in 1.5 x 10 m^2 plots with three replicates. Additionally, three 0.5 x 0.5 m^2 quadrates per species with five individuals were established in each plot, with uncropped controls nearby the plots. Eventually, due to climatic conditions, sprinkler irrigation was applied in 2019 and 2021, averaging 182.1 l m^{-2}. As compared to the control, the results showed that the height and weight of the studied weeds in competition with camelina decreased by more than 50%. For *C. album*, these parameters decreased similarly in 2019, 2020 and 2021. Nevertheless, height and weight in *P. aviculare* and *X. spinosum* showed seasonal differences. Such differences were due to the weather conditions. Where, camelina yield was severely affected too (1572, 739 and 298 kg ha^{-1} in 2019, 2020 and 2021 respectively). Phenology of weeds was also delayed. Furthermore, the number and size of *X. spinosum* thorns were reduced (78-87% and 59%, respectively). Therefore, two scenarios were set up. On the one hand, a particularly rainy spring, such as 2020, without water limitation for summer weeds, favors their development, increasing their competition against camelina. On the other hand, a dry growing period, combined with high temperatures, and followed by insufficient irrigation during flowering and ripening stages, can negatively affect both the crop and weed development, such as in 2021. The spring sown camelina has shown to be a useful tool for integrated weed management in rotation systems with summer crops with an irrigation support, being able to prevent the whole weed seed rain of summer weeds. However, more research is needed to improve the irrigation requirements and yields of camelina.

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RESPONSE OF *CAMELINA SATIVA* (L.) CRANTZ TO SOIL AND FOLIAR HERBICIDAL TREATMENTS

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Camelina (*Camelina Sativa* (L.) Crantz) is an oilseed crop grown in Europe since 4000 BC. Weed management is one of the main issues during camelina's cultivation. The plants are very sensitive to herbicide active substances and there is a very limited list of herbicidal products suitable for application before sowing or during the vegetation of the crop. The main aim of the research conducted during 2021 and 2022 was to study the efficacy of some herbicidal products against common weeds in the region such as; *Chenopodium album* L., *Galium aparine* L., *Consolida regalis* Gray., *Xanthium spinosum* L., *Setaria viridis* (L.) P.Beauv, *Lolium rigidum* Gaud., and *Convolvulus arvensis* L. and the selectivity for three camelina genotypes with different origin – "Czenstochowska" (Poland). "CAM 265" (Italy) and "BGR 436" (Bulgaria). The trial was performed in the experimental field of the Agricultural University of Plovdiv, Bulgaria. Four variants were implemented - soil application after sowing before germination of camelina (at BBCH 00 to 03) of Stomp Aqua (455 g/l pendimethalin) in a rate of 4.0 l ha^{-1} and Butisan 400 SC (400 g/l metazachlor) in a rate of 2.5 l ha^{-1} and foliar treatment with Lontrel 300 SL (300 g/l clopiralid) in a rate of 0.4 l ha^{-1} and Galera Super (240 g/l clopyralid + 80 g/l picloram + 40 g/l aminopyralid) in a rate of 0.2 l ha^{-1} when single true leaf on 5^{th} to 8^{th} node were developed (at BBCH 15-18). Comparisons were made to untreated control of the same accession. The herbicidal efficacy was assessed by the 10-score visual scale of European Weed Research Society (EWRS) on the 14^{th}, 28^{th} and 42^{nd} day after treatments. Herbicidal selectivity was evaluated by the 9-score visual of EWRS scale on the 7^{th}, 14^{th}, 21^{st}, and 28^{th} after emergence of the plants with soil application and on the 7^{th}, 14^{th}, 21^{st}, and 28^{th} day after the treatments with the foliar herbicides. Several growth and productive parameters of camelina were evaluated: plant height, number of branches, number of siliques $plant^{-1}$, seed yield $plant^{-1}$. The vegetative application of Galera Super – 0.2 l ha^{-1} and Lontrel 300 SL – 0.4 l ha^{-1} has more efficient weed control compared with the application of Stomp Aqua – 4.0 l ha^{-1} and Butisan 400 SC – 2.5 l ha^{-1}. The reported phytotoxicity was higher for the foliar applied herbicides, and the most sensitive camelina genotype was the Bulgarian landrace. The genotypic variability of camelina in the herbicide response is clearly presented by the plant depression. Soil treatment influence the stem to a greater degree for "Czenstochowska" and "CAM 265" while "BGR 436" has similar effect and shorter plants after application of Stomp Aqua and Galera Super. Better branching was preserved at introduced genotypes from the variant with Butisan 400 SC, while it allowed the formation of highest silique number of the "Czenstochowska" plants. The lowest seed yield $plant^{-1}$ was reported for the variant with foliar application of Galera Super for all three camelina genotypes. Best results were obtained by "CAM 436" treated with Stomp Aqua. The highest control of the broadleaf weeds was obtained by the application of Lontrel 300 SL, while the grass weeds were controlled by the application of Butisan 400 SL.

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PACBIO SEQUENCING AND ASSEMBLY OF A WINTER AND SPRING VARIETY OF *CAMELINA SATIVA*

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Camelina [*Camelina sativa* (L.) Crantz] is an important oilseed species of Brassicaceae, which consists of winter and spring biotypes that provide beneficial ecosystem services, food and feed byproducts, and are potential sources for sustainable biofuel production. The winter biotype (Joelle) and spring biotype (CO46) of camelina are known to have many differences in agronomic traits including freezing tolerance, growth habit, flowering time, seed yield, oil content, and the like. To gain a better understanding of the genetic differences associated with these two camelina biotypes, both were sequenced using PacBio hifi technology. The sequencing results produced ~30X coverage from CO46 and ~20X coverage from Joelle with average read lengths greater than 10 Kb. The sequences were assembled separately using Hifiasm with a predicted ploidy level of 3. The results produced high quality assemblies of both biotypes with end-to-end chromosome scaffolds assembled from ~3500 primary contigs with an N50 above 30,000,000 for CO46 and above 6,000,000 for Joelle. The chromosome-level assembly was 679,629,983 bases for CO46 and 559,281,586 for Joelle, and BUSCO scores were above 96% for both assemblies. Of the 89,419 genes annotated in the DH55 reference genome, 21 were not found in CO46 and 149 were not found in Joelle. The bulk of the missing transcripts were on chromosomes 3, 14, and 17. The collinearity of the reference transcripts (DH55) on the new assemblies was generally consistent, but there were also several discrepancies- usually near the chromosome ends. A cross between the spring and winter biotype was done and Recombinant Inbred Lines (RILs) were developed from 255 F2 seeds by consecutive single seed decent to the F7 generation (F6:F7). Over 200K high quality markers were identified between the lines by skim whole-genome sequencing and were mapped to the F6:F7 RILs. Selected markers will serve as the basis for QTL mapping agronomic traits of interest.

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IDENTIFICATION OF FLOWERING TIME QTL IN A CAMELINA BIPARENTAL POPULATION

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Camelina [*Camelina sativa* (L.) Crantz] is an annual oilseed crop from the *Brassicaceae* family. Recently, interest in camelina has reemerged with its potential use as a low-input high value oil crop for food and feed, biofuel, lubricant, and cosmetic industries. Camelina consists of both spring and winter biotypes with winter biotypes having exceptionally low temperature tolerance. Winter-hardy crops, such as camelina, can be planted in the fall and harvested early in the summer allowing for double- and relay-cropping options in the northern Great Plains. To enhance double- and relay-cropping systems, early maturing varieties of camelina are desired. The objectives of this study were to evaluate variation in flowering time (FT) and identify quantitative trait loci (QTL) in a biparental camelina population developed from crossing a winter (Joelle) and a spring (CO46) biotype. An F7 recombinant inbred line (RIL) population consisting of 253 individuals were phenotyped for the first day of flowering, with or without an 8-week vernalization treatment, in two separate experiments under greenhouse conditions. Variation in FT was observed in the RIL population and average FT ranges were 79 to 105 days after planting (DAP) (Exp 1) and 83 to 111 DAP (Exp 2) when vernalized. Without vernalization, spring types and some plants of mixed types flowered at 31 to 74 DAP (Exp 1) and 34 to 76 DAP (Exp 2). The RIL population was genotyped with skim sequencing and 4507 informative SNPs (single nucleotide polymorphisms) were used as markers to create a linkage map and perform QTL analysis. The map consisted of 20 linkage groups representing 20 chromosomes (Chr) of *C. sativa*. QTL analysis of FT with vernalization identified significant loci at Chr 8, 11, 13, and 16 with the highest LOD (logarithm of odds) score of 26.8 in Chr 13. For FT without vernalization, QTL were identified at Chr 8 and 13 with the highest LOD score of 48.3 in Chr 13. A closer look into the identified QTL regions in Chr 8 and 13 of camelina indicated the presence of a MADS-box protein encoded by *FLC* (*FLOWERING LOCUS C*). FLC is a known floral repressor and vernalization is required to reduce *FLC* expression and induce reproductive growth in varieties with functional FLC. Comparison of alleles for the most significant markers in Chr 8 and 13 showed CO46 allele decreased the FT by 3 days when vernalized and 9 to 11 days without vernalization, whereas Chr 11 and 16 decreased FT by about a day in both conditions. Further study of the identified QTL regions in the RIL population will help us to better understand the mechanisms regulating early flowering in camelina.

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QTL MAPPING TO IDENTIFY LOCI AND CANDIDATE GENES ASSOCIATED WITH FREEZING TOLERANCE TRAIT IN *CAMELINA SATIVA*

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Lack of freezing tolerance is a major constraint to produce agronomically important *Brassica* species, particularly in the Northern Great Plains (NGP) of the United States and Canada. However, within the Brassicaceae family, winter varieties of camelina [*Camelina sativa* (L.) Crantz] have shown excellent freezing tolerance and overwinter potential in the NGPs. Thus, camelina has recently re-emerged as an oilseed cash- or cover-crop option in these regions. Studies have also indicated that differences in freezing tolerance between a winter variety (Joelle) and the spring variety (CO46) of camelina may be controlled by a small number of dominant or co-dominant genes. To unravel the genetic mechanisms controlling differences in freezing tolerance, reciprocal crosses between these two camelina varieties were used to develop 25 Recombinant Inbred Lines (RILs). This RIL population was phenotyped at the F6:F7 stage for freezing tolerance following 4 weeks of cold-acclimation at 5°C under controlled conditions and genotyped by whole-genome skim sequencing. A one-way ANOVA test revealed a significant ($P < 0.001$) difference exists among the RILs for freezing tolerance, as determined by the range of average visual damage scores (0 = 100% damage, 1 = 75-50% damage, 2 = 50-25% damage, and 3 = 25-0% damage). A significant correlation (r = 0.61, $P < 0.001$) was also observed between freezing tolerance and flowering time, indicating that regulation of flowering time might also influence freezing tolerance in camelina. A de novo linkage map was constructed using 4507 SNP markers covering a total of 1208.5 cM map distance with an average of 0.3 cM distances between the markers, which formed 20 linkage groups representing the 20 chromosomes (Chr) of *C. sativa*. The QTL analysis revealed significant loci for freezing tolerance on Chr 8, 11, 13, 16 and, 18 with LOD threshold value of over 2.5. The QTL peaks with the greatest LOD values of 20.7 and 26.8 were observed at Chr 8 and Chr 13 which map close to paralogous FLC genes and accounted for 18.3% and 25.3% of the phenotypic variation, respectively. Of the 280 annotated camelina genes identified within ±50 Kb from our identified QTL markers, 28 were transcription factors including another *MIKC_MADS* on Chr 18 that annotate to an orthologue of FLC (MAF4), or closely related to FLC (MAF3) of Arabidopsis, and genes involved in processes such as response to abiotic stress, cell division and regulation, epigenetic regulation, and protein processing and degradation. Although many of the candidate genes identified near the freezing tolerance QTLs have previously been associated with cold responses in plants, further studies are needed to help unravel freezing tolerance mechanisms and improve freezing tolerance in other Brassica crop species, or for improving agricultural intensification through dual cropping in the NGP.

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CAN HERBICIDE-DAMAGED RAPESEED PLANTS RECOVER AFTER BIOSTIMULANT APPLICATION? AN HERBICIDE DRIFT STUDY

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Rapeseed (*Brassica napus* L.) is one of the most important oilseed crops in the world and ranks second as a source of vegetable oil. The seeds obtained from it are raw material for biodiesel production, which also determines the growing interest in the crop. In addition, oilseed rape is a potential source of specific proteins, biopolymers, surfactants and adhesives. The main factor limiting the growth and development of the crop is the weed. In modern agriculture, the application of herbicides is a primary method of weed management. Although modern herbicides are characterized by increasingly high selectivity, in certain cases they can have a toxic effect on the culture - herbicidal phytotoxicity. One phenomenon for herbicidal stress is the herbicide drifting from one field to another. Therefore, the aim of the current research was to study the response of the conventional rapeseed variety "PT 225" to simulated herbicide drift and subsequent medicative application of plant biostimulant (Amino Expert Impuls). The idea of the experiment was to imitate herbicide drift from field of Clearfield oilseed rape to conventional one. The herbicide product Cleranda SC (containing 17.5 g/L imazamox and 375 g/L metazachlor) registered for weed control in Clearfield rapeseed hybrids was used. The trial was conducted during 2020/2021 and 2021/2022 on the experimental field of the Agricultural University – Plovdiv, Bulgaria. The trial included the following treatments: 1. Untreated control; 2. Cleranda SC – 0.4 L ha^{-1} (20% of the rate 2.0 L ha^{-1}); 3. Cleranda SC – 0.6 L ha^{-1} (30% of the rate 2.00 L ha^{-1}); 4. Cleranda SC – 0.4 L ha^{-1} + Amino Expert Impuls – 3.0 L ha^{-1}, and 5. Cleranda SC – 0.60 mL/da + Amino Expert Impuls – 3.0 L ha^{-1}. The imitation of the herbicide drift was performed in 4^{th} – 6^{th} true leaf of the oilseed rape, and the ameliorative application with Amino Expert Impuls was done 7 days later. The levels of phytotoxicity caused by the herbicide by the 9-score scale of EWRS (European Weed Research Society) on the 7^{th}, 14^{th} and 28^{th} day was evaluated. Several parameters (physiological, growth, and productive) of the crop were studied and will be discussed including; Net photosynthetic rate and total leaf chlorophyll content, fresh and dry biomass, and number of leaves in crop growth stage end of flowering (BBCH 69), number of primary branches and plant height at the end of the vegetation, oilseed rape seed yield (t ha^{-1}) absolute seed mass, and seed oil content. Herbicide drift causes phytotoxic symptoms to the rapeseed hybrid PT 255, while the damage was more severely pronounced for the plants that received the 30% of the herbicidal rate (0.60 l ha^{-1}). The ameliorative treatment with the plant biostimulant Amino Expert Impuls helped the plants to resist the herbicidal stress caused by the herbicidal drift and the plants showed more vigorous growth and productive indicators evaluated were higher, which was supported by the values of the physiological measurements.

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CARINATA AS A SUMMER COVER CROP FOR NORTHERN ITALY

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The European bioeconomy is looking for low iLUC (indirect Land Use Change) feedstocks sourced within domestic territories. One feasible option is to grow dedicated non-food crops in inter-, relay-, and double-cropping systems, integrating them with typical stable food crops, without competing with them. When considering the possibility of growing summer cover crops in the Mediterranean basin to succeed winter cereal harvest, the list of suitable crops is very limited due to the harsh condition characterizing Mediterranean summer (i.e., high temperatures and prolonged droughts). Thus, usually northern Mediterranean soils are left fallow during summer months with remarkable risks, linked to erosion. Carinata (*Brassica carinata* L. Braun) is an emerging oilseed crop with great potential in southern European environments in relation to its good heat and drought tolerance, and suitability to marginal land. Additionally, the recent progress of NUSEED breeding program has permitted the selection of new carinata hybrids which should be better performing also in such harsh environments. In this scenario, a screening trial was performed for two consecutive growing seasons (2021 and 2022) at the experimental farm of Bologna University at Cadriano (Italy), comparing different carinata genotypes sown after winter cereals. Each growing season six (2022) or seven (2021) Nuseed carinata genotypes were tested including an open pollinated check variety, DH-129.B036, the commercial hybrid Nujet 400 in 2022, and several (5 in 2021 and 4 in 2022) experimental hybrids. Carinata was planted on June 04 in 2021, and on May 31 in 2022 by means of a plot seeder. An increased seeding density corresponding to 175 seeds/m^2 was applied in order to permit a good establishment to carinata. The preceding crop was winter barley. External irrigation was applied using sprinkler system beside the 20 mm, cumulative precipitation durin May to mid-August In both years, the beginning of flowering started about 60 d after sowing in the earliest genotypes, and about 10 d later for the others. The mean temperature from sowing to harvest was 24.6°C in 2021, and 22.9°C in 2022. The latter year was characterized by July and August with mean temperatures exceeding 25°C, which caused a huge stress to carinata prolonging its cycle of about 3-4 weeks compared with 2021 In both years, flea beetles (*Altica* spp.) were controlled by spraying pyrethroid insecticide mixtures. Flea beetles are a relevant pest in the study area, being highly diffused in many summer crops, such as root and sugar beet and spinach. Carinata harvest was carried out manually when plants reached full maturity at 13 to 25 of September in 2021 and one month later in 2022. Despite the harsh environmental conditions faced during its growing cycle, carinata demonstrated to adapt satisfactory to the test environment and in 2022 some of the NUSEED hybrids were able to reach a seed yield of about 2 Mg/ha., while the checks yielded less than 1 Mg/ha. Thus, carinata can be considered a good opportunity for sourcing a non-food oilseed during summer fallow period in northern Italy, but great attention should be taken to genotype selection to choose the most suitable and productive ones.

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EFFECTS OF HEAVY METALS CONTAMINATED SOILS IN THE PRODUCTION OF CRAMBE OIL

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Several crop species can be cultivated to produce bioproducts, biomaterials, bioenergy, and biofuels, representing an auspicious option for the partial substitution of fossil-based feedstocks. In addition, some crops also can tolerate and remove contaminants from the soil, potentiating soil remediation. Moreover, the production of energy crops in soils contaminated with heavy metals contribute to reduce land use competition with food crops and land use change controversies. Oilseed crops represent a source of medium-chain fatty acids and medium-chain polymer building blocks that can be used to produce plastics, surfactants, detergents, lubricants, plasticizers, and other products. In this context, this work aims to assess the potential of crambe (*Crambe abyssinica* Hochst R.E. Fries) for the oil production for the bioeconomy along with the phytoremediation of heavy metals contaminated soils. Therefore, *Crambe abyssinica* were sowed in different soils artificially contaminated with Zn: 450 mg/kg; Pb: 450 mg/kg; Cd: 4 mg/kg; or Ni: 110 mg/kg. This work was carried out in pots, under semi-controlled conditions, in Caparica, Lisbon, with the duration of two vegetative cycles (seeds sowing in November 2021 and 2022, harvested in May 2022 and 2023). Over the two growing cycles, yields of *Crambe abyssinica* were on average 160 g/m^2 and the crop presented a high tolerance index to the studied heavy metal contaminated soils (> 0.75). Yet, the oil content in the seed was slightly affected by the level of contamination in the soil. A small increment was observed in protein content and ash content, of the seeds, with a lower content in oil. In terms of phytoremediation, highest phytoextraction potential was observed for zinc and cadmium, and reduced potential for nickel and lead. Nonetheless, metals content in the siliquae fraction of crambe tested was minor and, therefore, although oil yields are a bit lower, the oil can represent a feedstock for the oleochemical industry, contributing to decarbonize the economy.

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OPPORTUNITIES AND OBSTACLES IN THE DOMESTICATION OF NORTH AMERICAN PRAIRIE PERENNIAL SILPHIUM AS AN OILSEED ALTERNATIVE

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Over 20 years ago, The Land Institute identified the genus *Silphium* as a source of candidates for *de novo* domestication due to their relatively large seeds and seed flavor similarity to the oilseed sunflower (*Helianthus annuus* L.). Members of this genus have long been noted for their tolerance of extreme heat and drought events in this abiotically stressful region. Deep coarse roots are one of the wild traits we hope to retain during domestication. However, while our initial focus on germplasm from the large-seeded western ecotype of *Silphium integrifolium* led to gains in seed yield potential, this ecotype was subsequently devastated by epidemics of (native) specialist pathogens and pests. Therefore, we have tested the strategy of rebuilding our breeding gene pool via hybridization with numerous other wild accessions of the same species and with other *Silphium* species. Despite the smaller seeds of these wild parents, early results suggest that previous gains in seed size can be quickly recovered along with improved disease resistance. In the case of domestication candidates sourced from small, declining, fragmented plant populations, what can practitioners of artificial selection learn from conservation biology's "genetic pollution" vs. "genetic rescue" debate?

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SCREENING TRIALS AMONG HIGH YIELDING CASTOR BEAN HYBRIDS IN GREECE

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Castor (*Ricinus communis* L.) is a valuable oilseed crop that can be either annual or perennial (similar to a small tree). The importance of castor oil arises from its richness (>80%) in ricinoleic having numerous chemical and medicinal applications. At world level the cultivation area of castor bean is more than 3 million ha (mainly located in India) and it is mainly harvested manually. Although the crop can be cultivated in the Mediterranean region, it is found only in experimental and demonstrative fields. Lately, improved annual castor bean hybrids had been developed with high seed yields (>3 t/ha). The aim of this research work was to compare four castor hybrids in the Mediterranean region for two subsequent years (2021 & 2022). The under-study hybrids (C1012, C1016, C1019, C1033) had been developed and provided by Kaiima Company. The targeted plant density was 6 plants/m^2. The sowing took place by hand between the end of April and the beginning of May. The size of each plot was 30m^2. In both years drip irrigation was used. Before sowing a basic fertilization was applied (300 kg/ha 11-15-15), while a top fertilization of 60 kg/ha was also applied through the drip irrigation (30-40 days from emergence). No diseases or pests had been recorded in the field trials. Both years no herbicides were applied to stop the growth of the crop and the final harvest was organized on 2 m^2 per plot (16th of September in 2021 and 1st of October in 2022). The harvested biomass was weighted and then separated to stems, leaves and racemes (the seeds have been manually collected from the racemes). Higher plants had been developed in 1st growing period (1.08 cm in 2021 vs 0.85 cm in 2022). At the final harvest the dry racemes corresponded to the 78% of the total produced in the 1st year and 82% in the 2nd year. The most productive hybrid in 2021 was C1016 (3.91 t/ha seeds) and C1019 in 2022 (3.50 t/ha seeds). Both years the least productive was C1033 with seed yields 2.8 in 2021 and 2.73 in 2022. In terms of straw yields the highest values had been recorded by C1016 (4.12 t/ha in 2021 and 4.24 t/ha in 2022). Seeds samples had been selected for oil content analysis, while samples from leaves and stems have also been selected, oven-dried and milled for their biomass characterization (calorific value, proximate and elemental analysis). The gross calorific value was 4203 kcal/kg for leaves and 4258 kcal/kg for stems. The corresponding values for ash content were 7.22% and 11.40%.

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ABSTRACTS

POSTER PRESENTATIONS

1. INTEGRATION OF INDUSTRY 4.0 TECHNOLOGIES FOR FACILITATING SUSTAINABILITY ASSESSMENT OF BIO-BASED PRODUCT MANUFACTURING

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The rapidly developing bio-based product manufacturing industry is aiding more sustainable ways materials can be processed into products. With the increasing world population and the rise in urban dwellers, optimizing bio-based renewable resources is necessary to meet the ever-rising demand for sustainable development. Bio-based product research and development increased dramatically over the past decade. However, sustainability assessment of bio-based product manufacturing remains a nascent research domain. Data variability is a critical challenge for sustainability assessment and industrial process improvement initiatives. To ensure the bio-based industry is competitive across its value chains, improve traceability and transparency, employ operations excellence, and promote bio-economy, Industry 4.0 technologies must be integrated. Especially, interconnected smart systems are revolutionizing manufacturing and agricultural operations. Employing these intelligent technologies to support sustainability assessment through data-driven product lifecycle management could ensure adequate evaluation of the impacts of bio-based product systems. The sustainability engineer can digitalize upstream, downstream, and end-of-life processes by interconnecting stakeholders, including the farmer, supply chain personnel, production engineers, ecologically conscious users and consumers, and end-of-life product management personnel. Smart sensors for real-time monitoring and collection of data from the different stages across the bio-based product life cycle will enable more agile, flexible, and reliable processes. Historical data managed with cloud computing technologies can be leveraged using AI and machine learning for evaluating sustainability performance, materials and energy use, operational characteristics, and process requirements. The broader impacts of this integration of Industry 4.0 technologies and sustainability assessment for bio-based product manufacturing include informed decision-making for policymakers, better-regulated farm operations due to forecasted market demand and agricultural variables, reliable and publicly available databases for crops, increased profitability and survival of startups and small and medium-sized manufacturers due to availability of data to make sound decisions.

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2. CULTIVATION OF FIBER CROPS FOR SUSTAINABLE SOIL REMEDIATION AND BIO-BASED RAW MATERIAL PRODUCTION FOR INDUSTRIAL USES

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This study was implemented under the frame of the FORTE project, which is granted in the context of the bilateral and multilateral joint R&T collaboration between Greece and China. The aim of the project is to investigate: (i) the ability of industrial hemp (*Cannabis sativa* L.), flax (*Linum ussitatissimum* L.), and kenaf (*Hibiscus cannabinus* L.) to be successfully cultivated in contaminated mining and agricultural lands, and (ii) the potential to use the produced biomass for industrial applications (i.e., particle boards, insulation panels, and lightweight crack-resistant mortar). In Greece, the experimental fields were established in a heavily contaminated mining site (prefecture of Attika, Lavrion) and in a non-contaminated control field (prefecture of Boeotia, Aliartos). In China, the fields were established in a contaminated agricultural land in Hunan Province, the first among China's provinces in rice production. In this work only the results from the Greek experiment will be presented. The soil of the Lavrion experimental field is contaminated by: Cd (25 mg/kg), Pb (10797 mg/kg), Zn (4958 mg/kg), Ni (172 mg/kg), Cu (138 mg/kg), As (590 mg/kg), and Sb (92 mg/kg). Two varieties per crop were tested, along with three irrigation doses [I: 108.6 mm (precipitation only), II 50% of ET: 421.1 mm, III 100% of ET: 733.5 mm], as well as three fertilization levels (N0: no addition of urea, N1: 30 kg/ha, N2: 60 kg/ha). The effects of mycorrhizae fungi were also examined. The experimental design was the split-split plot with three replicates. At harvest the plant height, shoot diameter, fresh and dry weights, as well as the heavy metal and metalloid contents in the above ground biomass were determined. The results showed that in the contaminated site the growth of all crops was affected by the presence of heavy metals and metalloids in the soil, and the plants remained smaller than in the control field; an important decrease of the produced biomass was observed. More specifically, the yield reduction for kenaf and industrial hemp was approx. 70-75% respectively, and for flax was 32%. The concentrations of contaminants in the aerial biomass of hemp were up to 0.99 mg/kg for Ni, 37.3 mg/kg for Cu, 93.1 mg/kg for Pb, and 197.8 mg/kg for Zn, while for Cd and Sb were below the detection limit of the ICP-OS. The concentrations in kenaf above ground biomass were up to 23.6 mg/kg for Cd, 1.9 mg/kg for Ni, 13.6 mg/kg for Cu, 21.2 mg/kg for Pb, and 137.9 mg/kg for Zn, while for Sb were below the detection limit. The corresponding concentrations in flax aerial biomass were up to 2.7 mg/kg for Cd, 13.7 mg/kg for Cu, 19.9 mg/kg for Pb, and 87.7 mg/kg for Zn, while for Ni and Sb were below the detection limit. As for the contaminant removal from soil, the accumulation of Cd, Ni and Zn was higher in kenaf, followed by hemp > flax, while Pb and Cu were more accumulated in hemp, followed by kenaf > flax.

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3. INDIGO (*INDIGOFERA SUFFRUTICOSA*) SEED GERMINATION TO IMPROVE COMMERCIAL VIABILITY

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Guatemalan Indigo (*Indigofera suffruticosa* Mill., 1768) is being grown as a regenerative rotational crop that is used to produce natural plant-based dyes rather than the harmful synthetics used in the current fashion and textile industries. Knowledge of Indigo germination rates will benefit the quality, improve crop yields, and enable large scale field plantings. This study was initiated to increase seed germination rates of Guatemalan Indigo and to find a commercially viable way to do so while fighting against disease pressures. Multiple lab studies were conducted on Indigo variety H022-TF01. Methods included mechanical scarification (blender protocol, sander), sterilization, gibberellic acid, dry heat, freezing, soaking, and boiling water. We tested four replicates at various time intervals, and temperatures for each treatment. The dry heat method at 80 °C for 30 minutes resulted in the highest average germination rates of 83%. Trials demonstrated that the dry heat method was the only treatment that resulted in higher germination rates than no treatment with an average of 64% germination. Dry heat at 90 °C across all time intervals (30 minutes, 1-hour, and 2-hours) did not show results higher than 34% germination. Methods of sterilization, gibberellic acid, mechanical scarification (blender protocol, sander), freezing, soaking, and boiling water resulted in germination rates lower than no-treatment. Improving germination rates of Indigo will allow for a commercially viable protocol to be created. This should allow producers to direct seed indigo rather than costly transplant production.

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4. ROCKY MOUNTAIN JUNIPER AND SAGEBRUSH ESSENTAIL OILS EFFECTS ON SEED GERMINATION OF BARLEY AND WHEAT

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The hypothesis of this study was that essential oils (EOs) extracted from native species in the Western United States, namely Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) and sagebrush (*Artemisia tridentata* Nutt.), could suppress the germination of barley (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L.) seeds, as well as the growth of their coleoptiles. Furthermore, the EOs could potentially be used to prevent pre-harvest sprouting in these crops. To assess the effect of EO concentration and timing of application on the germination of barley and wheat, controlled environment studies were conducted. The chemical profile of juniper and sagebrush EO was also analyzed and presented. The three-way interaction of juniper EO concentration by pre-treatment by day was found to be significant on the percentage barley germination, whereas the two-way interaction of juniper EO concentration by pre-treatment was significant on barley coleoptile length. Overall, the 72-hour pre-treatment with juniper EO (before adding water) was found to have the greatest reduction in percentage germination across all concentrations. Furthermore, the percentage of barley seed germination was found to decrease as the application rates of juniper EO increased. However, neither treatment was found to completely suppress barley coleoptile length. The three-way interaction of juniper EO x Concentration x Pretreatment days was found to be significant in relation to seed germination in wheat seeds treated with juniper EO, whereas the two-way interaction of JunEOConc x PreTrt was significant for wheat coleoptile length. The 4-hour pre-treatment with juniper EO at 90 µL completely suppressed wheat seed germination as measured on the 14th and 15th days (DAT). Overall, the application of sagebrush EO was observed to reduce the germination of barley seeds in comparison to the control. Additionally, the length of the barley coleoptile was reduced with a 24-hour pretreatment of sagebrush EO. This study represents the first effort to evaluate the effectiveness of Rocky Mountain juniper and sagebrush EOs in suppressing wheat and barley seed germination, with the ultimate goal of developing commercial products to control pre-harvest sprouting. The results obtained from this study can be used to develop products for both organic and conventional production systems.

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5. ANTI-INFLAMMATORY AND ANTIPROLIFERATIVE ACTIVITIES OF *RANDIA ACULEATA* L. FRUIT

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Lung cancer is on the increase and considered the first in mortality, especially in Mexico, around 8000 Mexicans die each year from lung cancer. The fruits of *Randia aculeata* L, known as "crucetillo" have attracted interest to be evaluated as an anti-carcinogenic due to its traditional use as infusion or alcoholic extract to treat snake bites, and its anti-inflammatory effects. Therefore, the objectives of this study were to determine the total phenolic content (TPC), antioxidant capacity and chemical composition of the Crucetillo fruit extracts, as well as the anti-inflammatory and antiproliferative activities *in vitro* on RAW 264.7 macrophages cells and, cytotoxic and antiproliferative activities on A549 lung cancer cells and ARPE-19 cells. Crucetillo fruits were collected in the municipality of Tlalixcoyan, Veracruz, México, and then, the samples were transported to the Antonio Narro Autonomous Agrarian University (UAAAN) in Saltillo, Coahuila. An aqueous extract was obtained, and the yield was determined. The TPC, antioxidant activity and identification of chemical compounds by ESI-IT-MS were assessed. Furthermore, the cytotoxic, antiproliferative and anti-inflammatory activities of the extract were evaluated. The results of the cellular viability assay with RAW 264.7 macrophages showed that the crucetillo extract had no cytotoxic effect on macrophage cells. These effects were maintained up to the concentration of 100 µg/mL. Moreover, an IC_{50} of 112.9 µg/mL was obtained in the cytotoxic assays on A549 lung cancer cells, and an antiproliferative effect of the extract was observed on this cell line. Moreover, a high antioxidant activity was observed in the extract, and a total of eight compounds were identified, observing the presence of hydroxybenzoic and hydroxycinnamic acids, as well as flavones. The hydroxybenzoic acids identified were gallic and quinic acid, which are antioxidants and have been reported to have anticancer properties. Additionally, glucuronic acid, from the hydroxycinnamic acids, have presented antiproliferative activities on adenocarcinomas cancer cells. The *p*-coumaric acid is an hydroxycinnamic acid that has reported cytotoxic property on several adenocarcinoma and tumor cells such as, A549 lung cancer cell. Interestingly, the use of this compound has been reported due to its anti-inflammatory and antioxidant properties. Besides, the apigenin was also identified in the extract. In conclusion, the aqueous extracts of *R. aculeata* demonstrated antiproliferative and anti-inflammatory effects on A549 cells. Therefore, the extract could be used as a natural anti-inflammatory agent to prevent lung cancer.

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6. HEMP (*CANNABIS SATIVA* L.) ESSENTIAL OIL CONTENT AND COMPOSITION DEPENDING ON THE CULTIVAR, SEEDING DATE, SPACING, AND SAMPLING TIME

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Hemp (*Cannabis sativa* L.) has been cultivated and utilized for thousands of years as a source of fiber, grain, and medicinal compounds. Nowadays, one prominent application of hemp is the extraction of its essential oil (EO), which is rich in bioactive phytochemicals and has diverse uses. The hypothesis of this study was that cultivar, sowing date, and row spacing would affect industrial hemp EO content and composition. The objective of the study was to investigate how cultivar, sowing date, row spacing, and their interactions influence the EO content and chemical profile. Field trials were conducted in Bački Petrovac, Serbia, during the years 2020 and 2021, at coordinates 45.3568° N, 19.6173° E, and an elevation of 82 MASL, using cultivars Helena (fiber, grain), J x USO31 (grain), Bob-1 (grain), H x USO31 (grain), and Marina (fiber). Three different sowing dates were selected, corresponding to the months of April, May, and June. The spacing between rows was set at 12.5 cm, 25 cm, and 50 cm (equivalent to approximately 4.92, 9.84, and 19.68 inches, respectively). The fresh samples of approximately 1 kg were taken from each plot by harvesting the top 50 cm of female plants (male plants were not sampled). Three sampling points were chosen: just before flowering, after 20 days, and at harvest time for fiber (full flowering). The EO extraction process involved using a Clevenger apparatus and 100 g of dried hemp material per distillation. Each distillation lasted for 3 hours using 2 L of water. Gas chromatographic analysis was employed to determine the composition of the EO. The results indicated that the Bob-1 variety consistently exhibited the highest content of EO across years, all three sowing dates, and various row spacing options. These findings underscored the variations in hemp EO composition, which contained a significant number of volatile components. Overall, the main constituents of the EOs were α-pinene, β-pinene, myrcene, limonene, 1,8-cineole, ocimene (E) beta, sabinene hydrate-cis, linalool, and eugenol. Notably, EOs have a large and growing market worldwide. Hemp EO, with its complex mixture of bioactive substances offering medicinal, insecticidal, antibacterial, and anti-inflammatory effects, could potentially enhance the profitability of hemp cultivation.

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7. EFFICACY OF ESSENTIAL OILS IN SUPPRESSING POTATO *(SOLANUM TUBEROSUM* L.*)* SPROUTING

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Potato (*Solanum tuberosum* L.) tubers are a popular food worldwide, but they are prone to sprouting during storage, leading to losses in yield and quality. Researchers have explored different methods to prevent or delay sprouting, including using synthetic chemicals like chlorpropham (CIPC). However, concerns over the potential environmental and health impacts of CIPC have led to increased interest in alternative sprout suppressors, such as essential oils (EOs). This study aimed to investigate the efficacy of nine EOs as sprout suppressants for potato storage at room temperature. Australian Crescent Fingerling potato tubers were used, obtained from the Oregon state university Hermiston agricultural research and extension center in Hermiston, OR, USA. The tubers were placed in sealed containers with cotton balls infused with one of the nine EOs: pennyroyal EO (*Mentha pulegium* L.), Pery Balsam EO (*Myroxylon pereirae* L.), pink pepper EO organic (*Schinus molle* L.), rose absolute oil (Rosa *damascena* L.), common sage EO organic (*Salvia officinalis* L.), Scotch pine EO organic (*Pinus sylvestris* L.) ,spearmint EO organic (*Mentha spicata* L.) ,St John's Wort EO organic (*Hypericum perforatum* L.) and tagetes EO (*Tagetes minuta* L.). The experiment lasted for 90 days. The study also examined the impact of various treatments on sprout length and number at different time points (30, 45, 60, and 90 days). The experiment included nine treatments and a control, with some demonstrating a positive impact on sprout growth while others suppressed it. Treatments # 218, 219, and 222 stimulated sprout growth at all time points, while treatment 221 suppressed sprouting until 60 days. Treatment 217 reduced sprout growth significantly but did not prevent its appearance. Out of the nine EOs tested, EO 223 proved to be the most effective in suppressing potato tuber sprout length and number. These findings suggest that certain EOs may serve as sprout inhibitors for potato storage at room temperature, providing valuable alternatives for sprout control in both organic and conventional sectors.

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8. PHYTOCHEMICAL COMPOSITION AND BIOPESTICIDAL POTENTIAL OF *PINUS MUGO* TURRA ESSENTIAL OIL

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Pinus mugo is an alpine species distributed at high altitudes in the mountains, and the species represents a resource for obtaining essential oil (EOs). *Pinus* essential oils show great potential as biopesticides in agriculture because they are biodegradable and environmentally friendly. Furthermore, these EOs have a wide specter of biological activity such as antibacterial, antifungal, antiviral, anti-inflammatory, and antioxidant properties. This study aimed to investigate the phytochemical compositions of *P. mugo* EO from different plant parts; leaves, twigs, wood, and cones, and evaluated its bioactivity. The biopesticidal potential of twigs EO against *Sitobion avenae*, *Rhopalosiphum padi*, and weed seeds of *Agrostemma githago* L., *Anthemis arvensis* L., *Avena fatua* L., *Consolida orientalis* (J. Gay) Schrödinger, and *Papaver rhoeas* L. were tested in Petri dishes. The composition of *P. mugo* EO was analyzed by GC Mass Spectrometry. The predominant constituents in *P. mugo* EO were *α*-pinene, *α*-phellandrene, *β*-phellandrene and *β*-caryophyllene. These constituents were found in all analyzed trees from the six populations but in different amounts, depending on the plant parts. The tested twigs EO at concentrations 5 %, 4.5%, 3.5%, 2.5 %, 1.5%, 1 % had significant insecticidal activity against the two aphids. The efficacy of the EO was 100% on both aphids 24 h after the treatment. The EO demonstrated repellent activity only in high concentrations of 3.5%, 4.5% и 5% for *S. avenae* and 4.5% и 5% for *R. padi* respectively. Bioherbicidal activities of the EO was tested in concentrations 0 µL; 5µL; 10 µL; and 20 µL against seeds of *A. githago, A. arvensis, A. fatua, C. orientalis,* and *P. rhoeas.* The essential oils of all investigated parts of the species have a strong antimicrobial effect against *Salmonella enterica* ssp. *enterica* and *Escherichia coli*. The needles extract of *P. mugo* contain polyphenolic compounds with pronounced antioxidant activity.

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9. PHYTOCHEMICAL COMPOSITION AND BIOPESTICIDAL POTENTIAL OF *PASTINACA HIRSUTA* PANČIĆ ESSENTIAL OIL

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Pastinaca hirsuta Pančić is a perennial, aromatic plant that belongs to *Apiaceae* family. The species is Balkan endemic, distributed in the central part of the Balkan Peninsula (Bulgaria, Albania, Serbia and Greece). Because *P. hirsuta* has restricted distribution, the data of its essential oil (EO) are rare. The objective of this study was to assess the variability of EO content and compositions of *P. hirsuta* distributed in the Bulgarian flora and evaluate its potential as biopesticides. Overall, 77 EO constituents were identified, belonging to the groups of ester and monoterpenes. n-Octyl butyrate and n-hexyl butanoate were the major constituents of the ester group in the EO. The potential of EO of *P. hirsuta* as biofungicides was investigated against three important postharvest pathogens; *Botrytis cinerea, Colletotrichum* sp. and *Fusarium* sp. The inhibitory effect of EOs on the radial mycelial growth was tested using the agar dilution method. *In vitro* screening was conducted at five concentrations (1.0, 1.5, 2.0, 2.5 and 3.00 µL mL^{-1}) of EOs. The tested EO showed significant antifungal potency against *B. cinerea, Colletotrichum* sp. and *Fusarium* sp. The tested *P. hirsuta* EO at concentrations 5 %, 4.5%, 3.5%, 2.5 %, 1.5%, 1 % had significant insecticidal activity against two aphids - *Sitobion avenae, Rhopalosiphum padi.* This species show promise as potential new crop species and its EO could be used in the development of biopesticide products.

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10. *ANTHEMIS NOBILIS* L. ESSENTIAL OIL ANTIMICROBIAL ACTIVITY EVALUATION OF *IN VITRO* AND *IN SITU*

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Anthemis nobilis L. (*Chamaemelum nobile* L.), the so-called Roman chamomile, is a perennial herb of the Asteraceae family. It possess antibacterial, antifungal, insecticidal, hypotensive, antiplatelet aggregation, anti-inflammatory, hypoglycemic, antioxidant, nervous, cytotoxic, bronchodilatory, endocrine, and many other properties. The aim of the research was to evaluate *in vitro* and *in situ* antimicrobial activity of the essential oil o A. *nobilis* produced in Slovakia, against Gram-positive and Gram-negative bacteria, and yeasts. The *in vitro* and *in situ* antimicrobial activity against Gram-positive bacteria: *Bacillus subtilis* CCM 1999, *Enterococcus faecalis* CCM 4224, *Staphylococcus aureus* subsp. *Aureus* CCM 8223, and Gram-negative bactéria: *Pseudomonas aeruginosa* CCM 3955, *Salmonella enterica* subsp. *Enterica* CCM 4420, *Serratia marcescens* CCM 8588, *Yersinia enterocolitica* CCM 7204, and yeasts: *Candida krusei* CCM 8271, *Candida albicans* CCM 8261, *Candida tropicalis* CCM 8223, *Candida glabrata* CCM 8270 were evaluated with the disc diffusion method, broth microdilution method, and vapor phase on vegetable and fruit models. The antimicrobial activity was either moderate or very strong with inhibition zones ranging from 8.67 to 16.67 mm on Gram-positive and Gram-negative bacteria and from 7.67 to 17.33 mm on yeasts. Among the tested bacteria and fungi, the lowest values of minimum inhibitory concentration (MIC) were determined against *S. aureus* and *C. glabrata*. The vapor phase of *A. nobilis* essential oil (ANEO) inhibited the growth of the yeasts of the genus *Candida* when tested *in situ* on pears. The strongest effect against yeasts on a pear model was observed against C. *glabrata* at concentrations of 250 and 500 µL/mL. The best antimicrobial activity of *A. nobilis* essential oil in the carrot model was found against *S. aureus*. The findings indicate that, besides being safe, *A. nobilis* essential oil has antimicrobial activity, which makes it a potential substitute for biological food preservatives.

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11. ANTIMICROBIAL ACTIVITY OF *VETIVERIA ZIZANOIDES* (L. NASH) ESSENTIAL OIL IN *IN VITRO* AND *IN SITU* CONDITION

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Vetiveria zizanioides (L. Nash) is a plant growing in Southern Asia; Myanmar, Sri Lanka, Bangladesh, and tropical Africa. It is used in these countries as an alternative medicine. *V. zizanioides* called as 'vetiver' belongs to the Poaceae family. It has many biological activities such as antimicrobial, antifungal, antiviral, anticarcinogenic, etc. activities. The aim of the research was to evaluate *in vitro* and *in situ* antimicrobial activity of the *V. zizanioides* essential oil produced in Slovakia. The antimicrobial activity by disc diffusion method, microdilution method, and vapor phase for three Gram-positive (*Micrococcus luteus* CCM 732*, Listeria monocytogenes* CCM 4699*, Staphylococcus aureus* subsp. *aureus* CCM 3853*),* Gram-negative bacteria (*Escherichia coli* CCM 3988*, Enterobacter aerogenes* CCM 2531 and *Pseudomonas aeruginosa* CCM 1959) and three *Penicillium* spp. isolated from grapes were used. The vapor phase of *P. citrinum, P. crustosum, P. expansum, M. luteus, L. monocytogenes, S. aureus, E. coli, E. aerogenes* and *P. aeruginosa* on bread, carrot (*Daucus carota* subsp*. Sativus*), potato (*Solanum tuberosum* L.), sweet potato (*Ipomoea batatas* (L.) Lam.), and apple (*Malus domestica* Borkh.) *in situ* was studied. The results of disc diffusion and broth diffusion methods showed that *V. zizanioides* essential oil was strongly effective against all tested microorganisms and the vapor phase method was effective and active against all *Penicillium* spp., but not strongly effective against bacteria in food preservation of food matrices. Thus, the various properties of essential oils offer the possibility of using natural, safe, eco-friendly, cost-effective, renewable, and easily biodegradable antimicrobials for food commodity preservation in the near future.

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12. TEMPORAL AND SPATIAL EXPRESSION ANALYSIS OF PRENYLTRANSFERASE GENES FROM AZ-2 GUAYULE (*PARTHENIUM ARGENTATUM* GRAY) EXPOSED TO COLD TEMPERATURES

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Guayule (*Parthenium argentatum* Gray) is a natural rubber (NR) producing perennial shrub cultivated in the Southwestern US, southern Europe, and other areas as an alternative source of NR. Exposure to cold temperatures between 6-15 °C during winter increases rubber biosynthesis in guayule parenchyma stem tissue. Understanding the molecular mechanism of this cold inducibility is critical for developing high rubber producing guayule lines through breeding and genetic engineering efforts. Functional genomics studies from several rubber-producing plants suggest the rubber biosynthesis enzyme known as Rubber Transferase (RuT) is an enzymatic complex composed of at least two proteins: *cis*-prenyltransferase (Cpt) and Cpt-binding protein (Cbp). *cis*-prenyltransferase, a ubiquitous enzyme present in all organisms, synthesizes polyprenols (isoprenoids) essential for many cellular functions. Cpt-binding protein, a protein with high sequence homology to Cpt, does not appear to have catalytic function, however it has been shown to be an essential component of the enzyme complex that synthesizes polyprenols in eukaryotes. To dissect the molecular events leading to RuT cold induction, the first step is to investigate this putative enzyme at the transcriptional level. In a reported diploid guayule transcriptome, three *Cpt* and one *Cbp* genes were identified, and only one *Cpt* member appears to be associated with rubber biosynthesis. In tetraploid AZ-2 guayule, a hybrid plant preferred for industrial NR production due to its field fitness and high biomass, one rubber biosynthesis-related and cold-inducible *Cpt* was identified on a reported transcriptome. To further characterize these RuT components, we analyzed the recently sequenced AZ-2 guayule genome and a new transcriptome. Three putative *Cpt* and one *Cbp* genes were identified, cloned, and sequenced. We report here temporal (seven days) and spatial (leaf and stem) *Cpt* and *Cbp* expression analyses from two-year old, greenhouse grown AZ-2 plants. The plants were maintained in a controlled environment chamber set at 25 °C day-light, and 10 °C night temperatures mimicking guayule's natural habitat. Identifying the precise cold induction timing of rubber biosynthesis related *Cpt* and *Cbp* genes will provide a timeline to search for cold-inducible transcriptional activators. Additionally, understanding the transcriptional cold-inducibility will help to determine the timing for RuT assembly and ultimately guayule rubber biosynthesis *in vivo*.

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13. MAPPING QTLs FOR SEED TRAITS IN RECOMBINANT INBRED LINES OF CAMELINA

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Camelina [*Camelina sativa* (L.) Crantz] is an oilseed species of the Brassicaceae family that is gaining popularity as a sustainable source of oil for the biodiesel industry, as an animal supplement, and as a cover crop with ecosystem benefits. However, producing the hundreds of millions of gallons of biodiesel proposed by industry will require over a million acres of land. Because both spring and winter biotypes of camelina can be double- or relay-cropped, options are available for producing camelina seed for industry needs without impinging on commodity crop production for other food, feed, fuel, and fiber needs. To improve these agricultural intensification systems, research continues to focus on traits for earlier flowering and maturation, freezing tolerance, and seed size. In this study, greenhouse-grown F7 Recombinant Inbred Lines (RILs: 253 individuals) developed from a bi-parental cross between a spring (CO46) x winter (Joelle) biotype of camelina were phenotyped for 1000 count seed weight (TSW). The F7 RIL population is represented by 38 winter, 181 spring, and 34 mixed biotypes. The average TSW of the RILs ranged from 0.7 to 1.5 grams indicating variation of seed weight in the population. A one-way ANOVA test did not show significant difference in TSW among the biotypes. However, a Pearson correlation analysis suggested a weak negative correlation between flowering time and TSW ($r = -0.34$; $P < 0.0001$), suggesting that flowering time could have an influence on TSW. We further used 4507 markers mapped to the camelina genome to identify QTLs associated with TSW in the RILs. One significant QTLs was identified in chromosome (Chr) 8, whereas a cluster of 16 significant QTL (logarithm of odds between 3.5 and 5) was observed in a 7.7 Mb region of Chr11. Of the 275 annotated genes within 50 Kb up- or down-stream of the 16 significant QTL markers, 14 were transcription factors (6 *bHLH*, 2 *MYB*, and 1 each *ARR-B*, *bZIP*, *GRF*, *HSF*, and *M-type_MADS*), and 12 F-BOX family or domain containing proteins made up the greatest number of genes annotating to known Arabidopsis proteins. Although further studies will be needed to validate the roles, if any, that the candidate genes within the 7.7 Mb cluster of 16 significant QTLs in Chr11 contribute to TSW, these markers provide a starting point for developing testable hypotheses and markers for breeders.

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14. OILSEEDS FOR IMPROVING AGRONOMIC AND ENVIRONMENTAL SUSTAINABILITY OF WHEAT-FALLOW ROTATION

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Dryland winter wheat (*Triticum aestivum*) production in large areas of the Palouse region, which includes parts of southeastern Washington, north central Idaho, and northeast Oregon, is primarily based on a wheat-fallow rotation. In this system, wheat is grown once every two years, with 10-months dedicated to fall-sown wheat and 14 months of fallow period (either conventional or direct seed system). This wheat/fallow rotation has been practiced for over a century, as the 14-month fallow period allows the soil to conserve moisture and store winter precipitation, which is crucial for the wheat crop in the following season. However, this system results in a crop being grown only every other year, leaving the ground bare or under chemical fallow for an extended period and causing environmental issues. The hypothesis of this study was that the current dryland winter wheat-fallow rotation could be enhanced by introducing an additional cash crop and transitioning to a three-year rotation: winter wheat/cash crop/fallow. We evaluated the agronomic and environmental feasibility of including 12 crops suitable for biodiesel and high-value chemical production in the existing winter wheat-fallow rotation. These crops included canola (Brassica napus), oriental mustard (*Brassica juncea*), camelina (*Camelina sativa*), safflower (*Carthamus tinctorius*), sunflower (*Helianthus annuus*), flax (*Linum usitatissimum*), coriander (*Coriandrum sativum*), caraway (*Carum carvi*), cumin (*Cuminum cyminum*), anise (*Pimpinella anisum*), dill (*Anethum graveolens*), and fennel (*Foeniculum vulgare*). The evaluation was conducted at two locations: Pendleton, OR and Moro, OR, characterized with 30.5 to 38 cm annual rainfall, respectively. We analyzed and presented data on seed yield, oil content and fatty acid (FA) composition, and essential oil yield. Overall, there was significant variation in oil content (measured by pNMR), fatty acid composition, essential oil content and yield, and biodiesel yield among the different crops and within a single crop depending on the location. However, except for camelina, most oilseed crops did not perform well after winter wheat at the Moro location, which receives an annual rainfall of 30.5 cm. Therefore, it can be concluded that incorporating oilseeds for biofuel and high-value chemical production into the dryland winter wheat-fallow rotation can enhance agronomic and environmental sustainability in areas where the annual rainfall exceeds 38 cm.

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15. CARINATA AND CAMELINA: TWO CASH COVER CROPS BOOSTING THE BIO-ECONOMY IN EUROPE: THE CARINA PROJECT

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In Europe there is the urgent need of supplying to the biobased industry domestically grown feedstocks certified as low iLUC (indirect Land Use Change). Furthermore, the actual European environmental and agricultural policies are trying to push for the spread of diversified crops and cropping systems able to couple low carbon footprint, positive impact on biodiversity (above and belowground), and satisfactory revenues for farmers. In this context the choice of the crop is even more challenging because of climate change, which is strongly and negatively impacting many stable European cash crops, particularly in southern and Balkan Europe. In this context the CARINA "CARinata and CamelINA to boost the sustainable diversification in EU farming systems" project, was funded by the Horizon Europe framework program with over 8M€ and started in November 2022. CARINA aims at addressing the very complicated situation presented above through the introduction of two novel oilseed crops belonging to the *Brassicaceae* family: carinata (*Brassica carinata*) and camelina (*Camelina sativa*). Carinata and camelina have a broad environmental suitability to European pedo-climates, can fit into different types of innovative and intensified cropping systems (i.e., inter, relay, double-cropping). Additionally, in marginal soils which are quite widespread in southern and Balkan Europe, oilseed rape is rapidly decreasing its acreage due to unsatisfactory yields and huge phyto-pathological problems, thus carinata and camelina could represent an opportunity for farmers in those regions. Within CARINA, the introduction of carinata and camelina will be demonstrated in nine different EU and northern Africa countries, namely Italy, Serbia, France, Spain, Greece, Bulgaria, Poland, Tunisia, and Morocco. Carinata and camelina have been identified as low-input, high resilient and very plastic crops, able to fit to different environments and cropping systems. Furthermore, these oilseeds have positive effects on the environment, promoting above and below-ground biodiversity, recycling nutrients, and being able to stock relevant quantities of carbon in the soil. The different fractions of carinata and camelina seeds, i.e. oil, meal and co-products, will be used to source multiple end-products, such as biofuels, bioherbicide, biopesticides, animal feed ingredients, and human supplements. The productive results from the first-year trials established in Italy, by the University of Bologna, and in Serbia, by the Institute of Field and Vegetable Crops, will be presented. Camelina has been tested as winter cover crop, allowing double cropping with typical summer crops, i.e., sorghum (*Sorghum bicolor* (L.) Moench) and sunflower (*Helianthus annuus* L.), while carinata has been tested in intercropping systems with legumes, i.e., chickpea (*Cicer arietinum* L.) and pea (*Pisum sativum* L.).

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16. CAMELINA: AN EXAMPLE OF AN INNOVATIVE COMPANION CROP FOR INTERCROPPING SYSTEMS

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Camelina (*Camelina sativa* L. Crantz) is an attractive crop for biofuel production due to its high oil content and low requirements for water and nutrients. The oil extracted from camelina seeds has a high level of unsaturated fatty acids, making it an ideal source for biofuels that can replace conventional fossil fuels. This alternative crop is also relatively easy to cultivate and harvest, requiring less energy than other biofuel crops (i.e., rapeseed, soybean). Additionally, camelina has a great potential for double cropping, fallow year production, growing on marginal lands, thus figuring out the issues related with indirect land use change (iLUC). Nevertheless, the inclusion of camelina in intercropping systems with food/feed crops is still little explored. In the present study two different intercropping systems (IC) were compared with the sole-crops (SC): winter intercropping camelina -forage pea (*Pisum sativum* L.) and spring intercropping camelina-lentil (*Lens culinaris* Medik.). The choice of the pulses to intercrop with camelina has been taken considering growing cycle contemporaneity and the possible mutual benefits (i.e., better nutrient usage, plant standing ability, etc.). In the intercropping systems, camelina was broadcasted and the pulses were row-seeded with a plant density of 50:50. The trial was carried out during 2021/22 growing season, at the experimental farm of Bologna university in Ozzano dell'Emilia (Bologna, Italy). At full maturity, the two crops were manually harvested, separated, and then threshed. The results showed that the winter intercropping reduced the seed yield of camelina (1.22 Mg/ha vs 0.5 Mg/ha, SC vs. IC respectively, $P \leq 0.05$) but not the one of pea (2.15 Mg/ha vs. 1.26 Mg/ha, SC vs. IC respectively), whereas the spring intercropping did not affect camelina seed yield (0.44 Mg/ha vs. 0.39 Mg/ha, SC vs. IC respectively) but it negatively affected lentil (0.39 Mg/ha vs. 0.12 Mg/ha, SC vs. IC respectively, $P \leq 0.05$). However, it must be kept in mind that the seeding densities of companion crops are half that of sole-crops. So, the LER (Land Equivalent Ratio) was 1 in the first intercropping system (winter pea-camelina) and 1.2 in the second one (lentil-camelina). Camelina seed oil content did significantly differ in the intercropping systems when compared with sole-camelina. Nevertheless, when analyzing camelina seed oil composition, omega-3 and omega-6 contents significant differences emerged in spring intercropping compared to sole-crop. Omega-3 content was found significantly higher in camelina oil in the intercropping system than in the sole-crop, while the opposite was surveyed for omega-6 content. Concerning the oleic acid, its content decreased when camelina was intercropped with lentil. Camelina has been demonstrated to be less competitive when intercropped with vigorous forage pea, but more competitive than lentil. However, camelina when intercropped with forage pea demonstrated to use soil resources equally (LER = 1), and when intercropped with lentil more efficiently (LER > 1) rather than sole-crops. In conclusion, camelina can be an interesting candidate for intensifying land use and obtaining oil with high request from the renewable fuel industry. However, establishing the correct seeding ratio is the next step to achieving the optimum yield and LER.

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17. EVALUATING GERMINATION RATES FOR LONG- AND SHORT-TERM STORAGE METHODS OF PENNYCRESS (*THLASPI ARVENSE* L.) SEED

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Determining the best way to preserve seeds is a challenge that plant researchers face when working with a new plant. This topic is particularly important when working with new crops in breeding programs and commercialization efforts. While growers are focused on maximizing germination rates and minimizing cost, breeders are focused on preserving diverse collections of seed over long periods of time. The objective of this study was to evaluate the seed storage environment and container type to determine the conditions for the highest germination rates for short-term and long-term storage of field pennycress (*Thlaspi arvense* L.) seeds. Three environments were evaluated for their effectiveness to preserve pennycress seeds. Two black seeded wild populations (ARV1 and SP32-10) and two golden seeded commercial varieties (tt8-2bp and tt8-t/ARV1) were used in this study. Pennycress seeds were stored at room temperature, in a refrigerator, and in a freezer. The average temperatures and humidities for the room temperature, refrigerator, and freezer environments were 22.7°C/33.9%, 1.7°C/28.1%, -31.0°C/NA, respectively. To determine if the container impacted germination rates, seeds were stored in both manila envelopes and 1.5mL microcentrifuge tubes for each of the three storage environments. Each envelope and tube contained one hundred pennycress seeds and replicated 4 times for each treatment. At 2-month intervals over a 2-year period, envelopes and tubes were removed from each of the environments and germinated in a controlled germination chamber. Germinated seeds were counted and removed from the germination trays on days 7 and 10. Total number of seeds germinated was recorded for all varieties, environments, and containers. While there was no statistically significant difference between the container type, there was a significant difference of germination rates based on the treatment type ($p<2e-16$) and the variety ($p<2e-16$). Additionally, there was a significant interaction between the treatment type and variety ($p<2e-16$). While the average germination rate in the freezer was 47%, it was 50% in the refrigerator and 42% for room temperature. Black and golden seeded varieties had an average germination rate across all environments of 20% and 73%, respectively. Having the knowledge of how to preserve pennycress seed is a requirement for making pennycress commercially viable and preserving germplasm for future breeding programs. This study benefits growers by providing the most cost-effective way to store large amounts of seed and breeders by providing an effective way to preserve germplasm.

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18. SYNTHESIS AND CHARACTERIZATION OF ESTOLIDE DIAMIDES FOR USE AS THICKENERS

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A series of diamides were synthesized from normal fatty chain fatty acids (oleic and erucic), hydroxy fatty acids (9-hydroxy stearate, 12-hydroxy stearate, ricinoleic and lesquerolic) and estolides (oleic estolide, laurate capped 9-hydroxy and 12-hydroxy stearate estolides, laurate capped ricinoleic and lesquerolic estolides and oleic estolide capped 12-hydroxy stearic estolide). The diamides were synthesized with stoichiometric amounts of carboxylic acid to diamine and reactions were run without catalyst at 150^{o}C for 24 hours. Reaction yields for the formation of diamide ranged from 72-99% with purities greater than 90% where crystallization from an appropriate solvent gave nearly pure diamides. Diamide formation with the estolides did cause some transamination with the estolide linkage generating free hydroxy containing mixed diamides. The hydroxy diamides could be esterified at the free hydroxy moiety using tin (II) octoate as a catalyst at 130^{o}C in nearly quantitative yields when excess lauric acid was used. Kugelrohr distillation was utilized to remove excess lauric acid after the amination reaction was complete which yielded laurate capped estolide diamides in purities >90%. All diamides were then evaluated for their ability to form gels in both Polyalpha olefins (POA) and mineral oils at 0.5 and 1.0 w/w%. The estolide diamides all formed gels in the mineral oils whereas the normal chain fatty acids and hydroxy fatty acids increased the viscosity significantly but failed to form gels.

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19. CHARACTERIZATION, PHYSICAL PROPERTIES, AND APPLICATIONS OF HIGH OLEIC PENNYCRESS OIL

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Pennycress (*Thlaspi arvense* L.) is a winter annual that has been adapted as an off-season cover crop in the midwestern United States. As a non-food crop that can be grown in-between corn (Zea mays L.) and soybean (Glycine max (L.) Merr.), it is an attractive source of seed oils. Our group has investigated the properties of several generations of modified pennycress oils for lubricant and biodiesel applications, including crude cress (CC), field pennycress (FP), and low erucic acid pennycress (LEAP). This study details the properties of a new generation, high oleic pennycress (HOP). The fatty acid composition along with phytosterol and tocopherol contents of HOP will be determined and compared to previous generations. The physical properties will also be analyzed, including cold flow properties, oxidative stability, viscosity, and lubricity. Finally, HOP will be converted into fatty acid methyl esters (FAME) and evaluated as biodiesel. Previous studies have shown that the cold flow properties of CC are poor and were substantially improved in FP and LEAP. Additionally, the oxidative stability of CC is too low for many target applications, especially for biodiesel. FP's oxidative stability was improved, but still poor due to its high percentage of oxidatively sensitive erucic acid. LEAP's oxidative stability was further improved, but the resulting biodiesel from both still fail to meet the ASTM biodiesel fuel specification D6751. High oleic pennycress was engineered such that it still maintains the low erucic acid content of LEAP while increasing the oleic acid content. This type of composition is advantageous for oxidative stability and biodiesel properties, as has been demonstrated with high oleic soy and sunflower oil. The properties of HOP biodiesel will be compared to previous generations as well as to the current standards for biodiesel.

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20. PHYSICOCHEMICAL CHARACTERISTICS OF DENSITY-GRADED INDUSTRIAL HEMP GRAIN

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Industrial hemp (*Cannabis sativa* L.) grain is harvested when shattering begins, which typically happens when 70 to 85 % of the grains are mature. The grains harvested, therefore, contain a substantial proportion of immature seeds. To assess the quality of the harvested hemp grain, dried grain (cv Henola) was density-graded into six fractions. Bulk and true densities, thousand seed weights (TSW), and proximate composition (moisture, oil, protein, and ash contents) were determined for each fraction. Oils obtained from each fraction by cold-pressing followed by hexane extraction were analyzed for acid value, color (CIE L*a*b* color scale), and chlorophyll content. The defatted meal was analyzed for the soluble protein classes (water-soluble albumin, saline-soluble globulin, ethanol-soluble prolamin and alkali-soluble glutelin). Seventy three percent of the fraction had densities and TSW greater than the starting bulk grain (538 g/L). The starting bulk grain had 28.6% d.b. oil while those of the density-graded fractions ranged from 31% (heavy fraction-46%) to 14% (lightest fraction-7%). A significant difference in crude protein content was observed only between the heaviest and the lightest fraction at 25.3% and 21.2%, respectively. Cold-pressed oil had markedly lower acid values than those of hexane-extracted oils and were also significantly lighter (>70 L* versus <13 L*, scale ranges from 0 - black to 100 - white). The difference in color was consistent with the amount of chlorophyll extracted with the oil. Glutelins were the major soluble protein group in defatted hemp grain meal, accounting for 58.6% of total protein in the heavy fraction and 41.2% in the light fraction. The two fractions had close amounts of albumins and globulins (7-9% and 11-13%, respectively). Prolamin content was the least; its amount in the light fraction (6%) was double that in the heavy fraction. Density-grading can be utilized to separate the light (immature) grains to keep the oil's acid value and color low, thus reducing the cost of oil refining and bleaching. The light grains can still be processed for other applications where quality is not critical.

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21. SCREENING OF SEEDS AND ROOTS FROM WILD PENNYCRESS (*THLASPI ARVENSE* L.) POPULATIONS USING A BLOOD GLUCOSE METER AND TEST STRIPS

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Field pennycress, (*Thlaspi arvense* L.), is a new oil seed cover crop being commercialized as a source of biofuel in the United States. Along the path to commercialization, pennycress seed and meal will be marketed as animal feed. As a member of the *Brassicacaeae* family, pennycress seed is abundant in glucosinolates which are anti-nutritional factors that make the seed and meal less palatable to animals. More specifically, *sinigrin* has been identified as the glucosinolate in pennycress. As work continues to develop varieties low in glucosinolates, a rapid assay is needed to determine the total glucosinolates in pennycress seed. Since glucosinolates in the roots provide pathogen resistance, a rapid assay for glucosinolates in roots is also needed. The objective of this study was to develop and utilize a rapid assay to screen pennycress seeds and roots in wild populations for total glucosinolate content. Pennycress seeds were ground in potassium phosphate buffer with endogenous myrosinase, and pennycress roots were ground in potassium phosphate buffer with the addition of exogenous myrosinase to catalyze the enzymatic hydrolysis of the glucosinolate sinigrin to equimolar amounts of glucose. Glucose content was determined using a blood glucose meter and test strips. From the molar concentration of glucose, the molar concentration of sinigrin was known and the glucosinolate level in seeds was calculated in µmol/g. The results were confirmed by LC/MS analysis. Glucosinolate levels in seeds and roots varied greatly in the pennycress varieties screened. Environmental factors also seemed to contribute to the levels of glucosinolates found within a variety. This rapid and inexpensive assay will allow breeders to efficiently screen varieties and select varieties with roots high in glucosinolates for pathogen resistance and seeds with low glucosinolates for improved feed value.

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22. ALFALFA-SUNFLOWER INTERCROPPING IS A PROFITABLE WAY TO ESTABLISH ALFALFA

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Intercropping is a way to better utilize the growing season and available resources more profitably. The integration of alfalfa (*Medicago sativa* L.) into crop rotations may also lead to a reduction of synthetic nitrogen use and losses by leaching or run-off. This research evaluated the possibility of intercropping alfalfa with sunflower (*Helianthus annuus* L.) using a randomized complete block design with four replicates and two field sites (Hickson and Prosper, ND) to establish alfalfa for the subsequent crop year. This approach could increase alfalfa forage yield and nutritive value in the second growing season, while providing a sunflower crop during the low-producing alfalfa establishment year. Treatments were alfalfa alone, sunflower alone at 76- and 152-cm row spacing, and sunflower intercropped with alfalfa at 76- and 152-cm row spacing. Sunflower achene yields in the first year (2021) were measured and no significant differences among treatments were determined. Alfalfa forage yield and nutritive value was also measured and calculated in Year 1, along with measurements of soil gravimetric water, soil NO_3-N content, and light interception. In Year 2 (2022) of the system, there was a significant decrease in soil NO_3-N in the upper 60-cm between treatments. Newly seeded alfalfa in Year 2, following sunflower alone in Year 1, resulted in a larger reduction in soil NO_3-N for alfalfa following 76-cm sunflower or alfalfa established in intercropping with sunflower at 152-cm rows in Year 1. Although soil gravimetric water content declined in all treatments through most of the growing season, it was lower in soil where alfalfa and sunflower were intercropped. In-row alfalfa dry biomass and forage nutritive value were not significantly different for the 76- or 152-cm sunflower row spacings. There was an interaction between treatments and date for light interception, mainly because alfalfa alone had much lower light interception than all treatments with sunflower. Stand counts were not different ($P \leq 0.05$) between alfalfa intercropped with sunflower at 76- and 152-cm row spacings and the alfalfa alone treatment in the fall of Year 1 or in the spring of Year 2. By combining current sunflower and alfalfa input costs and prices, establishing alfalfa through intercropping with 76-cm sunflower row spacing was the most profitable at \$127 ha^{-1} over the two-year period. In contrast, 76- and 152-cm sunflower followed by spring-seeded alfalfa in Year 2 were the least profitable ways to establish alfalfa with a \$325 and \$336 ha^{-1} loss, respectively. Even though the 152-cm sunflower intercropped with alfalfa was marginally better than the spring-seeded alfalfa following sunflower, it still was a loss of \$223 ha^{-1}, mostly due to the reduced sunflower achene yield. Moreover, spring-seeded alfalfa in Year 2 also had a loss of \$182 ha^{-1}. Therefore, it can be concluded that intercropping alfalfa with sunflower at 76-cm row spacings is a viable practice to establish alfalfa profitably in this cropping system.

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23. DOMESTICATION EFFECTS ON NITROGEN ALLOCATION, INTERNAL RECYCLING AND NITROGEN USE EFFICIENCY IN *SILPHIUM INTEGRIFOLIUM*

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Maximizing the efficiency of resource use is becoming a highly prioritized issue in agricultural research. The seasonal nitrogen recycling through the optimization of plant senescence and nitrogen resorption is the main determinant of N-use efficiency and N conservation in perennial crops, allowing to sustain a lower dependence of external resources and yield stability with age. However, improvements in seed yield during domestication are frequently achieved moving plants from the conservative towards the more acquisitive side of the plant resource use strategy, changing how plants acquire, allocate, use, and store C and nutrients in relation to their wild relatives. The Objective was to evaluate if early stages of domestication changed the relative N allocation to vegetative and reproductive structures, internal plant N recycling (N resorption efficiency and proficiency, and N storage) and N-use-efficiency, in *Silphium integrifolium*, a perennial relative of sunflower in the process of domestication. We compared a Wild (W) and an improved accession for increase seed-yield potential (S) in two locations, Kansas-USA, and Patagonia-Argentina. In both locations S accession produced more than twice the biomass and acquired twofold more N than Wild accession; S accession had higher allocation to leaves and lower to crown at pre-anthesis (Growth-Storage trade-off) and higher allocation to seeds and lower to crown at maturity (Reproduction-Storage trade-off), compared to Wild. Nitrogen use efficiency and mean residence time of N were reduced in S accession, related to the lower storage of N in the crown and N resorption from green leaves to seed production. As result S accession produced litter with lower N concentration (more proficient) than the wild accession. Wild accession had lower resorption efficiency, but N recycled was allocated to the crown for future remobilization and uses (better internal cycling). In conclusion, a high productivity was achieved by a higher N uptake capacity, and higher N allocation to photosynthetic tissue. Lower allocation and recycling of N to the storage pool in the crown could compromise the capacity to sustain biomass and seed production with age (yield stability) or would require external (fertilizer) N inputs Higher resorption efficiency (NRE) and N resorbed allocated hierarchically to seeds results in high seed yield and high seed quality (protein content). Higher resorption proficiency, which means that senescent leaf biomass has low N content and contributes with lower quality litter to the soil, could slow down biogeochemical cycling and soil nutrient retention.

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24. THE DOMINO EFFECT OF SELECTION FOR YIELD IN PERENNIAL SUNFLOWER: FROM CONSERVATIVE TO ACQUISITIVE

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Domestication and crop improvement have been largely focused on increasing yield of plants from wild germplasm. While choosing wild candidates for grain production and ecosystem services provision, selection for high yield inadvertently provoked a cascade of changes at different scales and levels, from whole plant (partition) to anatomy, altering the very same desirable traits for which wild plants were originally preferred. We present a hierarchical model and describe the changes observed in perennial sunflower (*Silphium integrifolium)* after five generations of breeding for yield. The potential consequences of those changes on plant survival, stress tolerance, pest resistance, resource-use efficiency, nutrients cycling, and profitability are discussed.

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