International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment

Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

BOOK OF ABSTRACTS

22-25 OCTOBER 2024

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Version 5

IPC

POPLARS AND OTHER FAST-GROWING TREES FOR CLIMATE CHANGE MITIGATION AND ADAPTATION - PATHWAYS TO CLIMATE RESILIENCE AND CARBON NEUTRAL SOCIETIES

22-25 October 2024 - BORDEAUX, FRANCE

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Publisher Institut Européen de la Forêt Cultivée

Editorial Office Institut Européen de la Forêt Cultivée
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Introduction

1. Global Context

In a world grappling with urgent challenges, the 27th Session of the International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC27) will bring together experts under the theme, "Poplars and Other Fast-Growing Trees for Climate Change Mitigation and Adaptation – Pathways to Climate Resilience and Carbon Neutral Societies." IPC27 highlights the pivotal role of fast-growing trees in fostering sustainability amidst evolving environmental landscapes.

Fast-growing trees (FGT), trees with a mean annual increment (MAI) of at least 10m^3 ha^{-1}, are part of large, globalized value chains as much as they matter to smallholders and family farmers for their livelihoods, and for the conservation and restoration of ecosystems. Planted forests, accounting for 46 percent of global industrial roundwood demand in 2020, will continue to grow in importance for sustainable wood production and are an important pillar of the bioeconomy. Advancing knowledge and policy on management of FGT is critical for upscale their use for restoration of ecosystems, land management, and increased supply of wood fibre.

Taking place in Bordeaux on October 22-25, 2024, IPC27 marks the first in-person session since the approval of its new strategy. The session will unveil the outcomes of the new Working Parties and convene experts on a range of aspects related to management of fast-growing species. A study trip will

take place prior to the session on October 17-20, 2024, and Italy will host a post-study trip on October 27-29, 2024. The IPC Executive Committee will hold its 53rd meeting on October 21st, 2024.

Join us at IPC27 as we chart a course towards resilient, carbon-neutral societies with fast-growing trees.

2. Why an IPC session 27 in France

France has always been a player in the International Poplar Commission. Following the creation in 1946 of the first national poplar commission in France, in 1947 it participated in the creation of the International Poplar Commission with 8 other founding members: Belgium, Italy, the Netherlands, Poland, the United Kingdom, Sweden, Switzerland and Czechoslovakia.

After the organization in France of the 9th session of the IPC in 1957, more than 66 years ago, the organization of the 27th session of the IPC in France in October 2024 is an opportunity to recall the importance of this international institution for France.

France, with an area of 200,000 ha of planted poplars and an annual timber production of 1.4 million m3, is one of the main poplar wood producing countries in Europe. This production represents 1/3 of the hardwood harvest in France. Production poplar plantations are mainly owned by more than 150,000 private owners. These poplar plantations are distributed in valleys throughout the French national territory. Poplar wood is mainly used for the manufacture of plywood panels or for the production of lightweight wooden packaging. Part of the wood is exported in particular to Italy and Spain.

The poplar sector is today organized around the National Poplar Council which brings together representatives of wood production, services (cooperatives, experts and forestry work companies) and processing industries. This Council is the main contact of the Ministry of Agriculture for poplar issues, and aims to support the development of poplar production within the framework of sustainable forest management.

The other fast-growing species present in France, according to the FAO productivity criterion of 10 m3/ha/year, are essentially eucalyptus and Douglas fir. Eucalyptus trees are rarely planted in France and their wood is mainly used for pulp. Douglas fir is a recent species in France and its weight has been increasing over the past 50 years. It is planted in the regions of Massif Central, Burgundy, and Normandy, where the soil and climate conditions suit it. Its wood is sought after for construction.

Two other species are considered in France as high-growth species in certain soil and climate conditions, but with a productivity below the criterion of 10 m3/ha/year at the national level: maritime

pine and black locust. Maritime pine represents 132 million m3 of standing wood, spread over 900,000 ha mainly located in the Landes de Gascogne massif. Its wood is widely used in sawing. Robinia represents 28 million m3 of standing wood, distributed throughout France over more than 150,000 ha. Its wood is widely used for making stakes.

WP COM

Working Party on Communication and Outreach

IPC - Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

TALK

Biomass Connect: an overview of the establishment phase

by William Macalpine | Rothamsted Research

ID du résumé: 130
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-COM Communication

The Biomass Connect Innovation and Information Hub is a UK based demonstration and knowledge-sharing initiative to showcase best practice and innovations in land-based biomass feedstock production to support the development of the UK biomass industry. Biomass Connect is funded by the Biomass Feedstocks Innovation Programme, which is a £36 million programme, funded through the UK Government Department for Energy Security & Net Zero's £1 billion Net Zero Innovation Portfolio. The Biomass Feedstocks Innovation Programme aims to increase the production of sustainable UK biomass feedstocks.

Biomass Connect has four primary aims:

1. Providing robust, independent information on biomass feedstock performance, agronomy, economics and environmental benefits to landowners and land managers.
2. De-risking new crop adoption by ensuring that geographic variations in the efficacy of biomass feedstocks and relevant innovations are fully evaluated and demonstrated to a broad range of stakeholders across the UK.
3. Sharing knowledge, experiences, and case studies to facilitate discussion and learning in the biomass sector.
4. Contributing to agricultural, environmental and bioenergy policy development by providing robust evidence and facilitating interactions between policy, academia, and industry.

Through the platform, the project is building a UK-wide, cohesive, regionally based community who will contribute to the development, establishment and operation of the platform. Building this focal point for the industry will support the ambitious scaling up of both the bioenergy industry itself and the scale of planting which is required to align with the Committee on Climate Change's modelling for net zero, which anticipates expanding from 10,000 ha to 700,000 ha by 2050.

The project comprises of eight demonstration hubs across the four nations of the UK, in Ceredigion, South Ayrshire, Buckinghamshire, Devon, Edinburgh, County Down, Northumberland and Yorkshire.

Each Biomass Connect Demonstrator Hub grows up to eleven crop types. These include short-rotation-forestry, short-rotation-coppice woody crops, perennial grasses and forbs. The project compares how well different crops and varieties grow in regions across the UK and demonstrates innovations that have the potential for economic and environmental benefits. Highlights and progress reports from across our Biomass Connect Demonstrator Hub sites will be showcased.

Creating a poplar information and resource center on the Internet: the French experience

by Emmanuel Naudin | Conseil National du Peuplier

ID du résumé: 118
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-COM Communication

In France, the poplar industry is facing many challenges in terms of communicating basic knowledge and technical informations :

- A large number of owners to inform, with little or no knowledge of poplar, new owners, or
- owners with a new interest in poplar constant and rapid changes in poplar-growing techniques
- inaccurate or false information, which has been circulating for a long time and is maintained by
- people who are ill-informed or unfavourable to poplar.

In such context, providing clear, sourced and easily identifiable information has become a major challenge for the Conseil National du Peuplier (CNP). The setting up of an original website by the CNP appeared to be the most effective way of meeting these needs: easily reaching a large number of people with a tool that is easy to update.

This led to extensive design and development work, the main phases of which were :

- creating a tailor-made system capable of evolving and accommodating new resources over time creating information about the sector and the latest news creating a directory of companies and
- players in the poplar sector, with a map-based location system and search filters distribute video
- tutorials on technical procedures or essential subjects create technical pages with the latest
- information set up a technical library in the form of a database accessible to the public,
- constituting a multi-strategic documentary resource • implement a simplified economic
- simulator.

Published at the end of 2021, the site records a traffic of around 30,000 visits per year, which is relatively high for such specific information.

After the home page with the latest news, the directory is the 2nd most visited page. This is followed by the wood marketing and cultivar pages.

Curently, the site is able to respond simultaneously to

- the general public, especially in regard to the uses of poplar wood the needs of non-professionals
- who have poplars and are looking for information to help them discover or improve their level of poplar cultivation, • professionals looking for technical information on poplar growing, or arguments and studies to answer questions relating to the environment.

IPC 'Highlight Sheets' – how we effectively disseminate information on fast growing trees to those who want and need it?

by Barb Thomas | University of Alberta

ID du résumé: 106
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-COM Communication

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Web-based "Highlight Sheets" can streamline and simplify the transfer of knowledge and technological advances regarding fast growing trees to IPC member countries' policy makers, researchers and practitioners. We will show how we develop a highlight sheet for knowledge transfer. This is a dynamic process and can be accomplished using various forms of communication. Our site currently features a worldwide poplar/willow interactive photo gallery, registration protocols of fast-growing trees, multiple global applications of fastgrowing trees in agroforestry systems and more. We are also keen to assist others in disseminating their applied research outcomes through our IPC working party (#5), on communication.

Analysis for the implementation of a web portal on the Italian poplar production and wood supply chain

by Bergante S. | Chiarabaglio P.M. | Cremonini C. | Negro F. | Zanuttini R. | 1) CREA – Research Center on Forestry and Wood. Strada per Frassineto, 35 - 15033 Casale Monferrato (AL) Italy | 1) CREA – Research Center on Forestry and Wood. Strada per Frassineto, 35 - 15033 Casale Monferrato (AL) Italy | 2) DISAFA – University of Turin, Largo Braccini, 2 - 10095 Grugliasco (TO) Italy, | 2) DISAFA – University of Turin, Largo Braccini, 2 - 10095 Grugliasco (TO) Italy, | 2) DISAFA – University of Turin, Largo Braccini, 2 - 10095 Grugliasco (TO) Italy,

ID du résumé: 86

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-COM Communication

Various elements useful to implement a website on the poplar supply chain in Italy are presented. This would constitute a relevant novelty considering the strategic importance of poplar cultivation in the Country, the insufficient amount of wooden raw material for the industry, the availability of new clones, and the local specificities of this type of arboriculture. A dedicated web portal could act as a reference point for the entire national sector, promoting better communication, supporting further expansion of poplar plantations, and valorising poplar wood.

To identify the main sections, the portals on the same subject existing in France, Spain and Belgium were analysed in detail. The search enabled to determine the most covered topics and interesting best practices.

As for the general structure, the content should be divided into a main body with general information, and complementary sections related to specific topics. The main body should provide information on planted areas and their history, data on the clones used in different plantation systems, biodiversity and ecosystem aspects associated with the specific plantations models. Regarding other sections, a specific aim should be to support growers in choosing the most suited cultivation methods. Thus, it would be helpful to provide a section with updated timber demands and future market trends. In addition, calculation systems for lot cubage and timber prices could be developed. A section dedicated to poplar timber auctions would be of particular interest to professional and industries.

Including descriptive data sheets of the main clones would also be a key aspect, also to provide guidance on the most appropriate choices based on the plantation sites. Another important topic is the wide range of products that can be made from poplar wood. This could be addressed by introducing a list of

products with their description, requirements and uses, or even by a section dedicated to matching supply and demand, with a view to increasing the value of quality timber.

To support transparency in the supply chain, it would also be useful to include a section on certifications for growers and wood industries, and another outlining current regulations and legislations. Finally, a section dealing with ecosystem services and carbon credits would provide relevant information.

The development of a specific website would be an important tool to innovate the Italian poplar supply chain and to foster interaction between stakeholders.

POSTER

Fast-Growing Trees Networks

by J-A. Adorno | C. Babor | B. Garzon | M. Schillberg | L. Urban | J. Kuzovkina |University of Connecticut, Storrs, Connecticut, USA

ID du résumé: 47
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-COM Communication

Fast-growing tree (FGT) species are significant components of agricultural and forestry systems worldwide and provide benefits in various environmental and industrial applications. In response to the IPC's initiative to include other fast-growing tree species, the USDA National Needs Fellows at the University of Connecticut initiated a project to construct a network of researchers, practitioners, and institutions with recently published work involving fast-growing trees. The objective is to provide a database to support the initiation of new networks that facilitate information exchange and collaborative projects. The FGT network was constructed through the analyses of publications, references, and researchers who have published work on twenty different fast-growing tree genera over the past seven years. The twenty genera include *Abies, Acacia, Acer, Alnus, Bamboo, Betula, Eucalyptus, Fraxinus, Larix, Morus, Paulownia, Picea, Pinus, Prosopis, Prunus, Robinia pseudoacacia, Quercus, Tilia, Juglans,* and *Tectona*. We used databases such as Google Scholar, BIOSIS, CAB Index, and Scopus with keywords to find active researchers within each genus. We recorded and sorted relevant publications and their authors into seven categories: Breeding, Selection, and Evaluation, Genomics, Plant Health, Resilience to Climate Change, Production and Utilization, Wood Products, and Environmental and Ecosystem Services. These categories reflect the five working parties making up the operation model of the IPC organization. This initiative aims to broaden the IPC membership, foster a collaborative network, and increase engagement from the scientific community. Expansion of this database can quantify the impact and acknowledgment of researchers working with fast-growing trees.

WP PRO

Working Party on Production Systems for the Bioeconomy

IPC - Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

KEY TALK

Resources and utilization of planted poplar in China: a comprehensive review

by Wanzhao Li | Xinwu Xu | Nanjing Forestry University | Nanjing Forestry University

ID du résumé: 14

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

In China, the distribution of poplar forests span from 25°N ~ 53°N and from 76°E ~ 134°E. Up to 2015, the total area of planted poplar forests exceeded 7.6million hectares, representing 75% of the total area of poplar forests in China, which leading the world. There are 4 million hectares of planted poplar forests from the Three-North Shelter Forest Program.

The poplar breeding work in China began in the 1940s and a large number of new varieties and germplasms have been successively introduced to forest cultivation. In late 1990s, the outstanding representatives, such as the European-American Poplar No. 107, No. 108, and triploid white poplar hybrids, were widely planted in provinces such as Shandong, Anhui, Hebei, Liaoning, Shanxi, and Henan. They have excellent characteristics such as fast growth, straight stem, good wood quality, wide planting range, strong wind resistance, cold resistance, and insect resistance.

Planted poplar wood can hardly be directly used as a product due to low density, poor dimensional stability, and low mechanical strength. In industry, planted poplar wood is commonly used after modification and processing. After thermal and impregnation modification, planted poplar wood can be used as decoration and engineered materials. It represents the efficient and high-value utilization of planted poplar wood, which also greatly alleviates the shortage of high-quality wood resources in China. Planted poplar wood has the advantage of easy for machining and bonding, which makes it an excellent raw material for producing wood-based panels. By the end of 2023, the production capacity of oriented strand board (OSB) in China was approaching 10 million m^3, and planted poplar wood is the most important raw material. In recent years, laminated veneer lumber (LVL) made from planted poplar wood has seen rapid development in regions such as Shandong and Jiangsu provinces. Plywood manufactured from poplar wood accounts for about 60% of the total production capacity in China, with an annual output of approximately 112 million m^3. The veneer from planted poplar wood is predominantly used as the core layers in plywood production.

Although significant progress, there are still some issues hindering the development of planted poplar wood industry in China. It is necessary to optimize forestry management to increase tree diameter,

straightness, and reduce knots. The processing techniques and equipment need to be further upgraded in terms of the characteristics of planted poplar wood.

Near-real-time and early warning system for water stress monitoring in poplar plantations using radiative transfer models with Sentinel 2 images, eco-physiological sensors and IoT

by Flor Álvarez-Taboada | Isabel Cristina Grisales Sánchez | Carlos Álvarez Cuevas | Rodrigo Arthus Bacovich | Joaquín Garnica López | Alexey Valero Jorge | Carlos Luis Camino González | Dracones research group Universidad de León Ponferrada (León), Spain | Dracones research group Universidad de León Ponferrada (León), Spain | Garnica Valencia de Don Juan Valencia de Don Juan (León, Spain) | Idaf sl Córdoba, Spain | Bosques y ríos Valencia de Don Juan (León, Spain) | Dracones research group Universidad de León Ponferrada (León), Spain | European Commission Joint Research Centre Via e. Fermi 2749 – tp 262 i-21027 Ispra, Italy

ID du résumé: 15

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Timely detection of water stress and forest health is critical for sustainable management of poplar plantations. The aim of this work was to develop an early warning and near-real-time system for monitoring water stress in poplar clone plantations using (i) radiative transfer models with Sentinel 2 imagery and (ii) sap flow density measured by eco-physiological sensors and transmitted by the Internet of Things (IoT). The system was calibrated and validated in a deep-rooted poplar plantation established in 2011 in Villamañán (León, Spain).

On one hand, three eco-physiological sensors TreeTalkers (TT+) were installed in March 2022 in the plot (Fig. 1), to record the sap flow density corresponding to each tree and transmit it each hour using the IoT. A code was developed in R for automated data processing and anomaly detection. Our previous results showed a high correlation between the sap flow density and the growth in diameter measured weekly in the field for trees under water stress ($r > 0.81$) and confirmed the suitability of this variable as an early warning indicator.

On the other hand, and to scale these results to larger areas, we explored the relationships between sap flow measurements and (i) chlorophyll (Cab) and (ii) water leaf content (EWT) obtained from Sentinel 2 imagery (Fig. 2, 3). To retrieve those two biochemical parameters, a hybrid approach was developed with machine learning algorithms coupling a PROSAILPRO radiative transfer model with Sentinel-2 imagery. Cab and EWT were then predicted for each one of the trees with the TT+, for each cloud free Sentinel image available during July and August 2022 and compared to the sap flow moving average for a period of 5 days.

Results showed a significant correlation ($p<0.05$) between the EWT estimated from Sentinel 2 imagery and the sap flow (Fig. 4), for the three trees analyzed ($r = 0.45$, $n = 29$).

Analyzing each tree separately (Table 1), the correlation reached $r = 0.88$ for the tree with the lowest water stress level. Moreover, a significant correlation was found between the Cab and the sap flow (Fig. 5), for the three trees analyzed ($r = 0.52$, $n = 31$). Analyzing each tree separately (Table 1), the correlations ranged from $r = 0.54$ to 0.91.

These findings emphasize the importance of integrating these technologies for real-time monitoring and informed decision-making in forest management, enhancing our ability to anticipate and mitigate environmental threats, ensuring ecosystem resilience and productivity.

Keywords: Hybrid poplar; Trees outside forests; Plywood; Agroforestry

Combining poplar with other wood species for Engineered Wood Products

by Joris Van Acker | Liselotte De Ligne | Tobi Hallez | Jan Van den Bulcke | Ghent University - Woodlab | Ghent University - Woodlab | Ghent University - Woodlab | Ghent University - Woodlab

ID du résumé: 82

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The historical use of poplar timber in construction demonstrates its potential as an alternative material to softwoods, such as spruce. Specific properties like the presence of tension wood impacting drying and surface quality might hinder the current use of timber products. Beech has not been considered for timber constructions as such, but is to some extent similar to oak which was the eminent wood species for construction in the past. The higher density of beech and the related low dimensional stability are also influencing the potential for building with wood. Both wood species can be used for engineered wood products and as such some of the properties can be designed to fit for purpose. Combining both in this respect might lead to major advantages in providing commodities suitable to complement the current volumes of wood products for green building.

Beech and poplar exhibit a low natural durability against fungi, similar to many types of softwood timber that are commonly used. Enhancing the durability of engineered wood products based on these species can be based on a range of technological solutions, such as thermal or chemical modification. The durability against insects is also low, but the biological agents involved might be less critical for these hardwood species. Furthermore, wood protection options can be positively integrated in a fit-for-purpose context.

Enhancing performance by combined engineered wood products, so-called hybrid EWPs should provide extra potential. For solid timber-based products like glulam (GLT) and cross laminated timber (CLT) this was already tested for both species and has been underpinned by research projects. Also veneer based products like plywood and laminated veneer lumber (LVL) are very suitable for combining wood species and rheological performance can further be improved by using natural fibres as extra embedded component. Current trends in strand-based panel and beam products like OSB and LSL demonstrate a tendency to incorporate multiple wood species as resources, with an increased interest in hardwoods. Here also properties can be defined through careful combination of wood species creating as such a fit for purpose mix of beech and poplar.

Satellite remote sensing techniques for monitoring and managing Eucalyptus plantations

by Guerric le Maire | Florian de Boissieu | Henrique Ferraco Scolforo | Clayton Alcarde Alvares | Nicolas Baghdadi | Mathieu Goral | Manizheh Rajab Pourrahmati | Vitoria Barbosa Ferreira | Evandro Nunes Miranda | Joannès Guillemot | Jean-Baptiste Féret | Jose Luiz Stape | CIRAD, UMR Eco&Sols, Montpellier, France | INRAE, UMR TETIS, Montpellier, France | Suzano SA Company, Jacareí, Brazil | Suzano SA Company, Jacareí, Brazil | INRAE, UMR TETIS, Montpellier, France | CIRAD, UMR Eco&Sols, Montpellier, France | INRAE, UMR TETIS, Montpellier, France | CIRAD, UMR Eco&Sols, Montpellier, France | Suzano SA Company, Jacareí, Brazil | CIRAD, UMR Eco&Sols, Montpellier, France | INRAE, UMR TETIS, Montpellier, France | Forest Science, Sao Paulo State University (UNESP), Botucatu, Brazil

ID du résumé: 94

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Satellite remote sensing is increasingly utilized in the forestry sector for spatial characterization, management, and monitoring of large areas at both stand and intra-stand scales. Despite the availability of numerous products suitable for forest monitoring and management, there is a growing demand for innovative methodologies to customize or create satellite image processing systems adapted to specific forest types and management objectives. This presentation reviews three applications of satellite remote sensing data developed by CIRAD through collaboration with forest industries, focusing on Eucalyptus plantations. In Brazil, Eucalypus are planted over 7.6 million hectares, and are predominantly established for the production of pulp and paper, charcoal, panels, and firewood. Firstly, we investigated the use of Sentinel-2 (S2) imagery, Global Ecosystem Dynamics Investigation (GEDI) lidar data, and Pléiades satellite stereo imagery to estimate eucalypt plantation biomass and growth at various scales, each utilizing distinct theoretical foundations. We will highlight the advantages and uncertainties associated with these remote sensing approaches. Secondly, we developed a time series analysis of Sentinel-2 (S2) satellite images to monitor the post-planting growth status of Eucalyptus plantations. By calibrating a machine learning algorithm, we predicted the volume of plantations at two years of age based on various plantation characteristics such as genotype and spacing. This approach was further enhanced with remotely sensed data from early-stage S2 time series, demonstrating the potential for precise growth monitoring and prediction. Lastly, we created an alert system for disturbance detection, aimed at identifying damages in vegetation caused by fires, illegal harvesting, storms, pests and diseases, and severe drought. This detection method, also based on S2 time series, integrates multiple auxiliary variables related to local vegetation and satellite acquisition properties through a machine learning algorithm. The system's ability to provide timely and accurate alerts is crucial for effective forest management, i.e. taking appropriate and timely decision. The quality of

satellite data preparation for atmospheric correction and cloud masking, and the extensive use of calibration and validation datasets, covering tens of thousands of hectares of plantations, were fundamental to the success of these three applications. The methodologies developed show the potential of satellite remote sensing in monitoring plantations at large scale. We will discuss how these three approaches can be practically applied to plantation forest management, highlighting their contributions to sustainable forestry practices and their potential for broader application in different forest types worldwide.

TALK

Growing Poplar in Agroforestry Systems: Economic Competitiveness with Arable Farming in Eastern Germany

by Thiesmeier, Alma | Leibniz Centre for Agricultural Landscape Research (ZALF) e.V.

ID du résumé: 8

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Agroforestry can address multiple challenges in agricultural landscapes such as biodiversity, climate change and soil quality simultaneously, while also providing additional biomass from trees. However, farmer uptake remains low in Germany. Therefore, this study investigates the economic performance of short rotation alley cropping with poplar for wood chip production compared to arable farming without trees in the East German state of Brandenburg. Additionally, different economic incentives in the form of policy payments and their impact on profitability are evaluated.

Economic performance and therefore competitiveness of agroforestry was measured by comparing the net present value of poplar alley cropping with arable farming without trees. The investigated agroforestry systems have three different spatial configurations and alley widths are set at 24m, 48m, and 96m. The crops grown in the agroforestry systems are identical to the crops grown in the arable system without trees. They do not represent crop rotations but crop shares to account for the economic importance of certain crops in the region. Crop shares also vary between different soil qualities, as do yields for crops and poplar and their associated production costs. Soil quality is separated into five classes where soil quality and therefore yield potential declines from soil quality class one to soil quality class five. Lastly, three wood chip prices are included based on net producer prices from the last five years.

Results showed that at average wood chip prices poplar alley cropping is not competitive with arable farming without policy support (scenario a). For agroforestry to be competitive for all soil qualities it is necessary to cover 100% of establishment costs (scenario e). At high wood chip prices poplar alley cropping can be competitive for some soil qualities without additional policy support but not all. For this, covering 40% of investment costs in the establishment phase is necessary (scenario d). When wood chip prices are low, higher policy support is necessary. Here, increasing eco-scheme payments to 850€/ha wooded area would be necessary (scenario c).

In conclusion, poplar alley cropping is not competitive with arable farming unless wood chip prices are very high. Current eco-scheme payments (200€/ha wooded area) (scenario b), is unable to remedy this situation. For poplar alley cropping to become viable under most soil qualities and wood chip

prices all investment costs should be reimbursed to farmers. To make poplar alley cropping competitive under all soil qualities and wood chip prices ecoscheme payments of 850€/ha are advisable.

Growth performance of Populus deltoides clones under Agrisilviculture System at Tarai region of Uttar Pradesh in India

by Anita Tomar | ICFRE -Eco-Rehabilitation Centre, Prayagraj , India

ID du résumé: 10

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

To identify superior *P. deltoides* clone in Tarai region of Uttar Pradesh (Tamkuhi raj, Kushinagar) in India,in which planted 17 clone *viz.,*T_1: AM 41,T_2:FS 57,T_3:L-30-82,T_4: AM 58,T_5: AM 59,T_6:FS 16,T_7:FS 32,T_8:L 89,T_9:G 48,T_{10}:FS 47,T_{11}:S7 C8,T_{12}:FS 175,T_{13}: AM 44,T_{14}:AM 32,T_{15}:L-200-84,T_{16}: AM 12 and T_{17}:FS 31.Experiment was established under Agrisilviculture System (*Populus deltoides* +Mustard) with 8 replications.The coordinate of trail 26°69'N, 84°18'E, 86 m above MSL.Data was collected in duration gap of six months *viz.* April 2023,October 2023 & April 2024 to see growth performance of Clones.The result shows maximum height recorded in FS-32 (10.00 ± 1.69 m) FS-16 (10.00 ± 0.93 m) followed by FS-31 (9.14 ± 1.35 m) & minimum in L-200-84 (6.13 ± 1.36 m).DBH was maximum recorded in FS-31 (10.69 ± 1.13 cm) followed by FS-32 (10.27 ± 1.07 cm) and minimum in AM-59 (5.97 cm) in month of April 2023.Whereas after six month (October 2023) the height was maximum recorded in FS-16 (13.58 ± 0.81 m) followed by FS-32 (13.53 ± 1.38 m) and minimum in AM-32 (9.94 ± 1.08 m) whereas the DBH was maximum recorded in FS- 31 (16.02 ± 2.34 cm) followed by FS-32 (15.98 ± 1.12 cm) and minimum in AM-59 (10.13 ± 1.18 cm). In April 2024 maximum height found in FS- 16 (13.86 ± 0.77 m) and FS- 32 (13.86 ± 1.39 m) followed by L 89 (12.98 ± 1.29) and minimum in AM-32 (10.30 ± 1.00 m) while maximum DBH was recorded in FS- 31 (16.88 ± 1.18 cm) followed by FS-32 (16.24 ± 1.11 cm) & minimum in AM-59 (10.43 ± 1.21 cm). Height increment from April 2023 to October 2023 maximum recorded in AM -12 (4.63 ± 1.09m) followed by AM 59(4.44 ± 1.50m) & minimum in AM 32 (3.31± 2.10 m).Height increment from October 2023 to April 2024 maximum recorded in AM 41 (0.55±0.22) followed by AM 59 (0.51±0.26) & minimum in FS 31 (0.19±0.15).DBH increment from April 2023 to October 2023 maximum recorded in FS-32 (5.71 ± 0.51 cm) followed by FS-16 (5.63 ± 0.99 cm) & minimum in AM-59 (4.16 ± 0.82 cm).DBH increment from October 2023 to April 2024 maximum found in FS 31 (0.86±1.43) followed by AM 32 (0.70±1.12), AM 58 (0.70±1.13) & minimum in FS 32 (0.26±0.08).On growth performace FS Poplar clone performed best among 17 clones thus recommended for cultivation in farmers field in eastern part of U.P.

Growth performance of three fast-growing tree species in different spacing at Prayagraj in India

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ID du résumé: 11

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

To study the growth performance of *Populus deltoides* (Poplar), *Eucalyptus spp.* (Eucalyptus) and *Casuarina equisetifolia* (Casuarina) tree species under high-density plantation at Prayagraj, Uttar Pradesh in India. The tree species planted in three different spacing *viz.,* 1m×1m, 1.2m×1.2m and 1.5m×1.5m. The trail was established in July 2021 and data was collected after first year (June 2022) and in second year (June 2023). In this experiment 135 trees are planted, each species in different spacing and replication. The height was measured with help of altimeter and girth was measured at 1.37 m above the ground level with help of tape. The high-density plantation will be harvested after four years. The result was indicated that the height increment in first year maximum recorded in T_2:Eucalyptus (1m×1m) 2.43 m followed by T_5: Eucalyptus (1.2m×1.2m) 2.38 m and minimum in T_9:Casuarina (1.5m×1.5m) 0.97 m whereas in second year the maximum height increment was recorded in T_2: Eucalyptus (1m×1m) 4.04 m followed by T_4: Poplar (1.2m×1.2m) 2.98 m and minimum in T_9: Casuarina (1.5m×1.5m) 1.87 m. The maximum mean height was recorded in T_2:Eucalyptus (1m×1m) 3.24 m followed by T_5: Eucalyptus (1.2m×1.2m) 2.63 m and minimum in T_9:Casuarina (1.5m×1.5m) 1.42 m. In first year,the maximum girth increment was recorded in T_2:Eucalyptus (1m×1m) 4.54 cm followed by T_5: Eucalyptus (1.2m×1.2m) 4.24 cm and minimum in T_9: Casuarina (1.5m×1.5 m) 1.35 cm whereas the in second year the maximum girth increment was recorded in T_4: Poplar (1.2m×1.2m) 6.96 cm followed by T_2: Eucalyptus (1m×1m) 6.65 cm and minimum in T_3: Casuarina (1m×1m) 2.90 cm. The maximum mean grith was recorded in T_2:Eucalyptus (1m×1m) 5.60 cm followed by T_4: Poplar (1.2m×1.2m) 5.45 cm and minimum in T_3:Casuarina (1m×1m) 2.14 cm. The maximum volume increment was recorded in T_2: Eucalyptus (1m×1m) 0.0076 m^3 tre e^{-1} followed by T_4: Poplar (1.2m×1.2m) 0.0068 m^3 $tree^{-1}$ and minimum in T_9: Casuarina (1.5m×1.5m) 0.0009 m^3 $tree^{-1}$. After two year the result indicate Eucalyptus (1m×1m) spacing perform best among all treatments. In most of case close spacing found more growth because of more competition in early age because in close spacing trees are competing for light and that may be causing them to grow taller than they would if spaced further apart. To overcome the persistent shortage of industrial, fuel wood and bioenergy production in India, can be achieved by raising High density plantation of fast-growing tree and managing them intensively at short rotations.

Operational Mapping of Poplar Plantations at the National Scale using Sentinel-2 Time Series Satellite Imagery

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ID du résumé: 16

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

In light of the challenges associated with accurately estimating the French poplar resource, this work leverages Sentinel-2 satellite capabilities for operational mapping of poplar plantations at a national scale. In collaboration with the research unit Dynafor, the National Poplar Council (CNP), and the National Forest Property Center (CNPF), we have developed an innovative approach integrating artificial intelligence and remote sensing to accurately map poplar plantations on a large scale.

This approach encompasses two complementary strategies: (i) the adoption of artificial intelligence techniques for efficient learning of image classification models from limited reference samples[1], and (ii) the development of a novel spectral index, the Poplar Index (PI)[2], harnessing specific spectral bands in the short-wave infrared (SWIR) and red edge domains available in Sentinel-2 imagery. The PI has demonstrated its relevance by achieving over 90% precision in discriminating poplar plantations from other deciduous tree species.

This methodological framework, focusing on the Poplar Index, has made it possible to produce six-year national maps from 2017 to 2022, demonstrating the ability to accurately identify poplar stands over large areas. It is noteworthy that this work represents a significant advance in the monitoring of poplar plantations through remote sensing. However, the precise assessment of surface areas remains pending as part of our ongoing endeavours. Further post-processing analyses are underway within the current initiatives to improve the accuracy of these estimates before their release to end users.

These efforts are part of an operational framework aimed at a systematic and regular production of poplar maps to be distributed through the Theia platform, thus ensuring thorough and recurrent monitoring for the poplar industry.

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Improving Soil Quality and Revitalizing Arid and Semiarid Areas by Planting Eucalyptus Species under Spate Irrigation

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ID du résumé: 20

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The planting of compatible and fast-growing tree species in arid and semiarid areas is a key strategy for reforestation and desertification control. In these areas, spate irrigation is also an appropriate technology to use the harvested floodwater. It not only provides the water needed for plant consumption but also improves soil quality in arid and semi-arid areas. A project to combat desertification through flood irrigation was initiated in 1983 in the Gareh Bygone Plain in the province of Fars, Iran, to replenish the groundwater table, stabilising the shifting sands and, in particular, improving the plant cover. This study examines soil quality and health indicators under the canopy of *Eucalyptus camaldulensis* Dehnh in spateirrigated fields compared to non-irrigated fields and control areas (without *Eucalyptus)*. Three transects were established in the central part of each field. Three eucalyptus trees were selected along the three parallel transects, and soil samples were taken from a depth of 0-30 cm around the fine roots and completely mixed: thus one sample was considered representative of each transect. Therefore, one sample was considered to be representative of each transect, resulting in three soil samples for each area. Soil samples were transferred to the laboratory in an icebox to determine the activities of acid and alkaline phosphatases, dehydrogenases, ureases, microbial biomass carbon, basal and induced respiration, and conventional physical and chemical soil characteristics. Duncan's test was conducted using R software to evaluate relationships between physical, chemical, and biological parameters, ensuring data normality and variance homogeneity. The results indicated that the loamy sand texture improved to loam, enhancing water availability. Additionally, moisture, organic carbon, and phosphorus percentages were significantly higher in the spate-irrigated area compared to the control area. Biological factors attributed to the Eucalyptus plantation such as the activities of acid and alkaline phosphatases, dehydrogenase, and basal and induced respiration were significantly higher three, six, four, and two times, respectively in the spate-irrigated area than in the control area. However, microbial biomass carbon was lower in the spate-irrigated area than in the control area. Soil microbial activity serves as a potential indicator of nutrient deficiencies. Afforestation in arid regions improves soil quality indicators, highlighting the importance of organic matter in enhancing biological indicators, soil quality, and soil health. Therefore, it is

suggested that flooded pastures be restored with compatible tree cover, and flood periods should be extended to increase soil organic matter.

“Populus adapt”: a project to monitor and prevent water stress in poplar plantations. Response of three different poplar clones to mycorrhizae and bacterial inoculation.

by Flor Álvarez-Taboada | Fernando Castedo Dorado | Jaime Olaizola | Joaquín Garnica López | Paula Ramos Pérez | Ignacio Arroyo Marcos | Dracones research group Universidad de León Ponferrada (León), Spain | Dracones research group Universidad de León Ponferrada (León), Spain | ID Forest, Spain | Bosques y ríos Valencia de Don Juan (León), Spain | Fundación Ciudad de la Energía - CIUDEN, F.S.P.CIUDEN, León, Spain | Sociedad Pública de Inf. y Medio Ambiente de Castilla y León SOMACYL, Spain

ID du résumé: 22

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Testing strategies for preventing water stress in poplar plantations is crucial due to increasing climate variability and its impact on forest health and productivity. This work evaluates the responses of three poplar clones (I-124, Raspalje, AF8) to mycorrhizae and bacterial inoculation with *Pisolithus tinctorius* and *Pseudomonas fluorescens*, respectively, aiming to enhance resilience and growth.

In May 2023, 48 two-year-old poplar seedlings were planted in twelve 4 m x 4 m x 2.25 m cells, where water levels can be controlled and monitored. In each cell 4 seedlings of each clone were planted at 1.25 m depth (Figure 1). The experimental design involved two factors with two levels: (i) induced water stress (low water level) (yes/no) and (ii) inoculation of fungus/bacteria (yes/no) (Figure 2). No water stress was induced during the 2023 growing season, to ensure the successful establishment of the trial.

In June 2023, initial soil samples were taken from each cell. According to the ANOVA tests (factors: clone, inoculation), there were no significant differences ($p>0.05$) for the 47 soil parameters analyzed.

In October 2023 soil samples near the plants and roots were taken from each cell to check the microbial community and mycorrhizae. These samples did not contain enough DNA for metagenomic analysis. An optical analysis of the roots confirmed the presence of *Pisolithus tinctorius* mycorrhizae in all inoculated trees (and only in those ones). The mycorrhization percentages were high (>60% all samples), fitting the criteria for productive mycorrhization.

To determine the seasonal growth in 2023, diameter at breast height (*d*) and total height (*h*) were measured in June and remeasured in November. To evaluate the responses of each clone to mycorrhizae/bacterial inoculation, an ANOVA test was used, focusing on *d* and height increments (factors: clone, mycorrhiza, interaction). Initial *d* and *h* were included as covariates in the analysis. For *d* increment, the mycorrhiza x clone interaction was significant ($p<0.05$), and inoculated clones of Raspalje and I-214 showed larger diametral growth than the ones which were not inoculated (Figure 3, Table 1). For *h* growth, inoculated Raspalje and I-214 showed larger values (Figure 3), but the difference was not significant ($p>0.05$) (Table 2).

These findings will contribute to sustainable forestry practices and climate change adaptation strategies, especially if the same response of inoculated plants is found when they are under induced water stress during the 2024 growing season, as planned.

AppPopuli+: Web application for real-time damage identification and report in poplar plantations using citizen science and artificial intelligence

by Javier Sánchez-San José | Rubén González-González | Rodrigo Arévalo Gonzalez | Eva Diez Presa | José Alberto Benítez-Andrades | Fernando Castedo Dorado | Carlos Álvarez Cuevas | Joaquín Garnica | Marcin Woźniak | Michał Wieczorek | Flor Álvarez-Taboada | Universidad de León, Campus of Vegazana s/n (León), Spain | Universidad de León, Campus of Vegazana s/n (León), Spain | Dracones research group Universidad de León Ponferrada (León), Spain | Dracones research group Universidad de León Ponferrada (León), Spain | SALBIS Research Group, Universidad de León, Campus of Vegazana s/n (León), Spain | Dracones research group Universidad de León Ponferrada (León), Spain | Garnica Valencia de Don Juan Valencia de Don Juan (León), Spain | Bosques y Ríos Valencia de Don Juan (León), Spain | Faculty of Applied Mathematics. Silesian University of Technology. Kaszubska 23, 44-100, Gliwice. Poland | Faculty of Applied Mathematics. Silesian University of Technology. Kaszubska 23, 44-100, Gliwice. Poland | Dracones research group Universidad de León Ponferrada (León), Spain

ID du résumé: 25

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Sustainable production of poplar wood is being affected by an increasing number of pests and diseases, and it is necessary to carry out surveillance and monitoring. AppPopuli+ is a web application that allows both foresters and ordinary citizens to report damages in hybrid poplar plantations (Populus spp.) on-line and to identify (by using a mobile phone) the pest or disease which causes them. This free application is available in English and Spanish at: https://test.apppopuli.es/ (Figures1-5).

This app features: (i) real-time identification of the pest/disease causing the damage based on images and artificial intelligence algorithms, (ii) intuitive and easy-to-use system aimed at both specialized and non-specialized users, (iii) web and mobile environment, (iv) integrated complementary information for improving pest/pathogen detection skills and knowledge, (v) location and data sent by the users and (vi) different user profiles (companies vs general citizens).

The damage report is done individually by the user through a form they fill in with information related to the damaged tree (i.e. the name of the pathogen causing the damage (if known), the geographical location, extent of the damage, etc.). This information is stored in a database, to monitor the status of poplar plantations and provide feedback to the app users about the damage they have reported. The help section includes information about the pests/diseases that could damage poplar trees, to help

identify them correctly. 30 pests/diseases are available in the database. The app has been in use since July 2023.

In addition, the real-time identification of pests and diseases by using the mobile phone and images from the damage was based on artificial intelligence. Supervised machine learning models were trained and validated to classify images into 29 categories of pests and diseases. More than 1,500 photographs of damages were used to train the models. These images were obtained from previous user's reports and from the databases of forest companies/administration. The images were manually classified according to their symptoms to assign them to the causative agent. Figure 6 shows the number of elements per class used to train/validate the model. Among all the models tested, a finetuned InceptionResNetV2 network was finally used, achieving an accuracy of 82% (70% of the data for training, 30% for validation). Cross-validation techniques were employed to avoid overfitting or underfitting issues.

This application will contribute to sustainable wood production, provide more resilient poplar plantations and promote the early control of potential pests and diseases.

Can Fast-Growing Trees Sustain Timber Supplies, Mitigate Climate Change, and Protect Ecologically Valuable Forests on Poland's Path to Carbon Neutrality?

by Marzena Niemczyk | Tomasz Wojda | Marcin Mionskowski | Forest Research Institute | Forest Research Institute | Bureau for Forest Management and Geodesy

ID du résumé: 29

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Fast-growing tree species (FGTS) plantations offer a promising option for the reforestation of private land and non-forested areas owned by the State Treasury. The Polish National Energy and Climate Plan (NECPs; Strategic Plan) advocates for sustainable management methods that promote the implementation of various forest and tree projects, such as afforestation of agricultural land, planting of field trees, development of agroforestry systems, and enhancement of biodiversity in private forests to bring Poland closer to carbon neutrality. Native for Poland species like birch, larch, and aspen, along with non-native species such as black locust and hybrid poplars, show significant growth potential among FGTS. Our study aimed to summarize long-term research on FGTS, review biomass production depending on species, environmental factors, and management techniques, and demonstrate the economic profitability of plantations. We also assessed the availability and suitability of land for FGTS plantations in Poland.

Among FGTS, poplars are the most productive, especially in medium rotations, which are economically most justified. Notably, the variety 'Hybryda 275' (='NE42'), well-suited to Polish climatic conditions, may reach impressive dimensions of 0.75 per stem at 15 years when planted at a spacing of 4 × 4 m. The European larch averages 0.18 m³ (DBH 19.7 cm; height 12.9 m) at 15 years. Silver birch reaches 0.24 m³ (diameter at breast height 20.6 cm; height 18.4 m) after 25 years at the same spacing. Black locust grows to 23-27 m in height and 26-32 cm in diameter at breast height, with an annual volume increment of up to 12-14 m³/ha. In plantations with a 5-year production cycle, dry matter yield varies from 5.7 to 11.4 t/ha/year depending on site fertility. The slightly lower yields of other species compared to poplars can be balanced by their valuable wood properties (e.g., wood density).

Our economic studies have demonstrated that poplar plantation in a medium production cycle (20 years) represents a profitable option for timber production. The economic outcome of the venture is significantly influenced by the management of the plantation, as well as annual precipitation amounts, and soil type, which differentiate productivity and therefore the profitability of establishing plantations

under different natural conditions. In turn, our analysis of land availability showed that only 16,745 hectares (probably even less) of nonforested areas of the State Treasury managed by the State Forests are suitable for FGTS plantations. Therefore, it is considered that private lands offer significantly higher potential for FGTS investment.

Can Fast-Growing Trees Sustain Timber Supplies, Mitigate Climate Change, and Protect Ecologically Valuable Forests on Poland's Path to Carbon Neutrality?

by Marzena Niemczyk | Tomasz Wojda | Marcin Minskowski | Forest Research Institute | Forest Research Institute | Bureau for Forest Management and Geodesy State Enterprise

ID du résumé: 46

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Fast-growing tree species (FGTS) plantations offer a promising option for the reforestation of private land and non-forested areas owned by the State Treasury. The Polish National Energy and Climate Plan advocates for sustainable management methods that promote the implementation of various forest and tree projects, such as afforestation of agricultural land, planting of field trees, development of agroforestry systems, and enhancement of biodiversity in private forests to bring Poland closer to carbon neutrality. Native for Poland species like birch, larch, and aspen, along with non-native species such as black locust and hybrid poplars, show significant growth potential among FGTS. Our study aimed to summarize long-term research on FGTS, review biomass production depending on species, environmental factors, and management techniques, and demonstrate the economic profitability of plantations. We also assessed the availability and suitability of land for FGTS plantations in Poland.

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Growth patterns of several poplar clones for plywood production in Spain

by Joaquín Garnica López | Bosques y Ríos SL

ID du résumé: 50

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Romero Pedro[1]., Fernández Sergio[2]., Garnica Joaquín[3]

“Bosques y Ríos” manages around 2.300 ha of poplar plantations in Spain, located mostly around the Duero and Ebro River basins. Most of these plantations are certified under PEFC and FSC standards. The destination of the timber is rotary cutting for obtaining plywood.

Traditionally Spanish poplar cultivation has been based upon the Italian clones I-214 and MC, and with the Belgium clones Beaupre, Raspalje and Unal. I-214 and MC are already having problems in many areas of Spain because of their susceptibility to Phloemyzus passerinii. In the other hand the Belgium clones Beaupre, Unal and Raspalje are very sensible to rust (Melampsora allii-populina) and this is affecting the health and growth of many plantations, especially with the clone Beaupre. To widen the genetic pool of poplar plantations in Spain and selecting other poplar varieties adapted to Spain several experimental plots have been established in the last 20 years, with special effort in the last 6 years, in which Bosques y Ríos has installed 39 trials with statistical design spread across de Duero and Ebro basins. 217 clones are being tested currently, coming from several research centers in Belgium, France, Italy and other countries. The poplar species tested are Trichocarpa, Maximowiczii, Deltoides and Nigra.

The results obtained in the oldest trial plots support the assumption that certain clones such as AF4, AF8, Guardi and Hoogvorst are a clear alternative to traditional clones used in Spain, growing in some cases 50% more than traditional clones. The results obtained in the younger plantations suggest that “new clones” like AF13, Aleramo, BIC, Diva, Eiffel, Maestrale, Missouri, Senna, Turbo and Venus can be a good alternative in the future. Other clones such as Dorskamp and Monviso are very productive but crooked as well. Some Belgium clones provided different results depending on the areas. Other clones that obtain excellent growth results have been rejected because of their affection by certain pests and diseases. In this study several clones are identified as potentially interesting from the growth perspective. Future monitoring of these plantations and testing their quality for peeling will determine in the future if they can be considered as viable alternatives for poplar plantations in Spain.

Keywords: poplar, clones, growth, plywood.

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Circular Economy around the Value Chain of Fast Growing Trees in India

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ID du résumé: 52

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Forestry sector has considerable potential for applying Circular Economy to encourage efficient use of forest raw materials in different applications by converting the unused produce and under-valued forest residues and waste into value generating products. Wood is traditionally the main produce from forestry sector. Gradually, the importance of other than wood and a large number of services has gained significant importance. Efforts have been made for valuation of forests by inclusion of non wood produce and services in the of production-utilization value chain of these resources. In India, the production and supply of tree produce has gradually shifted from government forests to non forest areas especially to the farmland. According to an estimate around 5 million ha area has been reported under the culture of fast growing trees that includes Eucalyptus, Poplars, *Acacia* spp., *Bombax ceiba*, *Casuarina*, *Ailanthus* spp, *Melia* spp, *Leucaena leucocephala* and a few others. These trees grown in Agroforestry are significantly contributing towards minimizing risks of crop failures; enlarging income portfolio from diversified crops including trees; receiving consolidated returns from the sale of trees towards doubling farm income; encouraging sustainable natural resource management; and meeting the demands of bio-fuel, fodder, timber, etc. Around 90% of the wood demand of the country's wood is now met with from these trees grown on farmland, 4% is obtained from government forests and 6% from imports.

Circular Economy is gradually gaining ground around the value chain of commercially fast growing trees. Eucalyptus and Poplars were the first two trees initially promoted for wood production on farm fields. Currently, Eucalyptus is the top planted tree in many parts and Poplar is grown along the foothills south of the Indian Himalayas. These two trees are now tagged as zero wastage trees as all their components/parts like foliage, thin and thick branches, extracted roots, industrial processing waste, bark and saw dust are increasingly used. Circular Economy around the value chain of Eucalyptus and Poplar has been captured at different levels of their production and utilization process, *viz.*, nursery raising, plantation management, pruning, harvesting and wood processing. Both these trees start adding value right from the stage their reproductive material is collected, nursery plants grown, plantations raised, managed and harvested; and wood processed. Economical activities involved around these new

activities are compared with the traditional value chain involved around the production and processing of tree produce from forests.

The Impact of Climate Change and Water Use Efficiency in Populus tomentosa (Chinese white poplar) Plantations: A Meta-Analysis

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ID du résumé: 53

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Populus tomentosa, commonly known as the Chinese white poplar, is an important hybrid tree species in China. Due to its rapid growth, high timber quality, and exceptional adaptability make it a vital tree species for forestry and ecological restoration in China. In order to develop adaptive management strategies, it is essential to comprehend how climate change affects water use efficiency (WUE) and the growth of *Populus tomentosa*. Investigating WUE in *Populus tomentosa* is crucial because it helps predict the species' resilience to climate change, ensuring sustainable forest management. Additionally, it enhances our understanding of how to optimize poplar cultivation for economic purposes, particularly in the timber and paper industries.

This meta-analysis aims to synthesize existing research on how climate change and variability influence the water use efficiency of *Populus tomentosa* plantations.

In order to determine the WUE of *Populus tomentosa* under various climatic circumstances, we thoroughly reviewed and analyzed published data from peer-reviewed studies. The purpose of our selection criteria was to focused on research that included quantitative measurements of WUE, important physiological and environmental components, and comprehensive climate data (such as temperature and precipitation). We finalized and analyzed a total of 50 studies that met these criteria. To analyzed the data, we included statistical methods to determine the general trends and intensity of correlation between climatic variables and WUE.

According to our meta-analysis, we found a significant negative relationship between higher temperatures and WUE in *Populus tomentosa*, with a mean 15% decrease in WUE for every 1°C rise in temperature. Furthermore, the relationship between changes in the patterns of precipitation and use of WUE was also complex; where WUE was adversely affected by both prolonged droughts and abundant precipitation. The study highlighted genetic variations between *Populus tomentosa* clones and regional environmental factors as a major source of variability in WUE.

The findings underscore the sensitivity of *Populus tomentosa* plantations to climate change, particularly in terms of water use efficiency. These results suggest that future management practices should focus on selecting climate-resilient clones and optimizing irrigation strategies to mitigate

the adverse effects of climate change. This meta-analysis provides a comprehensive overview of current knowledge and highlights key research areas for future research to support sustainable forestry practices.

Keywords: Climate change, water use efficiency, forest, management, environmental impact, *Populus tomentosa*

Wood quality benchmarks carried out in France: 24 cultivars studied.

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ID du résumé: 55

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The diversification of poplar varieties is a major objective for the French poplar industry, in order to limit the health risks associated with the use of clonal planting material, but also to adapt poplar varieties to the diversity of French soils and climates.

Faced with the diversity of poplar varieties available on the national seedling market, the question of the quality of the wood from these varieties is regularly raised by growers, who wish to find buyers for the wood they produce, and also by poplar manufacturers, who wonder about the future raw material they will have to use.

To provide answers to these questions, the Poplar National Council, with the help of FCBA and Arts et Métiers ParisTech Cluny, has for the past 15 years pursued a regular strategy of conducting studies on the wood qualities of poplar varieties. In 2009, the "wood quality standards for poplar varieties" study assessed the wood properties of 10 varieties, and in 2013 14 varieties were tested in the "wood quality standards for new poplar varieties" study.

The principle of these reference systems is to study mature poplars (45 cm diameter at 1.30 m), with a sampling plan representative of the soil conditions encountered in France. The sample trees are harvested, grouped and ridged, and the different ridges from each tree are sent to the relevant laboratories.

The qualities studied are: physical characteristics of wood and logs, mechanical characteristics of sawn timber, drying characteristics of sawn timber, peeling and veneer characteristics, panel characteristics and kraft pulping.

The main results obtained were

- harmonized and comparable quantified results for the 24 varieties and numerous technical criteria, thanks to the identical methodologies used between the two studies and the use of 2 control varieties, I-214 and Robusta,

- identification of possible uses (structure, pallet, joinery, light packaging, plywood or LVL panels, paper) depending on the varieties,

- the identification of a significant station effect on certain wood properties, although difficult to pinpoint,

- The identification of wood properties that vary with tree height, and others that remain stable.

The constant arrival of new varieties will necessitate the creation of a third study in 2025-2026 to evaluate 10 additional varieties.

Study of the cold preservation of poplar seedlings

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ID du résumé: 56

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

In France, as a result of climate change, poplar growers are experiencing increasingly shorter planting periods: from 5 months 10 years ago to 3.5 months today. In addition, winter weather events can often considerably delay work.

What's more, locally, seedlings have already been kept in cold storage for late planting, with good results.

Faced with this situation, the French national poplar council conducted a study in 2023 on the cold storage of poplar seedlings. The aim was to determine the benefits of two cold storage systems (positive cold and negative cold) for extending the planting period.

The study consisted in carrying out 3 field trials in the 3 main poplar-growing regions of south-western, western and north-eastern France.

In this study, 3 factors were tested:

- seedling storage in 3 modes: control outdoor storage, positive cold in a cold room between0°C and 4°C, negative cold in a cold room between -4°C and 0°C.

- planting date, with 4 modalities: normal, late, very late.

- poplar varieties according to bud-break earliness, with 5 modalities: Moncalvo, I-214, Diva,Rona, Koster.

Plant condition and bud break were monitored over time.

Despite some limitations, these trials once again demonstrated the beneficial effect of cold storage of poplar seedlings when the planting date is late. It enables planting well after bud break, with minimal risk of mortality, provided that planting and maintenance are optimal.

Cold storage extends the planting period by two months compared with the usual dates. It has been found that cold storage results in a slight gain in growth in the first year.

A small difference between the two cold preservation methods was noted for the latest planting dates, with better results for negative cold.

These results will make it possible to popularize the benefits of this approach among planting companies, but also open the way to further reflections on understanding the physiology of bud-break and growth as a function of cold levels.

Trees in cooler regions are more vulnerable to thermal stress: evidence from temperate poplar plantations in Northern China during the 2022 heatwaves

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ID du résumé: 60

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Climate change is resulting in more intense and frequent heatwaves, posing a potential threat to the structure and function of forest biome. However, due to the lack of *in-situ* data, the responses of forest plantations to heatwaves and the role of growth environments and management practices in mitigating these effects remain poorly understood. To address these knowledge gaps, we took advantage of the 2022 summer heatwave to assess their impacts on 8-year-old poplar plantations in Northern China characterized by differing thermal environments (cooler vs. warmer). In the warmer region, clone B301 (*P. tomentosa* × *P. bolleana*) × (*P. tomentosa*)) plantations under different irrigation treatments were selected as the research objects. Four poplar clones were selected for this study in the cooler region, including *P.* × *euramericana* cl. 'Bofeng 3' (B3), *P.* × *euramericana* cl. 'Jing 6' (J6), and two clones of *P. nigra*, namely, 'N46' (N46) and 'N102' (N102). Stem daily radial increment and sap flow density were continuously monitored in two regions. Additionally, physiological traits, such as leaf gas exchange and water potential, were measured in the warmer region to investigate the impact of irrigation on responses to heatwaves. Our results revealed that poplar trees in the cooler region experienced more pronounced negative effects from heatwaves compared to those in the warmer region. Poplar trees exhibited strong physiological plasticity to cope with heatwave stress, with increased sap flow density observed in both regions during heatwaves, facilitating a transpiration-cooling effect for minimizing thermal damage. However, increased transpiration rate also led to stored stem water depletion and higher tree water deficit. The ability of trees to regulate internal water balance, likely dependent on their root water supply capacity, accounted for the different responses of poplar growth to heatwaves in various regions. Unexpectedly, while irrigation assisted the functioning of poplar trees in some aspects, it did not alter their overall growth and physiological performance under heatwave conditions, possibly due to their deep root systems. Overall, growth environment temperatures and physiological plasticity are crucial factors affecting the ability to withstand thermal stress, and these variations will allow trees to persist in fluctuating environments. Our findings offer valuable insights for sustainable forest management (water management, adaptation mechanisms, species distribution) under extreme climate conditions.

Combination-SRC – Optimized Cultivation Method for Poplar Plantations, Agroforestry Systems, and Pioneer Forests

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ID du résumé: 64

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Traditional poplar plantation cultivation methods, distinguished by rotation periods (mini-, midi-, maxi-rotation), are typically managed using clear-cutting practices. Short and medium rotation plantations resprout post-harvest and are harvested multiple times. Due to poor market opportunities for by-products, growers traditionally prioritized process reliability and the optimization of a main target product (e.g., saw wood, industrial wood, etc.), leading to a process optimization plateau.

The climate crisis and the growing bioeconomy will boost the demand for wood, pushing up prices for poplar wood products and bringing by-products into economic focus. Factors contributing to this megatrend in due course include the strong impact of the new mandatory EU ETS2 emissions trading system for the building sector (starting in 2027), innovative carbon-storing timber construction materials, and a rising demand for lignocellulose.

By focusing on a main product, traditional methods miss substantial additional biomass and value creation potential across all product groups. As there is a strong correlation between planting density, diameter at breast height, rotation period, and biomass production. Plantations managed with maxi-rotation fail to fully utilize the site's biomass growth potential. However, plantations managed with short and medium rotations limit the potential log diameter and thereby higher-value utilization options. The low growth rate in the first-year post-harvest is also underestimated, ignoring poplars' exponential growth potential. The Combination-SRC method specifically aims to address this problem.

The Combination-SRC method, developed by Wald21 and EU-patented (No. 3257365), harnesses untapped potentials of traditional cultivation methods by combining these methods through predefined temporally staggered harvests (thinning), simultaneously exploiting their advantages. A preferred design using a dense planting pattern (about 4,000 plants per hectare) is used, where after the first harvest, about 10 % of the trees remain as target-trees, providing the light-demanding poplar species enough space for resprouting (vs. successive thinning). Target-trees and resprouting form two growth and production layers, optimizing the area's growth potential.

The method is technically uncomplicated and cost-optimized to produce high-quality and thick logs in final target stand (e.g., 7 m × 7 m spacing). It employs classical silvicultural principles such as the ability to coppice, the exponential growth, and the "self-training effect" of trees. The projected biomass growth is 10 % – 20 % higher than mini-rotations and up to 75 % higher than maxi-rotations. The method is particularly suitable for managing poplar plantations, in agroforestry systems, and with essential elements also in pioneer forests to support natural regeneration or reforestation.

Leuke and Persephone: demonstrators of forestry innovations based on the Poplar tree

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ID du résumé: 69

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The groups Leuke and Persephone are two entities, respectively mechanical demonstrator and chemical demonstrator of forestry innovations in the sector of the Poplar tree in France. Our missions are based on the complete knowledge of the poplar tree and all its byproducts.

Originally with the activity of uncoiling, we observed a high quantity of poplar juice extracted on a daily basis from the tree and we started to show interest in this co-product. We observed a rapid change in this poplar juice when left in the open air, confirming the presence of organic matter. We studied this juice and identified a large range of molecules both beneficial and non-beneficial. We developed a process to extract this juice, removing the negative bacteria, and store it without the development of further bacteria; the resulting product is now called Poplar Water. Rich in molecules of interest, we implemented research with a couple of labs to develop two brands of products based on this Poplar Water: Poplar+ and Aquilée. Poplar+ is a brand designed for the detergent industry with products gentle for the skin, the floors and the environment. Aquilée is a brand designed for the cosmetic industry, more specifically for the skincare sector. With a large range of sugars and polyphenols, Poplar Water is a real ally to skin hydration for all skin types. These two projects are being developed by Persephone among other projects on the chemistry of the Poplar tree.

Leuke, with its activities of agroforestry and wooden packaging, has been studying the benefits of the production remnants (such as the roots, the leaves, and the heart of the tree) for animal wellbeing. Working closely with the French Federation of Equine Activities, we have developed a floor made from these remnants designed for horse maneges. With a lower level of dust and a higher level of humidity, the poplar tree offers a real alternative to the water-consuming sand used in the majority of maneges but also real security for the horse's breathing system. Furthermore, it allows more comfort for the animal, its hooves, and joints.

The Poplar tree is a real source of opportunities and, with our innovative savoir-faire, we hope to contribute to the development of the sector and the appreciation of the species. In parallel, Leuke and Persephone are working on other projects to honour the tree in collaboration with many industrial and scientific actors.

Economic Incentives in Shaping the Forest Landscape: The Case of the Lama Forest Reserve in Southern Benin

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ID du résumé: 72

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Forest protected areas (PAs) are unable to effectively monetize the conservation of ecosystem services, leading to encroachments on reserve lands and a shortfall in ecosystem service provision. In situations where revenue from natural forest conservation is insufficient, the opportunity cost of forest land for agriculture and human settlement exceeds the value derived from non-timber forest products. To address this challenge and ensure successful biodiversity conservation in forest PAs, alternative financing mechanisms must be explored to attribute value to forest reserves. The Lama Forest reserve, established in 1946 and spanning 16,250 hectares, is managed by the national wood office (SONAB). Over three decades, it lost 75% of its natural vegetation due to encroachment by immigrant farmers, particularly the Holli ethnic group from eastern Benin, who practiced agriculture on black cotton soil. Adopting a market-based management approach, the PA aimed to achieve environmental goals more cost-effectively than conventional approaches, halting shifting cultivation and resettling immigrant farmers in designated agroforestry centers. A teak plantation spanning 7,000 hectares was established from 1985 to 1995 for timber production, and participatory management was initiated, with local communities organized into forestry management associations (COGEPAF). These associations manage the teak plantation, receiving 50% of the profit margin from timber sales, while the remaining 50% goes to the SONAB administration. The teak plantation's stand value was estimated at 1,115,661 cubic meters, allowing for cost-effective management and increasing profits. Since the inception of teak plantation activities in 1985, local populations, including men and women, have been involved in nursery activities, tree planting, wildfire prevention, and by 1995, villagers became professionals in teak management and sales. After fifteen years of management, the income generated from these activities surpasses that from cash crop production in the region, highlighting the economic significance of sustainable forest management initiatives. This emphasizes the significance of making long-term investments in the management of protected areas to ensure sustainability.

New structural products based on the combination of poplar with pine and concrete

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ID du résumé: 74

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Directive (EU) 2024/1275 on the energy efficiency of buildings aims to minimize greenhouse gas emissions and energy consumption in the construction sector. This sector is responsible for 36% of the polluting emissions in the European Union, making clear the direction of society and the different political bodies towards a climate neutral sector from 2050 (European Parliament). By 2030, all new buildings must be climate neutral. Furthermore, this limit is reduced to 2028 for publicly owned building stock. Concrete is the leading material in this panorama which, being the second most used substance on Earth, needs to make room for environmentally beneficial materials such as wood.

This work presents the results of two new structural products developed in the LIFE Wood for Future project. In both cases the objective is to highlight poplar wood in the construction sector, as an alternative to the traditional use of products based poplar peeling.

The first of the products are glued laminated poplar and pine beams. Poplar is used inside the laminate, as a wood with a lower modulus of elasticity and lower density. With this, the weight of the laminated beam is reduced. Pine is used on the outside of the laminate, as a wood with a higher elastic modulus and greater density, which gives greater rigidity to the final product. This enhances the value of the wood from poplar plantations and pine forests, promoting bioeconomy of the entire territory.

The second product is mixed wood-concrete prefabricated. The product is made up of modules that can vary from 1000 to 2400 mm depending on the need for calculation and implementation. In the case of wood, laminated wood beams are used. The wood is worked mainly by tension. The connection that allows the wood-concrete forces to be adequately transmitted is executed using metal connectors optimized to achieve high rigidity and high resistance, using adhesives for adhesion with the wood. Finally, different types of concrete have been studied, differentiating between conventional and self-compacting concrete in order to reach the optimal point of mechanical performance/cost. These elements have been modeled with finite elements (FEM).

The work also presents the company created for the manufacture and marketing of these products, Iberolam Timber&Technology (University of Granada spinoff), promoted by the poplar and pine forest owners (Agrupación Marjal and (Asociación Foret) created in Andalusia, Spain, within the framework of the LIFE.

Combining tree species with different resource use strategies promotes growth in young tree mixtures

by Joel Jensen | Harald Auge | Lander Baeten | Nadia Barsoum | Jürgen Bauhus | Christel Baum | Raimundo Bermudez | Friderike Beyer | Haben Blondeel | Pedro Brancalion | Jeannine Cavender-Bares | Nico Eisenhauer | Olga Ferlian | Sebastian Fiedler | Petra Fransson | Tobias Gebauer | Carolyn Glynn | Douglas Godbold | Joannès Guillemot | Peter Hajek | Dirk Hölscher | Hervé Jactel | Holger Kreft | Simone Mereu | Céline Meredieu | Rebecca A. Montgomery | Bart Muys | Charles Nock | Bill Parker | John D. Parker | Gustavo Paterno | Michael Perring | Quentin Ponette | Catherine Potvin | Peter Reich | Agnès Robin | Michael Scherer-Lorenzen | Hernán Serrano-Leon | Rachel Standish | Artur Stefanski | Kris Verheyen | Martin Weih | Swedish University of Agricultural Sciences, Department of Crop Production Ecology, Sweden | German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Germany; Helmholtz-Centre for Environmental Research – UFZ, Department of Community Ecology, Germany | Ghent University, Department of Environment, Belgium | Forest Research, Centre for Forest Management, United Kingdom | University of Freiburg, Faculty of Environment and Natural Resources, Chair of Silviculture, Germany | University of Rostock, Department of Soil Science, Germany | University of Minnesota, Department of Forest Resources, USA | University of Freiburg, Faculty of Environment and Natural Resources, Chair of Silviculture, Germany | Ghent University, Department of Environment, Belgium | Department of Forest Sciences, "Luiz de Queiroz" College of Agriculture, University of São Paulo, Brazil | University of Minnesota, Department of Ecology, Evolution and Behavior, USA; Harvard University, Department of Organismic and Evolutionary Biology, USA | German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Germany; Leipzig University, Institute of Biology, Germany | German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Germany; Leipzig University, Institute of Biology, Germany | University of Göttingen, Department of Ecosystem Modelling, Germany | Swedish University of Agricultural Sciences, Department of Forest Mycology and Plant Pathology, Sweden | University of Freiburg, Faculty of Biology, Chair of Geobotany, Germany; Geokonzept Gesellschaft für Umweltplanungssysteme mbH, Germany | Swedish University of Agricultural Sciences, Department of Crop Production Ecology, Sweden | Mendel University, Department of Forest Protection and Wildlife Management, Czech Republic | CIRAD, UMR Eco&Sols, France | University of Freiburg, Faculty of Biology, Chair of Geobotany, Germany | University of Göttingen, Faculty of Forest Sciences and Forest Ecology, Tropical Silviculture and Forest Ecology, Germany | University of Bordeaux, INRAE, France | University of Göttingen, Faculty of Forest Sciences and Forest Ecology, Biodiversity, Macroecology & Biogeography, Germany | Consiglio Nazionale delle Ricerche, Istituto per la Bioeconomia, CNR-IBE, Italy; National Biodiversity Future Center (NBFC), Italy | University of Bordeaux, INRAE, France | University of Minnesota, Department of Forest Resources, USA | KU Leuven, Nature and Landscape, Belgium | University of Freiburg, Faculty of Biology, Chair of Geobotany, Germany; University of Alberta, Department of Renewable Resources, Canada | Ontario Ministry of Natural Resources and Forestry, Canada | Smithsonian Environmental Research Center, USA | University of Göttingen, Faculty of Forest Sciences and Forest Ecology, Biodiversity, Macroecology & Biogeography, Germany | UKCEH, Environment Centre Wales, UK; University of Western Australia, UWA Institute of Agriculture, Australia | Université catholique de Louvain, Faculty of Bioscience Engineering & Earth and Life Institute, Belgium | McGill University, Montreal, Canada and Smithsonian Tropical Research Institute, Department of Biology, Panama | University of Minnesota, Department of Forest Resources,

USA; University of Michigan, Institute for Global Change Biology, USA | CIRAD, UMR Eco&Sols, France | University of Freiburg, Faculty of Biology, Chair of Geobotany, Germany | University of Freiburg, Faculty of Environment and Natural Resources, Chair of Silviculture, Germany; University of Freiburg, Faculty of Biology, Chair of Geobotany, Germany | Murdoch University, School of Environmental and Conservation Sciences, Australia | University of Minnesota, Department of Forest Resources, USA | Ghent University,

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ID du résumé: 75

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Mixed species forests are increasingly promoted and used to develop resilient and adapted forests in the face of global environmental change. Multiple studies have demonstrated that they tend to be more productive, resilient to stress and disturbances, and provide a wider range of ecosystem services compared to mono-specific forests. However, these results are highly variable and context-dependent, while the underlying mechanisms remain unclear. Increased functional and/or structural heterogeneity in mixed forests may improve the availability and use of resources by tree communities, contributing to explanations of synergistic effects of tree diversity on stand productivity. In this study, data from 23 tree diversity experiments across five continents revealed a positive curvilinear relationship between tree diversity and stand-level growth. Structural-equation modeling showed that both structural and functional diversity were positively influenced by species richness. Functional, but not structural diversity, acted as a positive pathway between species richness and stand productivity. This indicated that stand productivity is promoted in functionally dissimilar mixtures. Additionally, more acquisitive (fast growing) species, characterized by higher leaf nitrogen content and lower wood density, performed better in species mixtures, while more conservative species showed a neutral relationship with species richness, showing their productivity neither benefit from nor are negatively impacted by diverse neighbors. Our findings suggest that tree diversity promotes stand productivity, partly explained by the presence of dissimilar resource use strategies. In addition, we show that acquisitive species thrive in mixed stands without negatively affecting the productivity of more conservative species, highlighting the benefits of combining functionally different tree species in mixed forest stands.

Using X-ray CT to assess the potential service life of poplar-CLT

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ID du résumé: 76

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Hybrid poplar is the most common plantation hardwood in the temperate climate zone, and poplar wood is increasingly considered a valid alternative to softwoods for many construction applications, particularly engineered wood products (EWPs). However, the natural durability of hybrid poplar is low, and enhancing its decay resistance is crucial for improved performance. Thermal modification of poplar e.g., for cladding is becoming a standard product in the European market.

The growing potential of Cross-Laminated Timber (CLT) alongside glulam has spurred numerous studies and industrial trials exploring the use of poplar as a complementary material to softwoods. The properties of hybrid poplar, particularly its moisture dynamics, can be beneficial for construction products and support a bio-based circular economy in line with sustainability development goals.

Evaluating the biological durability of poplar CLT is essential alongside considerations of mechanical strength and fire safety, especially for its application as an engineered wood product in construction. Assessing moisture intrusion impacts on poplar CLT durability remains challenging, particularly its susceptibility to fungal attack and implications for service life prediction. Our study contributes to this knowledge by visualizing the degradation process of 3-layer poplar CLT samples using X-ray Computed Tomography (Xray CT), capturing intricate degradation patterns. Results indicate that sealing can enhance CLT durability by inhibiting fungal penetration, especially in the middle layer. The layer closest to the fungal source experienced the highest degradation and mass loss. However, the glue line's presence impeded fungal mycelium from reaching the middle layer, resulting in insignificant mass loss when the sides were sealed. Our findings underscore the complexity of evaluating poplar CLT's service life, highlighting the importance of innovative methods like X-ray CT for comprehensively monitoring degradation processes within wood structures. This approach is essential for understanding and improving the durability of poplar CLT, supporting its use in sustainable constructions.

Plywood production based on trees outside forest and the potential of agroforestry in Europe

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ID du résumé: 83

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Rotary veneer production for the production of fruit and vegetable boxes and especially for plywood production is the most important transformation of trees from planted forests in Europe based on fast-growing hybrid poplars (*Populus* spp.).

Besides plantations also trees outside forest are part of the resources used. Such trees are on farms, in orchards and small tree plantations, in cities, along roads and in parks and across other non-forest landscapes. Trees outside forest (TOF) are defined by FAO as all trees and shrubs that cannot be included in the "Forest" nor in the "Other Wooded Lands" categories of FAO forest classification. All trees encountered on agricultural or urban lands, regardless of tree cover extension, are therefore TOF. They can be found in homegardens, along roads and streams, in agroforestry systems, in small woodlands, along hedges, in fallows.

The hybrid poplar (*Populus x canadensis*) is widely recognized as one of the best trees for the establishment of agroforestry systems in temperate zones thanks to its rapid growth, short harvesting cycles and the existence of industrial demand for its wood for the plywood industry. As a result, the poplar plywood industry mainly located in Spain, Italy and France is a reference at European and world level for the quality of its products and its marked export character.

Both hybrid poplar originating from agroforestry and other TOF systems as well as trees that are linked to the edges of a poplar plantations grow in an altered environment compared to those coming form the inner part of poplar stand merely by the fact they are not surrounded by trees. Impact on tree quality and wood properties are of concern with probably worse suitability for peeling but also impacted by general growing parameters like planting distance, pattern, rotation... Critical tree and wood quality parameters can be tree shape like slope, branchiness, growth stresses, tension wood distribution and other related wood defects in poplar.

On the other hand, because of the limited availability of poplar in the EU vs the consumption needs this could be an interesting opportunity for increasing the area of poplars in the EU. Besides the potential for extra resources the cultivation of hybrid poplars is also very good from the point of view of carbon capture and can contribute to many aspects dealing with the increased impact of the bioeconomy, e.g. green building.

Poplar Short-Rotation Coppice Systems: Integrating Climate Sensitive Models and Economic Analysis for a Low-Carbon Bioeconomy.

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ID du résumé: 85

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Poplar plantations, managed at high density and short rotations, achieve high productivity in a short period, which is crucial for biomass production and short- to medium-term carbon sequestration, contributing to a low carbon bioeconomy. However, the productivity and profitability of these plantations are challenged by the impacts of climate change, making accurate estimation of productivity and profitability difficult. Climate-sensitive forest growth models can be used to calculate future estimates of biomass yield under changing environmental conditions. Moreover, integrating profitability assessment tools, considering the multifunctionality of these plantations, is essential for decision-makers.

In this regard, the present study aims to present an adapted version of 3-PG model (Physiological Principles Predicting Growth) for poplar SRC systems. This adaptation involves determining species-specific parameters for the genotype 'AF2' (*Populus* × *canadensis* Mönch) primarily from observed data and adjusting the model architecture accordingly. Economic analysis, applying 5% discount rate and considering both biomass and carbon (C) revenue, is also addressed. We simulated biomass growth and C stocks of poplar plantations in Spain over a complete plantation cycle of 12 years (4 rotations 3 years each) for two productivity scenarios. The simulations were conducted in an area where prior observed information was available to validate the obtained data. Profitability is estimate based on an economic analysis based on real data under Mediterranean conditions, which require irrigation systems.

After a 12-year production simulation using the model, our two productivity scenarios resulting in average productivities of 15.8 and 23.7 Mg ha^{-1} yr^{-1}, respectively. The Net Present Value (NPV) was -1979, and 3482 € ha^{-1} when only the above-ground biomass production was considered as revenue (dry

chip biomass = 90 € ha-1). This highlights the importance of good management and appropriate site selection. Including other ecosystem services, such as carbon sequestration (10 € ha-1) from the whole tree (above and below ground carbon stocks), increases the final NPV to more attractive values of -1154 and 4787 € ha^{-1} for our sites.

This understanding provides a broad knowledge base for the development of more accurate predictive management tools, aimed at promoting the establishment of poplar SRC systems, optimizing biomass production and meeting market demands in the transition to a low carbon bioeconomy.

Envirocrops - the digital consultant

by Mr Kevin Lindegaard | Crops for Energy

ID du résumé: 88

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Envirocrops.com is the digital consultant for biomass crops. The data driven web-app compares the suitability of planting Short Rotation Coppice (SRC) willow, Short Rotation Forestry (SRF) poplar and Eucalyptus, and energy grasses such as Miscanthus throughout the UK. Suitability is based on local yield data and climatic conditions, allowing for an online field-specific feasibility study to be carried out by farmers, land managers, consultants, and academics. Envirocrops aims to de-risk the planting of long-living perennial biomass crops.

Over 20 years, leading biomass crop consultancy and project collaborator Crops for Energy (C4E) has produced hundreds of feasibility studies and created many dissemination tools. Additionally, collaborators, the Agri-Food and Bioscience Institute (AFBI), has been researching biomass crop, genetics, agronomy, and on-farm deployment for the past 30 years. Envirocrops encompasses all this knowledge allowing users to be guided by the app to create an easily digestible consultant's report. However, whereas a report is relevant on the day of publication, users of the Envirocrops web app will be able to return to the information as and when circumstances change e.g. markets evolve, prices increase, incentives are made available, world events unfold etc. If humanity is to combat climate change and move towards net zero then farmers, policy makers, academics and students will need tools like Envirocrops to help growers understand the economics, logistics and best practice cultivation techniques for biomass crops.

Envirocrops enables users to:

- Identify biomass crop types and varieties suited for your land and needs
- Estimate land required for desired yields and end use
- Determine production timescales and costsAccess up to date best practice guidelines establishment and management of different biomass crops
- Find local contractors and markets
- Calculate overall economic potential and identify logistical issues Estimate carbon savings and valorisation.

This project is funded by the UK Department of Energy Security and Net Zero and is nearing the end of its 3-year development phase. The project is led by the Agri-Food and Biosciences Institute together with Crops for Energy, Calvium and NFU Energy. Envirocrops is not limited to the UK - the project is seeking interested parties in other regions so the tool can be modified and made relevant for growers and users worldwide.

Diameter growth models and performance of 100 tropical tree species of America, Africa, Asia and Australia in silvicultural trials in Brazil

by Daniel Piotto | Samir G. Rolim | Universidade Federal do Sul da Bahia | Universidade Federal do Sul da Bahia

ID du résumé: 90

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Projects of reforestation for sustainable production of tropical timber and for nature-based solutions must be based on reliable growth models. However, there is still a big gap in knowledge about the growth in diameter for native and exotic tropical timber species. In this study, we used diameter growth data from 100 tropical tree species in silvicultural experiments established from the late 1970s to the early 1990s in the north of Espírito Santo state, Brazil. Plantations were periodically measured, usually over 20 to 30 years, which allowed us to produce growth models for all species and recommend those that can help boost silviculture in Brazil. We also used the data to test a large set of tree species against the same set of models, to assess model's performance. Among 71 native species studied, 31% showed slow growth (Mean Annual Increment - MAI < 0.70 cm/yr), 40% medium growth (0.70≤ MAI < 0.97 cm/yr) and 29% high growth (MAI ≥ 0.97 cm/yr), while 47% of the 30 exotic species showed high growth rates. Within the native species with a high growth rate and consolidated market value, the following stand out: *Astronium urundeuva, Bertholletia excelsa, Cariniana legalis, Dalbergia nigra, Hevea brasiliensis, Hymenaea courbaril, Ochroma pyramidale,* and *Swietenia macrophylla*. Among the native species with medium growth rate and consolidated market value, the following stand out: *Amburana cearensis, Astronium graveolens, Bowdichia virgilioides, Centrolobium tomentosum, Lecythis pisonis,* and *Paubrasilia echinata*. Species' most valuable on the wood market, such as *Swietenia macrophylla, Dalbergia nigra,* and *Hymenaea courbaril* have great potential to be included in large scale silvicultural projects in Brazil. Regarding the 29 exotic species, many of them (48%) also showed high growth rates. The species with best growth and consolidated market value were *Khaya senegalensis, Araucaria cunnighamiana, Terminalia ivorensis, Khaya ivorensis, Eucalyptus urophylla*, and *Pinus caribeae*. However, some high-value timber species did not perform well locally, such as *Swietenia mahogany* and *Dalbergia retusa*. Based on our analysis, we recommend the use of Korf, Levakovik II, Hossfeld IV, and Levakovic III models for growth studies, because they showed a better fit for most species or because they were plausible competitor models. Even though many species have shown a great performance for silvicultural projects, more experimental trials must be established in

different site and management conditions, to fully explore the silvicultural potential of these tropical timber species.

Species interactions dynamics in poplar forestry and agroforestry systems: from water and nitrogen use efficiencies to tree productivity.

by Anaïs THOMAS | Abdoulaye NDIAYE | Erwin DALLE | Nicolas MARRON | UMR Silva, Université de Lorraine, AgroParisTech, INRAE, 54000 Nancy, France | UMR Silva, Université de Lorraine, AgroParisTech, INRAE, 54000 Nancy, France | UMR Silva, Université de Lorraine, AgroParisTech, INRAE, 54000 Nancy, France | UMR Silva, Université de Lorraine, AgroParisTech, INRAE, 54000 Nancy, France

ID du résumé: 93

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

In recent years, plantations of fast-growing tree species have emerged as a possible way to meet the increasing demand for biomass for renewable energy in Europe. Agroforestry and mixed forest plantations including fast-growing tree species could be an attractive option for maintaining high productivity while optimizing the sustainable use of nutrient and water resources. Our objective was to assess the performance of poplar trees (*Populus deltoides ´ P. nigra, Dorskamp clone*) when associated with a N_2-fixing-species either herbaceous (succession alfalfa and clover; agroforestry) or woody (alder, forest mixture) compared to poplars in monoculture in an experimental plantation set up in 2014 in northeastern France.

Annual poplar aboveground biomass production was monitored from tree to plantation levels over nine growing seasons. During the early stages, interspecific competition between crops and poplars predominated. A facilitation process in the agroforestry treatment, due to soil nitrogen enrichment by the N_2-fixing crops, led to higher aboveground biomass production at tree level in agroforestry poplars than in the forest mixture and the monoculture from the 6^{th} growing season. Poplar grown in mixture with alder exhibited similar growth dynamic to poplar in monoculture. The aboveground yield at plantation scale was similar for the three investigated treatments although tree density was halved in the agroforestry system.

Tree productivity is closely related to **water and nitrogen-use efficiencies,** i.e. the quantity of biomass produced per unit of water or nitrogen used (WUE and NUE respectively). Poplar trees in both mixture types showed higher WUE than those in monoculture during the seventh growing season. The more WUE was integrated in time (leaf < wood < tree), the more the differences among treatments were marked. In addition, at tree level, poplar NUE was significantly higher in the forest mixture than in the agroforestry and monoculture systems, due to a decrease in litter production and a decrease in litter nitrogen concentrations in the forest mixture.

The higher biomass production and lower water consumption occurring when poplar is associated with a N_2-fixing crop make such mixtures promising in a context where water could become a limiting resource. Our results also underline the importance of litter management practices and crop rotation strategies to promote soil nutrient restoration and maximize poplar productivity. Understanding the determinants of poplar productivity, NUE and WUE in different systems is indeed of practical importance for land managers to devise strategies to optimize resource use and improve agricultural sustainability.

Simulating water dynamics and wood production in Eucalyptus plantations with a process-based model

by Guerric le Maire | Ivan Cornut | Joannès Guillemot | Yann Nouvellon | Otavio Campoe | José-Luiz Stape | Jean-Paul Laclau | Nicolas Delpierre | CIRAD, UMR Eco&Sols, Montpellier, France | CIRAD, UMR Eco&Sols, Montpellier, France | CIRAD, UMR Eco&Sols, Montpellier, France | CIRAD, UMR Eco&Sols, Montpellier, France | Federal University of Lavras – UFLA, Lavras, Brazil | Forest Science, Sao Paulo State University - UNESP, Botucatu, Brazil | CIRAD, UMR Eco&Sols, Montpellier, France | Université Paris Saclay, UMR ESE, Saclay, France

ID du résumé: 96

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Water availability is crucial for the growth of Eucalyptus plantations, particularly in tropical and subtropical regions where drought frequency and intensity are expected to increase due to climate change. The susceptibility of fast-growing tropical plantations to drought and rainfall variability necessitates new management strategies to limit water use and to enhance drought tolerance. These strategies include selecting drought-tolerant species, reducing stocking densities, shortening rotation lengths, promoting soil water recharge by extending the period between harvesting and replanting, prioritizing afforestation on deep soils, and limiting water use through reduced fertilizer applications. Deep soil water storage is essential for tree survival and growth, making effective water resource management critical for the sustainability of these plantations. To address this need, we developed CASTANEA-MAESPA, a novel ecophysiological process-based model that simulates interactions between plantation growth, soil water dynamics, and water-table balance over multiple rotations. The model was parameterized and validated using 12 years of time-series data on soil water content, water-table levels, and evapotranspiration from eddy covariance measurements. Additionally, it was tested for its ability to predict changes in wood production under a 33% rainfall exclusion experiment. Results demonstrate that the model accurately represents soil water flows and water table dynamics. It captures the initial rise in water table at the start of the rotation followed by its continuous decrease over time. The model successfully simulates biomass production decreases due to reduced rainfall, consistent with observed data. Simulations under various climate and management scenarios revealed the long-term effects of reduced rainfall on water table height and its recovery during the inter-planting period. In conclusion, CASTANEA-MAESPA provides a robust tool for evaluating the sustainability of Eucalyptus plantations under different climatic and management scenarios. By integrating detailed ecophysiological processes, it supports informed decision-making regarding water resource management.

The wood of poplars – Research at the University of Sopron

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ID du résumé: 122

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Recognising the problems and opportunities identified by our predecessors, the University of Sopron has been conducting research on low-density hardwood species, mainly poplar, for several decades. As a result, books, doctoral theses and numerous articles have been published and are still being published. Our current major focus is on mapping the properties, modification potential and possible new uses of grey poplars from different quality sites and forests. In the last decade, mostly the quality of the wood of the noble poplars were investigated, but as the most important poplar species in Hungary (42%; 76 282 ha), grey poplar also needs to be addressed. Knowing the characteristics of the growing sites will give an indication of the primary uses from which timber can be produced. Some wood modifications can improve important properties and climate change is expected to increase the demand for hardwoods at the expense of softwoods. It is thus important to find ways to make universal use of poplar, which is found in large quantities in Europe (more than 1 million hectares). This paper gives a brief overview of some results published by researchers at the University of Sopron over the last decade to raise awareness. Research in recent years has shown that substantially different clones generally produce mature wood from the age of 16-17. This is important information to foresters to produce wood for the timber industry. A mathematical method has been developed to determine the juvenile age. The juvenile wood of the best clones (Durvakérgű, Pannónia, Koltay) has a bending strength close to that of mature wood (80 MPa) as well as a modulus of elasticity (8.7 GPa). Compared to the Scots pine, poplar has 25% lower lateral screw withdrawal resistance, while its lateral nail withdrawal resistance is about half. From the point of view of energetical use, it is important to note that the ash content of their wood is 1.15 - 2.31%, while that of the bark is 4.41 - 6.92%. In agroforestry, poplar trees increase the nitrogen content of the soil, helping to grow crops, as well as able to provide high quality sawlogs. In addition to these selected information, more will be available in the paper.

The establishment of poplar plantations in the Nordic-Baltic region using five different types of planting material

by Anneli Adler | Mindaugas Silininkas | Almir Karacic | Dr. | Dr.

ID du résumé: 133

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The Large-scale poplar cultivation have a potential to improve the industrial wood fiber supply in the Nordic-Baltic region. The key issue is plantation establishment, which depends on site conditions, the availability of fast-growing and climate-adapted clones, site preparation and management, and the quality of planting material. In this study, we evaluated five different types of planting material using the climate-adapted clones of *Populus trichocarpa* planted on different soils in Sweden, Lithuania and Estonia. The soils represented a range of conditions from very suitable light-textured soils to the soils with limiting growth and establishment conditions such as dry sand soils, heavy clay and soil with a deep organic layer. Four to ten years after establishment the survival was generally high on almost all sites and for all the types of plant material. The exception was a deep peat soil in central Sweden, where survival initially was extremely low leading eventually to a complete failure of establishment. The survival was lowest for short cuttings (30 cm length) whereas longer cuttings (80 cm), 2-year-old poles (180-200 cm), and two different types of rooted cuttings (bare root and containerized plants) had almost equally high survival. The advantage of planting poles was mostly reflected in early growth on more productive soils and a generally better diameter development. However, almost equal results were achieved with rooted cuttings (plants). Our results indicate that rooted cuttings (both bare-root and containerized plants) are the optimal planting material for deploying new climate-adapted clones through commercial nurseries in the Nordic-Baltic region. This type of planting material offers several advantages, including lower production costs, easier transport and handling, improved weed control, reduced susceptibility to game and frost damage, and greater flexibility in planting timing. However, all five tested types of planting material are viable, although short cuttings require intensive weed management both before and after planting.

PappelWERT: Storage chambers to understand dry matter losses in wood chips from Poplar during storage

by Ralf Pecenka | Albert Hernandez-Estrada | Gabriele Joanna Kowalski | Leibniz Institute for Agricultural Engineering and Bioeconomy | Leibniz Institute for Agricultural Engineering and Bioeconomy | Leibniz Institute for Agricultural Engineering and Bioeconomy

ID du résumé: 134

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

PappelWERT is a German project on value chains based on poplar cultivation in agroforestry systems. Agroforestry systems (AFS) allow climate-adapted agriculture and provide raw material for different value chains from energy production to building. Depending on the value chain, different wood properties are desired: wood chips for energy production and tree trunks for building. Additionally, the wood must be dry (low moisture content=MC) with minimal dry matter loss (DML). PappelWERT investigates and improves techniques for processing harvested poplar to demonstrate best-practice AFS for the production of poplar wood for material and energy value chains that fulfil the requirements of the wood industry in terms of material properties, quality and costs.

In PappelWERT we will continue working with storage chambers as done in our recent study: A laboratory scale storage chamber was developed and investigated regarding its ability to recreate the conditions that chips are exposed to during the initial phase of outdoor storage. The storage chamber, with controlled conditions like ambient moisture and temperature, allows decoding the process of DML that wood chips undergo during initial phase of storage in outdoor piles. Three trials with poplar Max-4 (Populus maximowiczii Henry × Populus nigra L.) chips were performed for 6–10 weeks in the storage chamber under controlled temperature and assisted humidity. To recreate the ambient humidity of outdoor piles two different setups were tested: one using water containers and one assisted with a humidifier. At different storage times the MC and DML of wood chips were measured, including microbiological analyses of the culturable fraction of saproxylic microbiota, focussing on: mesophilic fungi, xerophilic fungi, mesophilic bacteria (with special attention on actinobacteria). Looking at MC, DML and saproxylic microbiota will provide a good understanding on storage processes poplar and other tree species undergo after harvest and during storage. This experiment showed that DML up to 8.8–13.7% occurred in the chips within 6–10 storage weeks. The maximum DML were reached in the trial using the humidifier, which seemed a suitable technique to keep a high relative humidity in the testing chamber, and thus, to analyse the wood chips in conditions comparable to those in outdoor piles during the initial storage phase. Our findings allow recreating environmental conditions on lab scale,

enhancing the understanding of wood decay processes. In PappelWERT, the gained knowledge will foster the development of storage methods with reduced DML, enabling poplar wood to meet industry requirements.

Studying the collection and use of tree bark as a non-timber forest product in the Federal Capital Territory of Nigeria

by Michael Adedotun Oke | Michael Adedotun Oke Foundation

ID du résumé: 135
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-PRO - Production Systems for the Bioeconomy

It is conceivable that animals that remove and eat bark are doing so to add essential nutrients, such trace elements and other minerals, to their diet. (Nichols et al., 2016; Welch et al., 1987; Camperio Ciani et al., 2001). Usually, this is thought to be salt, according to Au et al. (2018). We found that a portion of the Australian population, consumes the only food source in their sub-alpine zone, the bark of eucalyptus trees, which has rather high sodium content. A few other species eat bark; however they only eat the bark that is on the outside. Among them is the small Indonesian squirrel. (Whitten and Whitten 1987). However, it is unclear what they stand to gain from this. Through field observation and pictorial representation, we were able to gather evidence that some residents of Gwagwalada, the Federal Capital Territory's area council, remove a portion of a tree's bark. They also carefully choose the kind of tree to cut and the method of cutting, but they don't cut all the way through to the cambium underneath. Additionally, the study noted the various demographic trees and the removal of bark from some forests and communities in the Federal Capital Territory, including (1) partial debarking of stems, (2) ring-barking trees, and (3) felling trees at a height of approximately one meter above ground level. These practices have an effect on the asymptotic population growth rates. We found that various harvesting techniques, which entailed underutilized and unharnessed labour, had resulted in the removal of more than half the trees in an open forest where people lived and enjoyed themselves. Bark removal, which typically occurs almost entirely around the stem, results in high death rates; yet, some trees are able to flourish in spite of this. The bark of the trees is being used for application in therapy, medicine and other health advantages. These applications raise concerns regarding the value of the bark, the drawbacks of tree cutting, whether it is harms the trees, the recording of the effects on people and the economy and the devastation of the trees.

Keywords: Federal Capital Territory, harvest, population, bark

Reinventing the poplar forestry wood chain in the Low Countries: vision and mission of Peppelhout

by Job Wittens | Joris Van Acker | Peppelhout | Ghent University - Woodlab

ID du résumé: 138

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The company Peppelhout, founded in 2018, emerged from a collective passion for sustainable forestry and a commitment to revitalizing the Dutch poplar-landscape. Peppelhout aims to reintroduce and promote the cultivation of Dutch poplar trees, leveraging their fast growth and ecological benefits. The company's ambition is not only to supply high-quality timber but also to enhance biodiversity, improve soil health, and contribute to carbon sequestration. The name "Peppelhout" reflects the regional Dutch term "peppel", historically used to refer to poplar trees, symbolizing the company's roots in rediscovering poplar wood as a valuable resource (mainly for the production of wooden shoes and matches).

Peppelhout's value proposition centers on providing sustainably sourced poplar wood to the building and interior sectors, focusing specifically on the production of decorative wooden products. These include ceilings, roof decking, walls, floors and cladding. The focus is not on structural construction components (such as beams). The company prides itself on a transparent supply chain, ensuring that every piece of wood is traceable from the moment the tree is planted until the final product reaches the customer. By focusing on poplars, which are known for their rapid growth and adaptability, Peppelhout ensures a continuous and reliable supply of timber that meets the highest environmental standards.

A key component of Peppelhout's strategy is the implementation of a short supply chain, minimizing the distance between the source of the raw material and the end consumer. This approach not only reduces carbon emissions associated with transportation but also supports local economies by providing jobs and fostering community involvement in sustainable forestry practices. Peppelhout collaborates with local farmers, landowners, and craftsmen, creating a network that benefits all stakeholders and ensures the longevity and sustainability of the supply chain.

Peppelhout's mission extends beyond commercial interests, aiming to plant more poplar trees and align with the growing trend of agroforestry. Agroforestry, which integrates trees and shrubs into agricultural landscapes, offers numerous benefits, including enhanced biodiversity, improved water

management, and increased resilience to climate change. By advocating for the integration of poplars into farming systems, Peppelhout supports sustainable land use practices that benefit both the environment and agricultural productivity.

The company is dedicated to raising awareness about the advantages of poplar trees and actively participates in initiatives to plant more trees.

In summary, Peppelhout combines a strong environmental ethos with innovative business practices to promote the sustainable cultivation and use of poplar wood.

POSTER

WHICH PESTICIDES ARE USED IN NURSERY PRODUCTION OF POPLAR SEEDLINGS?

by Verica Vasic | Milutin Djilas | Leopold Poljakovic Pajnik | Sreten Vasic | Lazar Kesic | Sasa Orlovic | Zoran Novcic | University of Novi Sad, Institute of Lowland Forestry and Environment | University of Novi Sad, Institute of Lowland Forestry and Environment | University of Novi Sad, Institute of Lowland Forestry and Environment | University of Novi Sad, Institute of Lowland Forestry and Environment | University of Novi Sad, Institute of Lowland Forestry and Environment | University of Novi Sad, Institute of Lowland Forestry and Environment | University of Novi Sad, Institute of Lowland Forestry and Environment

ID du résumé: 6

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Different pests are known to attack poplar seedlings resulting in significant losses in nurseries. Integrated pest management (IPM) is the most practical and ecologically sound approach for control of nursery pests using all available control methods. However, chemical control is the most widely known method and represent integral component of IPM.

The most common harmful insects that appear in poplar nurseries in Serbia are *Paranthrene tabaniformis, Chrysomela populi, Phyllodecta vitellinae, Byctiscus betulae, Byctiscus populi*, and *Cryptorrhynchus lapathi*. These pests can be effectively treated with insecticides like deltametrin, acetamiprid, chlorantraniliprole, and thiametoxam. For sucking insects like aphids and cicadas, deltamethrin, acetamiprid, malathion, and cyantraniliprole are suitable insecticides.

The most prevalent diseases on poplar leaves are poplar black spot disease (*Marssonina brunnea*) and poplar leaf rusts (*Melampsora* spp.). Copper fungicides can protect seedlings from *M. brunnea* infection, while the systemic fungicide azoxistrobin prevents the disease from spreading. Fungicides like tebuconazole, fluxapyroxad, and difenconazole can effectively control poplar leaf rust.

In addition to insects and diseases, a great problem in poplar nursery production are weeds. Pre-emergence herbicides like pendimethalin, dimethenamid, S-metolachlor, and metribuzin can be used for weeds control. Grass weeds can be suppressed with selective herbicides like fluazifop-P-butyl, cycloxydim, and propaquizafop.

However, forest managers should be using pesticides only in combination with other IPM measures or in situations where other IPM methods have not failed to produce satisfactory results.

Growth performance of Populus deltoides under High-density Plantation in North India

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ID du résumé: 9

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The experiment was conducted during year 2021-23 for the observation of growth performance of *Populus deltoides* under high-density plantation in three spacing *viz.,* 1m×1m, 1.2m×1.2m and 1.5m×1.5m. The experiment was located 25.45°N 81.84°E, at an elevation of 98 metres (322 feet) at Prayagraj in north India. The experiment was established in July 2021 and height and girth data was recorded in June 2022 and June 2023. The result indicated that the maximum height was recorded in year 2022 and year 2023 in Poplar (1.2m×1.2m) 3.53 m and 6.52 m followed by Poplar (1m×1m) 3.19 m and

5.94 m, respectively. The height increment was recorded in first year in Poplar (1.2m×1.2m) 1.59 m followed by Poplar (1m×1m) 1.24 m whereas in second year the maximum height increment was recorded in Poplar (1.2m×1.2m) 2.98 m followed by Poplar (1.5m×1.5m) 2.84 m. The maximum GBH was recorded in year 2022 in Poplar (1.2m×1.2m) 6.91 cm followed by Poplar (1m×1m) 5.91 cm whereas in year 2023 the GBH was recorded in Poplar (1.2m×1.2m) 13.87 cm followed by Poplar (1.5m×1.5m) 11.35 cm. The GBH increment was recorded in first year in Poplar (1.2m×1.2m) 6.96 cm followed by Poplar (1m×1m) 2.67 cm whereas in second year the maximum height increment was recorded in Poplar (1.2m×1.2m) 6.96 cm followed by Poplar (1.5m×1.5m) 5.78 cm. The result indicated that the Poplar (1.2m×1.2m) spacing performed best among other three spacing. Therefore, this spacing is recommended for plantation of Poplar at Prayagraj in North India.

Key words: Growth, Height, GBH, Increment, High-density Plantation

Poplar technological wood properties in the supply chain from tree-log-veneer and final product

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ID du résumé: 18

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Poplar is one of the most planted forest species in Spain. The most important technical products manufactured with this wood in Spain are plywood and Laminated strand lumber. However, currently there is a lot of variability and heterogeneity of poplar wood that enters the industry, probably due fundamentally to the 5 clones that are cut and the environmental variability of its origin. The final industry sees both the performance and quality of the raw material altered, making the homogeneity of the technological quality of its product very difficult. In this work, the technological properties of wood in the supply chain will be evaluated with sonic methods, core extraction and near infrared spectroscopy, maintaining traceability from tree-log-veneer and final product. The results demonstrate that the impact wave displacement speed measured on the tree correlates significantly with those obtained on the logs at different heights and with the sound velocity obtained on the veneer. These results, together with the density values, determine the final quality of the product. Physical-mechanical properties such as the modulus of elasticity and the density of the wood are essential to optimize the rigidity of the fiber and optimize the mechanical behavior of the final product and its suitability for use in different products. It is observed that the technological properties increase in height in the shaft, being of great interest for obtaining products with greater resistance.

Production potential of various wheat varieties and soil nutrient status under poplar based agroforestry system in Indo-gangetic plains of northern India

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ID du résumé: 19

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The present study was carried out in an already established 7 and 8 years of age of poplar boundary plantation in East-West and North-South directions at research farm of Department of Forestry, CCS Haryana Agricultural University, Hisar, Haryana. In this study, all five wheat varieties (WH-1105, WH-542, HD-2967, HD-943 and DPW-621-50) when compared for their yield under boundary plantation of *Populus deltoides* were found producing lower crop yield in comparison to sole crop (devoid of tree), however variety HD-2967 had significantly higher yield as compared to other varieties. This variety was observed as shade tolerant and showed maximum test weight, grain and straw yield at all the distances (2 m, 4 m, 6 m, 8 m and 10 m) from tree line followed by variety WH-542 and DPW-621-50 in both consecutive years. In all the wheat varieties, the yield reduction was maximum in east-west direction as compared to north-south direction of poplar boundary plantation. The highest per cent decrease in grain yield over control was recorded in wheat variety WH-1105 (90%) in northern aspect near the tree line (0-2 m) and it followed the order: HD-943 (82.0%) > WH 542 (74.4%) > DPW-621-50 (71.4%) > HD-2967 (65.1%) during 2013-14. However, under control the maximum grain yield (5.00 and 4.70 t/ha) was observed in wheat variety WH-1105 followed by WH-542 (4.70 and 4.30 t/ha) during both the years. In different row directions of poplar, the availability of macro-nutrients (N, P and K) and organic carbon were determined at different distances (2 m, 4 m, 6 m, 8 m and 10 m) from poplar tree line at surface soil (0-15 cm depths). The organic carbon was (0.74%) found significantly higher up to 2 m distance from poplar tree line with the advancement of tree age. The available N was significantly higher (365.6, 355.4 and 348.5 kg ha^{-1}) in southern aspect up to a distance of 6 m from tree line closely followed by western aspect after harvesting of wheat crop. The available phosphorus and potassium were also significantly influenced by row directions of bund planted poplar as in organic carbon and available nitrogen. Under this study, the overall growth pattern of bund planted poplar generally followed a rising trend with age. After 8 years of plantation, the height was found significantly higher (21.3 m) in North-South direction than from East-West direction (20.2 m).

Characterization of intra-annual diameter increment in poplar plantations in the Duero Basin (Spain)

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ID du résumé: 21

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Characterization and explaining the intra-annual diameter stem growth dynamic in poplar plantations is important to fine tune the diameter growth projections made at annual level. Additionally, they could help for understanding how poplar plantations can respond to climate change. However, such intra-annual variations are not well studied to date. The aims of the work were: (i) to characterize the intra-annual pattern of diameter growth and (ii) to explore the weather variables that can explain this pattern.

We studied the diameter growth of 80 trees of 4 poplar clones ('I-214', 'AF8', 'Beaupre' and 'Raspalje') at 3 sites across the Duero Basin (Spain) over 3 years (2021, 2022 and 2023). The sites were in 3 plantations at the locations of Turcia (847 m a.s.l.; planted in 2014), Villoria de Órbigo (817 m a.s.l.; planted in 2012), and Villasabariego (850 m a.s.l.; planted in 2015). From May 2021 onwards, diameter at breast height growth was recorded via permanent measuring tapes marked with Vernier scales of 0.1 mm resolution (Type D1 Permanent Tree Girth, UMS, Germany) (Fig. 1). The girth tapes were examined weekly from April to October (with some variations depending on the year). Open access weather data (Inforiego network; www.inforiego.org/) from the weather stations of Hospital de Órbigo (Turcia and Villoria sites) and Mansilla La Mayor (Villasabariego site) were used to relate diameter growth with meteorological variables.

Results showed that onset and cessation of growth occurred about the middle of April (DoY = 100) and the middle of September (DoY=260), respectively (Fig. 3). Diameter growth onset take place soon after bud break, when leaves are unfolded. This could explain the later onset growth observed for clone AF8, which has the delayed bud breaking. The growth cessation occurs long before the leaves fall. Diameter increments for the 4 clones showed a unimodal pattern, with the highest growth rate usually occurring between DoY 150 and 225 (i.e., since the beginning of June to the middle of August) (Fig. 3). Correlation analysis showed that diameter increments are highly and positively correlated with solar radiation and the insolation hours for the 4 clones (r= 0.65-0.76) (Fig. 4). On the other hand, as was

expected *a priori*, precipitation and relative humidity were poorly correlated. These findings emphasize the importance of the daylength as environmental factor for explaining the intraannual diameter growth pattern.

How accurate are mobile laser scanners to estimate tree attributes in commercial poplar plantations? Comparisons between sensors (Geoslam, Navvis) and measuring patterns.

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ID du résumé: 26

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

In this work, the suitability of two Mobile Laser Scanner (MLS) was tested to estimate tree attributes in *Populus* x spp plantations. Two approaches were tested: using MLS (i) as a "digital caliper" (the aim was to gather only diameters at breast height -DBH) and (ii) to create a "digital twin" of each tree to estimate its merchantable volume (*V*, i.e., tree volume up to a 20 cm diameter, the minimum required for our partner plywood company).

The work was performed in a 16-year-old I-214 clone plantation located in La Aldea del Puente (León, Spain) which had 225 poplar trees. The plantation was measured on September 15th 2023 under leaf-on conditions using a Geoslam ZEB-Horizon (Fig. 1) and Navvis VLX3 Personal Laser Scanner. For Geoslam two alternative survey paths were followed, going in between each 2nd and 3rd plantation rows (hereinafter, trajectories A and B, respectively). Both laser point clouds (Fig. 2) were processed with 3DFin software, obtaining sections every 10 cm. A LOESS function was used to remove stem profile outliers.

Additionally, DBH and *V* field measurements were acquired and were considered reference data, allowing to obtain the discrepancies regarding the laser measurements. DBH for each tree was measured using a digital caliper to the nearest 0.1 cm. All trees were felled, and 15 of them had the stem perimeter recorded at 1 m intervals with measuring tape (Fig. 3).
Later on, *V* was calculated using the Smalian formula applied to each 1 m log.

Both scanners achieved values in the detection of 100% completeness and correctness. Geoslam had lower RMSE and bias in DBH estimation than NAVVIS, regardless survey path used (Table 1) (RMSE% < 3.1 vs 4.5 cm), and trajectory B yielded most accurate DBH (RMSE = 1.01 cm). For the 15 trees, the RMSE(%) for DBH using Geoslam was almost 50% lower than using NAVVIS (12.4 vs 22.74 cm). The

most accurate V was obtained using Geoslam each 3 rows (RMSE = 0.10 m3 (10,9%)). Regarding V of the whole plot (225 trees) and considering the value calculated by Garnica as reference, the RMSE% obtained using Geoslam were <4.5%, regardless trajectory followed (Table 2). No V were obtained for Navvis since only part of the point cloud could be processed.

The results show that ZEB-Horizon is accurate enough to estimate *V* and DBH in poplar plantations, even in very intensive surveying patterns.

Mechanical properties of plywood from the most widely planted Populus clones in Spain

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ID du résumé: 27

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The GO BIOPOPTECH Operational Group project aims to promote Populus plantations in Spain, considering certain innovative aspects such as clonal selection, sustainable management, optimization of wood properties, quality of the final product and digitalizing the results in technological tools to increase the added value of the plantations and the wood obtained.

The most widely used Populus clones in Spain are P. x euroamericana: I-214 (56.2%) and MC (5.7%); P. x interamericana: Beaupré (13.5%), Raspalje (10.1%) and Unal (8.8%). The technological properties of the wood of each of these clones have an impact on the processing, yield and final quality of the product to be produced. Physical-mechanical properties such as the wood's modulus of elasticity, modulus of rupture and density are fundamental for optimizing the stiffness and mechanical behavior of the final product and its suitability for use in different applications. These properties vary according to clone, plantation age, seasonal quality, plantation density and even within each individual along the stem.

As part of the activities developed in the GO BIOPOPTECH, we have evaluated, following the UNE-EN 789:2006, the local modulus of elasticity in longitudinal bending (MOE) and the modulus of rupture (MOR) of plywood boards manufactured with wood from the aforementioned clones (I-214, Beaupre, Raspalje, Unal and MC). The wood was obtained from productive plots (3 per clone) aged between 14 and 16 years. In each case, first log (0.3 to 3.5m) and second log (3.5 to 7m) were separated. Ensuring traceability, the wood from each clone-log was sent to Garnica where 8 plywood boards (1.2 x 1.2m) were manufactured from each clone-log combination.

The results indicate that both MOE and MOR are higher in the Beaupre, Raspalje and MC clones with respect to the I-214 and Unal clones. In all cases, and especially for MOE, the second log presents notably higher values (Table 1). Based on the results obtained, the possibility of manufacturing Populus plywood boards with structural characteristics could be evaluated by making a correct selection of the clone and of the different logs, broadening the range of products.

Comparing the strength of *Pinus radiata* plywood (6110 – 8819 N/mm^2) with other poplar plywood (4865,4 - 8666 N/mm^2), archived similar strengths, demonstrating the structural and competitive capacity of poplar plywood with other types of plywood.

Estimation of Tree Metrics in Poplar Plantations Using Photogrammetry

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ID du résumé: 36

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Fast-growing, short-rotation poplar plantations are among the most important for wood production in Spain, providing raw materials for high-quality, value-added products such as plywood and laminate veneer lumber (LVL). However, there are still some shortcomings in the digitalization of the entire supply chain, particularly regarding the assessment of standing resources before harvesting.

In this context, the use of remote-sensed data can represent a significant improvement in terms of efficiency and accuracy for calculating a large number of variables, such as standing volume, merchantable height or crown depth, all of which are crucial for optimal management of poplar plantations.

In this study, tools have been developed to estimate total height, diameter at breast height (DBH), diameter at the base of the bole, crown area, and the height to crown base from photogrammetric images captured using a multispectral camera (RGB+NIR) mounted on a Mavic 3 drone. Field data from 320 trees in 9 plantations of the I-214, Beaupré, MC, and Raspalje clones located in the Duero and Ebro river basins (Spain) were used to fit and validate the mathematical models.

Equations were obtained to predict DBH and base diameter of the bole independently for each clone with mean squared errors between 10% and 15% and virtually zero bias. Similarly, the height to crown base was predicted with mean squared errors around 10% and also unbiased. Total height and crown area were calculated directly from the photogrammetric point cloud.

The semi-automation of the entire workflow (flight planning, flight, data processing, variable calculation) would also result in a significant reduction in both time and resources, thereby increasing the profitability of this type of plantations.

Fast-growing Poplar and Eucalyptus trees in India and their Role in climate resilience

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ID du résumé: 38

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The 2015 Paris climate change agreement has set a long-term goal of keeping the increase in global average temperature well below 2°C above pre-industrial levels, and the aim to limit the increase to 1.5°C. The rising concentrations of anthropogenically produced greenhouse gases, mainly CO_2, in the Earth's atmosphere, are leading to global warming and changes in the climate. Therefore, the sequestration of carbon from the atmosphere to Earth is the need of the hour. In India, several fast-growing trees, such as Poplar (Populus *deltoides*), Eucalyptus (Eucalyptus *tereticornis*), Acacia, and Bamboo are suitable tree species for carbon sequestration under agroforestry schemes that are used for various industrial purposes. Due to the fast growth rate and the potential to capture a significant fraction of the atmospheric carbon and store it in plant biomass, these trees also contribute to reduced greenhouse gas emissions. It is reported in the literature that the Poplars have the potential to sequester carbon stock of 10.3 Mg C per hectare/per year and the Eucalyptus 12.7 Mg C per hectare/per year. Poplar has grown to a noticeable extent in plantation programs because of their market demand and high returns. Poplars are most commonly used to make plywood and packaging material for the agri-food industry. It has been estimated that nearly 60,000 hectares equivalent plantations of Poplar and over 100,000 hectares equivalent of Eucalypt plantations (one of the most important uses of Eucalypt wood so far has been in the paper and pulp industry) exist in India helping in removing the atmospheric CO_2. The Indian government is all set to increase tree cover up to 33% of the total geographical area under the agroforestry scheme. The National Agroforestry Policy of India is a comprehensive policy framework designed in 2014 to improve agricultural livelihoods by maximizing agricultural productivity for mitigating climate change. The agroforestry further fixes Nitrogen of about 50 -100 Kg N/ha/year in the soil. Such fast-growing Poplar and Eucalyptus tree species will not only increase green cover, sequester carbon, and mitigate climate change but also produce higher biomass for power production that would otherwise be made from fossil fuels.

Black poplar clones suitable for growing in SRC (short rotation coppice) systems

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ID du résumé: 41

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The research of black poplar (*Populus nigra* L.) biomass yield in SRC systems began in our Institute nearly thirty years ago. At first, field trials with plus trees collected in nature guaranteeing high genetic diversity were established. Suitable genotypes for growing in SRC systems were selected from trials. Trees with required characteristics were used for controlled crossings. Following field tests have been established with obtained seedlings. The best of them were vegetatively propagated, multiplied and further tested. Nowadays, black poplar clones with high biomass yield, stable and high resistance against leaf rust *Melampsora-larici populina*, and drought tolerant are selected. These clones have comparable yield with commercial inter-specific poplar hybrids. The oldest trial was harvested eight time in three-year intervals where the best clones reach similar yields from the third harvest and little fluctuation follow the amount of precipitation. The selected black poplar clones are suitable for growing also in marginal land and their planting is possible without any law restrictions.

Adaptation towards climate change mitigation: the efficiency of forest diversity through innovative tree-planting systems

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ID du résumé: 42

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Climate change poses significant challenges to forest ecosystems worldwide, necessitating effective adaptation strategies to mitigate its impacts. This study investigates the effectiveness of forest diversification through dynamic tree-planting regimes in addressing climate change mitigation in the forest landscape of Ghana. Using advanced modeling techniques incorporating growth and response functions from established models, the study evaluates the outcomes of different planting regimes under various climate scenarios derived from global circulation models. Results indicate that forest diversification through innovative tree-planting regimes can enhance the resilience of forest ecosystems to climate change. By incorporating diverse tree species with varying tolerances to environmental stressors such as drought and shade, the forests exhibit increased adaptability to changing climatic conditions. The study highlights the importance of considering multiple climate scenarios to assess the robustness of adaptation strategies and their effectiveness under different plausible futures. Policy implications of these findings underscore the significance of proactive forest management practices in the face of climate change. Implementing diversified planting regimes can help maintain ecosystem services, enhance biodiversity, and promote carbon sequestration in forests. By strategically selecting tree species based on their adaptive traits and growth characteristics, forest managers can optimize the resilience of forest ecosystems to future climate scenarios. Furthermore, the study emphasizes the need for collaborative efforts among stakeholders, policymakers, and researchers to develop and implement adaptive strategies that promote sustainable forest management in the context of climate change. Integrating climate change considerations into forest management plans and decision-making processes is crucial for ensuring the long-term health and productivity of forest ecosystems. In conclusion, this research underscores the potential of forest diversification through innovative tree-planting regimes as a viable climate change adaptation strategy. By enhancing the adaptive capacity of forests, these practices can contribute to climate change mitigation efforts and support the resilience of forest ecosystems in the face of ongoing environmental challenges.

Advancing Sustainable Bioeconomic Production Systems: Integrating Efficiency and Innovation

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ID du résumé: 49

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Introduction

In response to the escalating global environmental challenges, the development of sustainable bioeconomic production systems has become crucial. Fast-growing tree species present a significant opportunity within these systems due to their rapid growth rates, high biomass yields, and ability to sequester carbon. These species can play a pivotal role in enhancing resource efficiency, supporting circular economy practices, and contributing to renewable energy production. By integrating fast-growing trees into agricultural and forestry practices, we can optimize bioeconomic systems to mitigate environmental impacts while fostering economic growth and sustainability.

Objective

The primary objective of this study is to investigate the potential of fast-growing tree species in improving sustainable bioeconomic production systems. This involves:

- Assessing the ecological benefits of fast-growing trees, including their impact on carbon sequestration, soil health, and biodiversity.
- Evaluating the economic advantages of integrating these species into bioeconomic practices, such as increased biomass production and cost-effectiveness.
- Identifying the challenges and limitations associated with the cultivation and utilization of fast-growing tree species.
- Proposing strategies for effectively incorporating these trees into existing bioeconomic frameworks to maximize their benefits.

Goal

The overarching goal of this research is to provide a comprehensive framework for integrating fast-growing tree species into sustainable bioeconomic production systems.
Specifically, we aim to:

- Demonstrate how these species can enhance the resilience and efficiency of bioeconomic systems.
- Offer practical recommendations for policymakers, industry stakeholders, and researchers to support the adoption and scaling of fast-growing tree species.
- Contribute to the global sustainability agenda by promoting practices that reduce environmental impacts and support economic development.

Recommendations

1. **Promote the Use of Fast-Growing Tree Species:** Encourage the adoption of fastgrowing trees in agriculture and forestry to boost biomass production, enhance carbon sequestration, and support renewable energy initiatives.
2. **Strengthen Interdisciplinary Collaboration:** Facilitate collaboration among governments, industries, academia, and civil society to develop and implement policies that support the sustainable integration of fast-growing tree species.
3. **Invest in Research and Technological Innovation:** Allocate resources towards research and development to understand the full ecological and economic potential of fast-growing trees and to innovate technologies that optimize their use.

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Keywords: Fast-Growing Tree Species, Sustainable Forestry, Biodiversity, Carbon Sequestration, Bioenergy Production

Net Zero Willow

by Jamie Rickerby | Willow Energy

ID du résumé: 87
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-PRO - Production Systems for the Bioeconomy

The UKs maritime climate makes it very difficult to plant and harvest Short Rotation Coppice (SRC) willow plantations at the correct time. Most machinery developed for willow cultivation was produced in countries with drier soils and harsher winters. These machines have been used in the UK for 30 years. However, the changing climate means that these inefficient machines are no longer suitable. The Net Zero Willow project is developing the most significant step forward in the history of willow cultivation technology.

The Net Zero Willow (NZW) project is constructing, testing and developing to full commercial deployment three innovations for SRC willow multiplication, planting and harvesting:

- An All-Terrain Robotic Base Vehicle (ATRBV) complete with two separate attachments,
- Rod Harvester Attachment (RHA)
- Rod Planting Attachment (RPA)
- A tracked harvester with integrated storage bunker with telematics functionality.

The project seeks to benefit from marginal gains achieved at every step of the pathway. This will result in a significant dual benefit for farmers based on lower costs and greater income potential.

The new NZW machines will have the following benefits:

- Light weight with lower footprint and reduced the impact on the soil
- Increased automation helping to address labour storages
- Increased efficiency leading to higher yields
- Longer working windows enabling field work at optimum times
- Produce increased quality products
- Reduced inputs and lower costs at every stage

Reduce lifecycle greenhouse gas emissions at all parts of the SRC willow supply chain.

The innovations have been developed from the ground up to travel and operate on UK marginal land in the harshest of conditions. They are not conceptual designs but have been designed to work and

with mass production in mind. The innovations use components that have been tried and tested in other applications and are readily available. The specialist parts have been designed to be tough but also cheap and easy to replace when requested.

The modular design of the ATRBV base vehicle and attachments means that it can be adapted to many other uses including poplar multiplication and planting as well as many other applications.

This NZW project is UK Government funded and was instigated in 2020. It is nearing the end of the development and prototypes will be completed in the autumn of 2024.

Agroforestry and agrivoltaics co-location - is it possible? – first experience with experimental installation

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ID du résumé: 95

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Agroforestry systems (AFS), which combine cultivation of trees and conventional crop production, can improve resilience agriculture in EU (Lojka etal., 2020, Weger etal., 2022). Agrivoltaic systems (AgPV) which aim similarly combine agricultural production, with solar panels, have potential to diversify opportunities of farmers on land, to expand their products and increase energy independence (Dupraz etal., 2011). Our survey among members of Association of Private Farming shows that farmers are significantly interested in AgPV. Most of them would choose to combine use of electricity from AgPV for their own supply and to sell to electrical grid. In our contribution we present first result of social, environmental, energy and economic aspects derived from experience with small experimental agroforestry-agrivoltaics installation at field station Michovky, the Czech Republic.

Michovky AFS (0.6 ha) consists of six tree lines of maples, linden, ash, rowan and poplars in NWW–SEE direction and five crops strips (10 and 15 meters wide) farmed with conventional crops. Trees are 15-18 year old and 8-11 meters high. Three types of PV modules (CIGS 135W, mono c-Si 400W, bifacial c-Si 380W) were installed in second tree line in January 2021 (Picture 1). We have measured efficiency of electric production of PV modules. We have also conducted experiment with drying of woodchips on flor drying grid with air flow propeled with AgPV electricity in island operation mode in different periods of year (Picture 2).

According to methodology of AgPV experiment, different interventions were carried out including tree pruning and changing inclination of panels. Based on our evaluation, it can be stated that the

annual volume of electricity produced reached very promising values, namely 63 - 89% according to the installed specific performance if proper and regular maintenance is provided of tree crowns. Results also show that AgPV in AFS can achieve a reduction of only 10% of the annual electricity production compared to conventionally located PV plants.

Best results in drying experiment where reached in spring-summer period were the moisture content around 10% was achieved in 45 day of poplar/willow woodchips (calorific value improved +5GJ/t), while in winter-spring period the drying period was 2-3x longer depending on air temperature and moisture.

The combination of AgPV and AFS has the potential to help the local energy self-sufficiency of rural areas and farmers, while at the same time bringing environmental benefits of agroforestry of the adjacent landscape and agricultural production.

Our research was supported by the project TACR Theta (TK 04010166).

Tree - crop interactions in adult agroforestry systems: first results and experience from the Czech Republic

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ID du résumé: 98

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Agroforestry systems (AFS) are recommended as efficient measure against effects of climate change esp. heat waves, torrential rains in current landscapes with intensive agriculture in Central European conditions (Lojka etal., 2020, Weger etal., 2022). According to results of research (Lehmann etal., 2020), it is possible also to maintain or increase productivity per unit area (LER) in appropriately cultivated agroforestry systems, but there are avalalble few empirical experience for farmers. The aim of our work was to evaluate quantitative, qualitative and economic parameters of different annual and perennial crops grown in an experimental agroforestry system with semi-closed canopy and compare them with crops grown on field with standard conditions (without trees).

The experimental silvoarable AFS Michovky (0.6 ha) consists of 6 tree lines planted in NWW–SEE direction and six crops strips (7, 10 and 15 meters wide) farmed with conventional crops. Trees (maple, linden, ash, rowan and poplars) were 16-19 years old and 9-11 meters high during experimental period. Since 2020 arable soil has been farmed with the same annual crops and similar agronomy as on a neighboring field (FIELD: 45 ha, 50 m from AFS). Agricultural crops include varieties of wheats RGT Reform, Patras, barley Bojos, sweet pea, potatoes (Marena, Bellarosa, Red Sonia) and horse radish. Multiple samples of these crops were taken to evaluate their quantitative (yield, height) and qualitative parameters in different parts of AFS and FIELD each year. Quality assessment of crop products (grains, bulbs, roots) were performed in specialised laboratories using standard methods and parameters (including gluten index, crude protein content, vitamin content etc.)

Our results show that quantitative parameters of cereals in experimental AFS were mostly lower/worse than in FIELD monoculture e.g yield of grains were lower by 30-50% depending on site, variety and year. On the contrary results of qualitative parameters of wheat in 2020 and 2022 were mostly better in AFS than in FIELD, especially in the parts with higher shading. Results of other crops have shown also strong influence of trees on production and quality parameters, but some crops show better or more suitable adaptation for conditions of AFS (potatoes, pea). Our results from experimental AFS Michovky also show ideas for improvement of tree selection, planting and pruning in adult AFS so that they better meet the production conditions of field crops and at the same time preserve the environmental benefits of agroforestry.

Research was supported by institutional funding (VUKOZ-IP-00027073) and project TACR Epsilon (TH04030409).

Carbon credit availability in support to poplar growers

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ID du résumé: 108

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Poplars, due to their fast growth and high biomass accumulation capabilities are perfect tool for climate change mitigation in agriculture/forestry. Newly established poplar plantation can accumulate carbon several times faster than traditional forest tree species, and many times more than other traditional agricultural activities (if poplars are considered agricultural crop rather forest tree).

Global attempts to mitigate climate change open new possibilities for poplar growers to utilize this efficient climate tool. This comes with efforts to support various climate actions, through such instruments as issue of carbon credits.

Today in the EU already exist some possibilities for poplar growers to benefit from carbon sequestration and will increase with higher requirement for carbon neutrality.

Four years ago Estonian startup Ecobase.earth launched “European afforestation project” to be registered under VERRA’s VCS. According VERRA’s VCS only rotation not shorter than 20 years can qualify for voluntary carbon credits according afforestation methodology. In addition to that, owners have to commit that trees will be grown at least for 40 years on the same soil, meaning at least two rotations. While calculating carbon sequestration by newly established poplar plantations increments of different carbon pools are being considered: above ground biomass, bellow grass biomass, leaves, dead wood, soil organic carbon. Current Ecobase.earth poplar CO2 sequestration models are based on biomass models developed by Swedish university of agricultural sciences models at North European latitudes, and assume that poplar growers can get (net of Ecobase.earth commissions) 210 voluntary carbon credits for polars planted on pastures and 250 voluntary carbon credits for polars planted on cropland.

In May 2024 EU adopted new regulation on Carbon removal certification framework (CRCF) (recently name changed to “Carbon removal and carbon farming”, the purpose of which is to contribute towards GHG reduction through creation of unified EU voluntary carbon market. With adoption of CRCF directive unified EU voluntary carbon credit market is taking fists steps, therefore it is not expected to be functional before 2028-2030. Carbon removal capabilities of poplars and other short rotation woody

crops are expected to be included in agricultural methodologies to become part of voluntary carbon credits generated by agricultural (not forestry) activities.

With new climate mitigation opportunities business of poplar growing may switch from fast biomass economics toward climate economics.

Growth and Productivity of Populus deltoides and hybrid clones in semi-arid condition of Alborz province

by Calagari, M; Ghasemi, R; Salehi, A; Ahmadlu, F | Research Institute of Forests and Rangelands, Poplar and fasr-growing trees division

ID du résumé: 110

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

The poplar species culturing for wood production are supplied through the private sector. The Eastern cottonwood (*P.deltoides*) and its hybrids (*P. xcanadensis*) clones has been extensively grown by farmers on their fields in North of the country along the coastal plain of the Caspian Sea for five decades. A study was conducted from 2018 to 2022 in the Karaj research station (Alborz province) to determine growth and productivity of 14 clones of *P.deltoides* and its hybrids. The experiment was laid out in completely randomized block design with three replications. A boundary row of non-experimental poplar trees was planted to check the border effect. The saplings were planted at 3x4 m spacing. The Irrigation system was in the form of furrows and once a week, and weed control was done regularly. At the end of each growing season, growth characteristics including survival percentage, diameter at breasts height (dbh), and height were measured yearly during dormancy on all trees. Also, the volume of standing trees and current annual increment were calculated. The results of the variance analysis of the growth characteristics at the end of the fifth year showed that, apart from the variable of survival percentage, there was a significant difference in diameter at breast height (dbh), height and stand volume per hectare variables among the poplar clones. The Mean annual volume increment and total volume per hectare at the end of the fifth year showed that two clones of *P. xcanadensis pacher* and *P. deltoides Marquette* with 8.21 and 7.27 $m^3. ha^{-1}.year^{-1}$ and 41.05 and 33 $m^3. ha^{-1}$ had the highest values of wood production respectively. Also, two clones of *P.deltoides 92/258* and *P. xcanadensis 92/40* were ranked second compared to other poplar clones. Therefore, planting *P. xcanadensis pacher* can be used as successful clone for wood farming in semi-arid areas of Iran.

Investigation on Growth, morphology and phenology characteristics of willow species in germplasm collection of Karaj

by Mohsen Calagari | Research Institute of Forests and Rangelands, Poplar and fasr-growing trees division

ID du résumé: 111

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Willow species is one of the main trees of valleys, plains and the banks of river in most of the different provinces of Iran. It is important for wood production and environment applications. The willow species and its provenances were collected from different regions of the country. From each species numbers of 9 trees were planted with 3 by 3 meters spacing. Growth (diameter at breast height, height, and number of shoots above 2 meters) and phenology (stage of flowering, leaf emerging from the buds, seed release and leaves fall) characteristics for four consecutive years and 18 morphological traits were also measured and recorded in July of the third year of the growing season.

The results at the end of the fourth year of trees showed that the two species S. alba and S. excelsa had the highest growth with a dbh of 15.1 and 15.2 cm and a height of 9.3 and 13 meters, respectively. The three species *S. zygostemon*, *S. pycnostachya* and S. purpurea had the highest number of shoots above 2 meters with 18, 12 and 10 shoots, respectively.

Analysis of variance showed significant differences among the willow species for leaf morphologic traits. Principal component analysis (PCA) plot on all morphological traits revealed three separate groups including *S.babylonica* (group1), S. aegyptiaca and S. caprea (group2) and *S. alba*, *S. excelsa*, *S. acmophylla*, *S. purpurea*, *S.elbursensis*, *S. wilhemsiana*, *S. zygostemon* (group3).

The variables of leaf length, maximum leaf width, PLB leaf circumference, leaf tip angle and leaf area had a great impact on the grouping of willow species.

Phenology results for four consecutive years showed that the earliest time for flowering starts from late February (*S. aegyptiaca*) until middle April for other species (8-13 °C). Leaf emerging from the buds starts from late February (*S.babylonica*) and the latest time is related to *S. aegyptiaca* and *S. purpurea* species (8-14 °C). The seed release time starts from late April (*S. aegyptiaca* and *S. wilhemsiana*) until late May in *S. alba* species (18-21 °C). Also the earliest time of leaf fall occurs from the first half of November in *S. aegyptiaca*
(12 °C) until the end of November for other species (5-11 °C .(

SANDALWOOD ON SEMI-ARID FARMLANDS: A WAY FOR SOCIO-ECONOMIC UPLIFTMENT OF FARMERS

by Baragur Neelappa Divakara | Institute of Wood Science and Technology (IWST)

ID du résumé: 112

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Indian sandalwood (*Santalum album* L.) is one of the most extensively ingrained fragrant tree species and is the glory of Indian culture with inextricable heritage which has eulogized as the most precious and valuable among Indian forest trees. Obtaining a good yield in order to gain a profitable revenue is a significant factor of any farmer to stride up the socioeconomic status. Cultivation of sandalwood in their farmland can advance their future as it is considered as the national asset with a huge overseas demand. Although, there are certain barriers to access the sandalwood streamline quality, if the farmer pays meticulous attention at required intervals they can create an impactful farming. This paper overviews the present status of sandalwood cultivation and its market, technologies applied for its cultivation, schemes offered by the government, and in what way the farmers by knowing these aspects can uplift their socio-economic background by establishing the sandalwood in their private farmlands.

Key words: sandalwood, economics, legal aspects, flagship species, farmers, plantations

Enhancing Poplar Wood Valorization through Innovative Non-Destructive Tools for Wood Quality Assessment: The Tree Inspection Kit (TIK)

by Irene Gil-Martin | Elisabet Suarez | Andrés Roldán-Aranda | Yaiza Fuentes | Antolino Gallego |
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ID du résumé: 128

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-PRO - Production Systems for the Bioeconomy

The determination of poplar wood quality using non-destructive methods is essential for the advancement of the sector, as it allows the alignment of supply (owners/farmers) and demand (industries and users of structural bioproducts) in an efficient, rigorous and profitable way. The University of Granada is currently developing several prototypes of technological tools generically called Tree Inspection Kit (TIK) to assess the quality of poplar wood both in standing trees and in sawn boards. The TIK system allows the competitive marketing of raw material, promoting the production of high-quality wood for bioproducts and helping the sustainable management of poplar plantations.

The TIK system consists of two tools: TIK TREE and TIK TIMBER, which offer a comprehensive solution for the classification of wood throughout its production chain. TIK TREE is applied to standing trees, logs and swan timber, and allows the determination of the modulus of elasticity (MOEdyn) by measuring the time of flight of an acoustic wave. TIK TIMBER is designed for application to sawn timber, and also allows the determination of MOEdyn based on the resonance frequency of an induced acoustic wave.

The main features of the tree inspection kit system include:

- Technological innovation: The TIK system offers a novel approach to non-destructive classification of wood, essential for the rapid and cost-effective selection of structural elements.
- Valuation of wood: TIK TREE significantly benefits the forestry industry by providing a non-destructive tool to evaluate the mechanical properties of standing wood. This allows for more competitive marketing of quality wood from sustainable forest management and promotes higher wood prices.

- Accuracy and reliability: Extensive testing has demonstrated the accuracy and reliability of the TIK system, with results consistent with existing commercial equipment. This optimization improves hardware and software performance for better market adaptation.
- Adaptability and versatility: both TIK TREE and TIK TIMBER are versatile, suitable for different needs and experience levels, and applicable in advanced measurements and laboratory tests.
- User-friendly interface: The TIK system features an intuitive interface and advanced software, allowing for efficient testing and clear presentation of results.

- Interconnection and traceability: Both devices will be interconnected through a common application that will ensure the traceability of the wood at all stages.irene

Poplar timber production in Argentina: relationships between productivity and mechanical wood properties determining stiffness

by Martinez-Meier Alejandro | Thomas Esteban | Diez Juan | Caballé Gonzalo | Fantino Laura | Bonnin Sebastián | Alvarez Javier | Instituto Nacional de Tecnología Agropecuaria (INTA), EEA Bariloche Dr. Grenville Morris Bariloche, Río Negro, Argentina. Instituto Forestal y Agropecuario Bariloche (IFAB INTA-CONICET) | INTA, EEA Alto Valle Ing. Agr. Carlos H. Casamiquela, Ctte. Guerrico, Río Negro, Argentina | Instituto Nacional de Tecnología Agropecuaria (INTA), EEA Bariloche Dr. Grenville Morris Bariloche, Río Negro, Argentina. Instituto Forestal y Agropecuario Bariloche (IFAB INTA-CONICET) | Instituto Nacional de Tecnología Agropecuaria (INTA), EEA Bariloche Dr. Grenville Morris Bariloche, Río Negro, Argentina. Instituto Forestal y Agropecuario Bariloche (IFAB INTA-CONICET) | INTA, EEA Delta del Paraná, Campana, Buenos Aires, Argentina | INTA, EEA Delta del Paraná, Campana, Buenos Aires, Argentina | INTA, EEA Delta del Paraná, Campana, Buenos Aires, Argentina

ID du résumé: 132

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-PRO - Production Systems for the Bioeconomy

Argentina began a process that highlighted the value of wood as a structural material. Despite these advancements, the structural characterization of wood has been limited to small afforestation areas. The objective of this work was to determine the physicalmechanical properties of wood by using non-destructive methods. Thereby, large-scale phenotyping would facilitate proactive decision-making across the value chain of sawn timber industry to produce superior structural timber. We phenotyped more than 750 trees located across the two main regions where poplar is planted in Argentina: the Delta del Paraná (Delta) and the irrigated valleys in the north of Patagonia (Valle). Growth data (diameter at breast height - DBH - and total height - Ht), wood density, and the time of flight (TOF) of acoustic stress waves in standing trees were measured. These last two variables are used to estimate stiffness, which defines the structural behavior of wood. Slenderness was estimated from the Ht/DBH ratio of the trees. We conducted a Principal Component Analysis (PCA) to elucidate the relationships among the variables and to establish significant differences between regions and between the euroamerican hybrid (*Populus x canadensis*) and deltoides (*Populus deltoides*) clones planted in both regions. The structure of the variation explained by the PCA indicates that the increment in DBH and Ht decreases the slenderness and wood density, with a lesser impact, almost null, on the velocity (computed from the TOF) of the acoustic wave. In Delta, the individual variability is associated around the greatest increase in height. In Valle, the variability is greater and is mainly associated with slenderness, wood density and velocity. In the first two axes of the factorial analysis of the PCA, *Populus deltoides* and *Populus x canadensis* differ significantly from each other. In Delta *Populus x*

canadensis is significant different from *Populus deltoides* while in Valle no difference was found between both groups. In the factorial axes represented by the first and third axis, *Populus deltoides* from Delta forms a single group that differs significantly from the rest, expressing the associations between growth versus form and mechanical wood properties. There exists an east-west gradient decreasing growth increments, interrupted by the differential performance of the hybrid clones of *Populus* x *canadensis*, highlighted by form and wood technological properties. Desirable slenderness and best structural quality timber seems negatively associated with highest productivity of *Populus deltoides*.

WP POL

Working Party on Policy and Livelihood

IPC - Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

KEY TALK

New EU regulations, opportunity or threat to plantation forests in the EU?

by Oscar Crespo Pinillos | Sergio Souto Suárez | Grupo Garnica Plywood, S.A.U. | Grupo Garnica Plywood, S.A.U.

ID du résumé: 24

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-POL - Policy and Livelihood

According to the FRA 2020 report from FAO, plantation forests cover 3% of the world's forests, and account for 45% of the total area of planted forest. The EU has a high proportion of planted forests at about 8% of the total forest area, but it has the smallest percentage of plantation forest in the world. However, plantation forests are becoming more relevant at the EU level to meet the increasing demand for roundwood and ecosystem services.

Plantation forests supply a large part of the raw material for Europe's forest industry, especially for certain products such as pulp or plywood. This is especially true in some countries such as France, Ireland, Italy, Portugal or Spain that depend largely on plantation forests for their roundwood production. Plantations that are managed sustainably can offer significant advantages at the EU level for fulfilling the future needs of roundwood and ecosystem services.

One of the most relevant EU regulations for the trade of forest products in the EU is the EU Regulation on Deforestation (EUDR), which was adopted in September 2021 and will enter into force in January 2024. The EUDR aims to prevent and reduce the consumption of products that are associated with deforestation or forest degradation in third countries, and to promote the conservation and sustainable use of forests worldwide.

This presentation will analyse how the EU Regulation on Deforestation (EUDR) and other recent EU regulations may impact plantation forests in and around the European Union, particularly poplar plantation forests in Southern Europe and especially in Spain, aspects analyzed within the framework of the GO BIOPOPTECH project.

TALK

La Décennie Africaine et Mondiale de l'Afforestation et du Reboisement (DAMAR), une initiative salutaire dans la lutte contre le réchauffement

by MATONDO Rosalie | François MANKESSI |, Pierre TATY2| Enseignant Chercheur à l'Ecole Nationale Supérieure d'Agronomie et de Foresterie (ENSAF), Université Marien NGOUABI | Ingénieur Forestier, Agent du Service National de Reboisement (SNR)

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies
Topic: WP-POL - Policy and Livelihood

La triple crise planétaire du changement climatique, de la perte de la biodiversité et de la pollution, couplé à l'accroissement de besoins en produits forestiers divers, est une menace réelle de la survie de l'humanité. Pourtant la solution pour juguler les effets liés au changement climatique est connue : la préservation des écosystèmes forestiers et l'accroissement de la capacité de séquestration de carbone. Dans cet optique la République du Congo propose aux Etats membres des Nations Unies, une Décennie Africaine et Mondiale de l'Afforestation et du Reboisement, dont l'objectif est l'accroissement de la superficie forestière mondiale à travers la mise en œuvre par les Etats, des programmes nationaux d'afforestation et de reboisement financés prioritairement par les budgets Etats. L'initiative a eu le consentement de tous les Etats membres de l'Union Africaine ainsi que des agences du système des nations unies et a fait l'objet d'une première Conférence Internationale sur l'Afforestation et le Reboisement, tenue à Brazzaville, du 02 au 05 juillet 2024. Cette conférence a connu la participation des décideurs politiques, des scientifiques, des peuples et populations autochtones, du secteur privé, de la société civile, et formulé de nombreuses recommandations parmi lesquels la rédaction d'une stratégie globale de l'afforestation et du reboisement à partir de sept axes stratégiques, la mise en place d'un organe spécifique dédié aux forêts naturelles et plantées. Toutes ces recommandations font l'unanimité des pays africains.

Mots clés : Changement climatique, Décennie globale, afforestation, reforestation.

Innovative tree -based farming by small land holding farmers of Malda district of West Bengal, India for sustainable income and livelihood security.

by Dr.M.S.HAQUE | Retired as Forestry Officer in 2010 from National Bank for Agriculture and Rural Development, INDIA

ID du résumé: 37
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-POL - Policy and Livelihood

Malda district was famous for two economic activities viz. Mango (*Mangifera indica*) cultivation and rearing mulberry silkworm (*Bombyx mori*). Earlier silkworm rearing was a flourishing cottage industry and every household of Kaliachak block reared silkworm for cocoon production. It was the major livelihood of rural farmers but they suffered heavily due to cheap import of silk from China. Thus, the backbone of farmers was crippled, hence they started cultivating various trees in mulberry fields along with agricultural crops for sustaining their livelihood. Present study was undertaken to know how farmers adjusted to new situation, their knowledge about trees, income growth and sustainability. It was observed that mulberry was raised as herb and leaves were fed to the silkworm larvae at home. Traditionally farmers planted Sissoo (*Dalbergia sissoo)* and Neem (*Azadirachta indica)* trees on the border of mulberry fields but later on they started planting other trees too. A few farmers uprooted their mulberry bushes and converted to broad leafed Mahgony (*Swietenia macrophylla)* plantation. Some farmers converted their entire land to Mango and Lychee (*Litchi chinensis)* orchards for long term gains. Besides, some traditional farmers, around 10% still continued with silkworm rearing for their livelihood but planted few rows of trees like Teak (*Tectona grandis)*, *D.sissoo*, Silk cotton tree (*Bombax ceiba)*, *S. macrophylla and Acacia auriculiformis*. Few big farmers converted their mulberry fields into ponds for fishery, however, planted Mango, Sissoo, Acacia and Lemon (*Citrus limon*) trees on the broad border in two rows. The first crops inside the tree plantations were Maize (*Zea maize*), Mustard (*Brassica nigra*) Papaya (*Carica papaya*) and Vegetables like Spinach *(Spinacea oleracea)*, Tomato (*Solanum lycopersicum*), Coriander (*Coriandrum sativum)*, Brinjal (*Solanum melongena*) and Flax (*Linum usitatissimum*) which gave farmers quick income. Later, Banana (*Musa paradisiaca*), Mango and Citrus were planted. These activities are still continuing, but harvesting of timber specially Mahgony has also started which will give the small land holding farmers very high income. A recent visit to a farmer's land in June 2024, I was surprised to see several Mahgony plantations of different ages but were very closely planted, however, the farmer agreed to remove few trees later on. Such treebased farming not only provided sustainable

income to farmers, but also made them drought resilient through climate change mitigation and adaptation besides conserving plant biodiversity.

Creative and Economic opportunities growing and weaving with willow

by Howard D Peller | Living Willow Farm

ID du résumé: 62
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-POL - Policy and Livelihood

Living Willow Farm

Howard Peller

Living Willow Farm (https://www.livingwillowfarm.com/) located in the foothills of Appalachia Ohio, USA, specializes in growing 14 acres of willows for various types of weaving and artistic installations. Living Willow Farm was founded by artist/designer/farmer-Howard Peller who has been engaged in the design and weaving of a wide range of materials for more than 30 years. His work represents an example of the unique and utilitarian collaboration between peoples their cultural heritage and native plants. Living Willow Farm provides cuttings for propagating various varieties, dormant long stems for garden borders, sculptures and living structures. Stems of various lengths, thicknesses, and colors for a wide variety of weaving (baskets, furniture, sculptures) are sorted, dried and stored using certain technologies. Many artworks are made from willows from Living Willow Farm have been installed across the country, including at Rockefeller Plaza in New York and the Bellagio Casino in Las Vegas. Sustainable practices at the Farm promote long-term profitability and provide ecosystem services to the surrounding landscapes. Additional international workshops are conducted using a wide range of plant materials in many rural agrarian communities which further demonstrate the unique relationship between growing plants and making both useful and creative goods from plant fibers

Living Willow Farm

Instagram: livingwillowfarm

Website: www.livingwillowfarm.com

Research and development of native species silviculture in Brazil

by Daniel Piotto | Miguel Calmon | Samir G. Rolim | Universidade Federal do Sul da Bahia | Conservation International | Universidade Federal do Sul da Bahia

ID du résumé: 91

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-POL - Policy and Livelihood

Brazil is rich in forest resources, with more than 500 Mha of native forests and approximately 9.5 Mha of planted forests of exotic species. However, it has traditionally undergone high rates of deforestation followed by unsustainable land uses, which led to an estimated 50 Mha of degraded pasturelands with low suitability for agriculture that could benefit from reforestation for timber production. This is about half of the area necessary to meet the growing global demand for timber by 2050. Despite this competitive advantage, Brazil currently supplies less than 10% of tropical timber production. Nevertheless, shifting tropical timber supply from illegally harvested natural forests to sustainable managed forest plantations requires public policies and investments to combat illegality and to establish a national long-term research and development (R&D) program for native tree species. To conceive a R&D program to boost native species silviculture in Brazil, a taskforce of more than 30 researchers from various institutions and regions conducted a literature review on native species silviculture to identify the main research gaps and priorities. Given the great diversity of native tree species in Brazil, 15 species from the Amazon and 15 from the Atlantic Forest biome were initially selected to start the R&D program, based on several criteria such as silvicultural characteristics (growth, form, pests), economic characteristics (market and price), and efficiency of the research process (cost and time to obtain results). The selection of a relatively high number of species for the R&D program was intentional because silvicultural systems for native species such as mixed-plantations and agroforestry include more species than those traditionally used for exotic species in Brazil. Furthermore, climate change and biodiversity conventions require the use of multiple species together and the market for tropical timber also demands diversity of colors, textures, and uses. For the selected species we mapped the main gaps and priorities within eight thematic research programs: seed and seedling production, vegetative propagation, genetic improvement, wood technology, plantation management, topo-climatic zoning, markets and marketing, and policy and legislation. The R&D program involve leading universities and research institutions, as well as the private sector, governments, and civil society, which has become a concerted research effort to untap the enormous potential to accelerate and increase the scale of silviculture of native species in Brazil.

MINIMUM SUPPORT PRICE MECHANISM FOR POPLAR WOOD: HOW RELEVANT WILL IT BE?

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ID du résumé: 102

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-POL - Policy and Livelihood

Poplar (*Populus deltoides*) is one of the most popular agroforestry trees in the plains of north India. It is cultivated in agricultural fields in association with crops. The tree is planted in linear rows on farm boundaries or in the interspaces of crops throughout the cropped field. Procurement of planting material, planting operation, cultural practices, harvesting of trees, conversion and transportation of wood to the poplar wood market entail sizeable expenditures from the growers. The plantation is maintained for 4 to 6 years before it is harvested for sale. A decline in the yield of agricultural crops due to the presence of trees further impacts the economics of growing poplar. The plywood industry is the major buyer of poplar wood and the poplar market is centred in very few places.

The market prices of poplar fluctuate widely. The prices for standard logs, trading nowadays at about Rs. 1,200 to 1,500 per quintal, decline to about Rs. 400 to 500 per quintal in some years. A stable and remunerative price regime is necessary to sustain the interest of tree growers and ensure a steady supply of wood to the industry. Growers demand higher prices for wood during periods of low market prices. Few growers advocate for a minimum support price (MSP) mechanism for the wood of poplar and other species. MSP has long been used in India's agriculture sector for agricultural crops. The government of India fixes the MSP, and the markets operated by the government are encouraged to buy produce at or above this price. The MSP is usually fixed around one-and-a-half times the cost of production incurred by the farmers. The MSP is announced at the beginning of the sowing season of crops. Crops that receive a steep increase in MSP at the sowing time attract more growers during that season. This intervention helps the government indirectly regulate the extent of the area under different crops.

Trees are long-gestation crops; therefore, it is not easy to foresee the price scenario at the likely times of harvest. Trees are subject to great uncertainties due to the changing weather, pest and disease conditions over a long period. An assurance about MSP could go a long way in encouraging the farmers about threshold prices in the market. A critical analysis carried out by the authors shows that the prevailing MSP mechanism may not solve the problem for poplar growers.

Fast-growing forest trees as a solution to sustainable development in the face of climate change

by Emmanuel Frimpong | Mavis Appiah-Kubi | Tropenbos Ghana | Rural Education and Agriculture Development International

ID du résumé: 113

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-POL - Policy and Livelihood

Climate change poses a significant threat to global ecosystems and human livelihoods, particularly in developing countries. As a response to this pressing issue, tree planting has emerged as a viable climate change adaptation strategy that not only mitigates environmental degradation but also promotes sustainable development. This paper examines the role of tree planting in Ghana as a means to address climate change challenges while fostering ecological and socio-economic benefits. The primary objectives of this study are to evaluate the current state of tree planting initiatives in Ghana, assess their effectiveness as a climate change adaptation strategy, and identify the socio-economic and environmental benefits associated with these initiatives. Additionally, the study aims to raise awareness about the importance of tree planting in enhancing climate resilience among various stakeholders. The research employs a comprehensive literature review to analyze existing studies and reports on tree-planting activities in Ghana. By synthesizing data from various sources, the paper highlights the theoretical frameworks and practical applications of tree planting as a climate adaptation strategy. The analysis focuses on the benefits of tree planting, including carbon sequestration, soil erosion prevention, and biodiversity maintenance, while also considering the challenges faced in implementing these initiatives. The findings reveal that tree planting significantly contributes to climate change mitigation by enhancing carbon sequestration and improving local microclimates. The study also identifies the socio-economic benefits of tree planting, such as job creation, improved agricultural productivity, and enhanced community resilience. However, it highlights a critical gap in climate change awareness, particularly in rural areas, where knowledge about the benefits of tree planting remains limited. The paper concludes that tree planting is a crucial strategy for climate change adaptation in Ghana, offering both environmental and socio-economic advantages. However, the success of these initiatives is contingent upon increased awareness and education among communities, particularly vulnerable groups. To enhance the effectiveness of tree-planting initiatives, the study recommends the implementation of comprehensive awareness campaigns targeting rural populations, the establishment of partnerships between government agencies and local communities, and the integration of tree planting into national climate change policies. Furthermore, it advocates for the involvement of non-governmental organizations and private sectors in promoting tree planting as a sustainable development strategy, ensuring long-term commitment and resource allocation for successful implementation.

Current French forestry policy and poplar production.

by Eric Paillassa | Gabriel Chazallon | Marc Fournier | CNPF-iDF | CNP | Ministère de l'Agriculture et de la Souveraineté alimentaire

ID du résumé: 114
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-POL - Policy and Livelihood

French forestry policy uses a variety of regulatory and aid tools to ensure forest protection and sound management for the two main types of forest: public (25% of surface area) and private (75% of surface area). Poplar production, mainly in private forests, is governed by the same rules as other forest species.

The first tool is the Forestry Code, which is a collection of laws and regulations governing forests. This code, for example, makes it compulsory to preserve the wooded state after harvesting, on pain of a clearing tax.

A second tool is the Schéma Régional de Gestion Sylvicole (SRGS). The SRGS is the regional version of the national forestry policy. Its aim is to define management rules for the region's private forests, and it is the reference for the approval of sustainable management documents.

The third tool, in private forests, is the obligation to have a simple management plan (PSG) for properties of over 20 ha, issued by the Centre National de la Propriété Forestière. This document guarantees sustainable management. The PSG helps forest owners, generally non-professionals, to manage their forest assets. This document entitles the holder to a 75% exemption from transfer duties when the property is transferred.

National forestry policy also includes tax and financial incentives to support foresters in the economic management of their forests.

The “DEFI travaux” scheme offers tax deductions for forestry work carried out, while the “DEFI Assurance” scheme provides tax credits for insuring forests. There are also exemptions from property tax, which lasts for 10 years for poplar.

Public financial aid is available at national and regional level, for a variety of purposes. The national “France 2030” plan supports forest reconstitution in the face of fire, health and climate risks. In the case of poplars, funding from the New Aquitaine region is used, for example, to revive poplar cultivation in the Marais Poitevin, afforestation of farmland and poplar pruning.

Finally, private financial aid is available for poplar afforestation, with the Label Bas Carbone (LBC) financed by private and public carbon contributions, as well as for poplar reforestation with the Charte Merci le peuplier financed by the poplar industry.

National forestry policy also includes support for research, such as the GIS peuplier, which is helping to develop new poplar varieties, as well as support for the Conseil National du Peuplier, which represents the entire poplar industry.

Merci le Peuplier Charter : an industry initiative to promote reforestation

by Emmanuel Naudin | Conseil National du Peuplier

ID du résumé: 119
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-POL - Policy and Livelihood

With 194,000 hectares of poplar groves and an average of 1.4 million m3 of wood harvested each year, France is Europe's leading producer of poplar wood, exporting around 20% of its annual log harvest.

Since 2005, poplar reforestation has fallen sharply. Many poplar growers do not reforest their plots after harvesting, as the price of the wood obtained is insufficient to cover the investments made. In addition, a complex set of other constraints weighs on French poplar plantations, including social factors and sometimes excessive environmental regulations.

At the same time, public authorities were no longer supporting poplar, and some local authorities were even fighting against poplar plantations because of a number of inaccurate or false preconceptions.

As early as 2008, professionals began to raise the alarm about the lack of reforestation. In 2011, industrialists in a French region created the "Merci le Peuplier" charter to encourage owners to reforest. This is a system of financial aid organised by the manufacturers: the companies that sign up to the charter undertake to finance part of the reforestation directly to the poplar grower from whom they have purchased the wood. If the grower reforests within two years of harvesting the wood, the buyer will pay around half the cost of the seedlings on presentation of the invoice, i.e. €2.50/plant in France.

In 2014, following good local development (over 30,000 seedlings assisted) and to meet the needs of companies operating in several regions, the charter was extended to the national territory by the Conseil National du Peuplier (CNP). This awareness-raising initiative was urgently needed because in 2013-2014, only half of the areas harvested were actually reforested.

This initiative is unique in several respects:

- it comes from industrialists in the sector, the financial aid for reforestation comes directly from the companies that are members of the Charter, it is not a fund • operating costs are very low, since the aid is paid directly from the wood purchaser to the poplar grower.

The entire operation is monitored by a system of declarations made by Charter members via an intranet on the Conseil National du Peuplier's peupliersdefrance.org website.

"Merci le Peuplier" has also made a major contribution to promoting the poplar and communicating the need to renew this resource. Its exemplary nature has enabled local authorities to support reforestation and even poplar plantations.

Merci le Peuplier has been extended to Spain in 2020-2021, and the reforestation rate in France has now reached 90%.

Types de partenariat dans la mise en place des plantations forestières et agroforestières en République du Congo

by MATONDO Rosalie | Cassagne Bernard | Bertaux Paul | Enseignant Chercheur à l'Ecole Nationale Supérieure d'Agronomie et de Foresterie (ENSAF), Université Marien NGOUABI | CEO – Fondateur de « Forêt Ressources Management », FRM | Directeur Technique / ESG de « Forêt Ressources Management », FRM

ID du résumé: 141

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-POL - Policy and Livelihood

L'Afrique Centrale, et la République du Congo en particulier, a une longue tradition de plantation et afforestation d'essences à croissance rapide en savane basée sur une politique forte et résolue de promotion des plantations forestières depuis plus de 50 ans.

Avec près de 10 millions d'hectares, les importantes surfaces de savane y sont fortement anthropisées et dégradées (feux anthropiques généralisés, agriculture itinérante et peu efficace sur une faible proportion), elles représentent une immense opportunité de déployer à grande échelle différents schémas de plantations forestières et agroforestières. Au cours de la prochaine décennie, les surfaces plantées avec plusieurs essences à croissance rapide vont quadrupler en Afrique Centrale, sur base des projets existants, et pourrait approcher 500.000 ha rien qu'en République du Congo.

Les modèles actuellement déployés sont d'une nouvelle génération avec des stratégies multi-produits-marchés sur différentes filières (crédit-carbone, bois d'œuvre, bois-énergie, alimentaire-vivrier, PFNL, etc …) et des volet sociaux et environnementaux fondamentaux (forte intégration sociale, développement socio-économique local, programmes villageois parallèles, protection/conservation des HCV et forte amélioration de la biodiversité).

Cette nouvelle donne a conduit à l'élaboration de schémas sylvicoles, techniques et économiques novateurs ainsi qu'à l'arrivée de nouveaux types de partenaires investisseurs, beaucoup attirés par la création de puits de carbone naturel. Ainsi, ces acteurs financiers et industriels se sont ajoutés aux investisseurs historiques sur ce type de projet et conduisent à l'émergence de nouvelles formes de partenariat privé-public dépendant directement des différentes filières économiques visées.

La République du Congo joue continue de jouer un rôle de leadership dans le montage et l'implémentation de partenariats novateurs et le déploiement à grande échelle de nouveaux modèles de plantation à fort impact économique et socio-environnemental en milieu rural. Elle a su adapter sa

législation forestière avec un code forestier sécurisant la dimension carbone des opérations nouvelles de plantations en les accompagnant d'une politique forestière efficace.

Mots clés : Afforestation, Partenariat Public/Privé, Plantations forestière, Développement local, Puits de carbone, Investissements.

Abstract: Policy and Livelihood: The Role of Poplars and FastGrowing Trees in Sustaining Communities and Environments.

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ID du résumé: 45

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-POL - Policy and Livelihood

The integration of poplars and other fast-growing trees into policy frameworks is essential for sustainable development, especially in communities that rely heavily on natural resources. These trees play a crucial role in supporting livelihoods, enhancing environmental health, and contributing to economic stability. This abstract explores the multifaceted benefits of poplars and fast-growing trees, focusing on their contributions to community resilience, ecosystem services, and policy implications.

Introduction

Poplars and other fast-growing trees are increasingly recognized for their ability to provide rapid biomass production, carbon sequestration, and soil improvement. Their versatility makes them suitable for a variety of uses, including timber, fuel, and non-timber forest products, which are vital for the livelihoods of rural communities. The rapid growth rate of these trees allows for quick economic returns, making them an attractive option for both small-scale farmers and large-scale industrial applications.

Poplars and fast-growing trees offer several environmental benefits, such as improving soil fertility through leaf litter, reducing erosion, and enhancing biodiversity by providing habitats for various species. These trees are also efficient in carbon sequestration, helping to mitigate climate change impacts. Economically, the cultivation of fast-growing trees can diversify income sources for rural populations, reduce poverty, and enhance food security by integrating agroforestry practices.

Policy frameworks that support the planting and management of these trees can significantly influence their success. Governments and international organizations can promote the use of poplars and fast-growing trees through subsidies, technical assistance, and market development initiatives. Additionally, incorporating these trees into land restoration and reforestation projects can accelerate efforts to combat desertification and land degradation.

In conclusion, poplars and other fast-growing trees play a pivotal role in sustaining communities and environments. By integrating these species into policy and practice, it is possible to achieve substantial environmental and socio-economic benefits, thereby supporting sustainable development goals and fostering resilient communities.

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Explanation

French initiatives to promote poplar : original regional and public/private policies

by Emmanuel Naudin | Conseil National du Peuplier

ID du résumé: 120
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-POL - Policy and Livelihood

The discontinuation in 1999 of the National Forestry Fund, created in 1946 to help foresters with afforestation/reforestation and management work, left a gap. In some regions, local authorities have provided support for specific poplar initiatives.

Faced with the inadequacy of these actions in favour of poplar, in 2011-21012 the poplar industry began to set up the Merci le Peuplier charter, designed to encourage reforestation after harvesting.

In 2014, an original public-private initiative to encourage poplar reforestation was set up in Poitou-Charentes (in the north of the Nouvelle-Aquitaine region). Two factors played a major role in making the public authorities aware of the advantages of the poplar: a local storm in 2012, which prompted questions and a need for support, and the national extension of the Merci le Peuplier charter by the Conseil National du Peuplier (a private association).

Thanks to this original support for the exemplary Poplar and the development of Merci le Peuplier with the support of local professionals, other French regions have decided to support Poplar reforestation in the same way, such as the Grand-Est and Pays de la Loire regions, which have the most developed programmes along with Nouvelle-Aquitaine.

Support for Poplar also involves communication and research.

The actions carried out by the Conseil National du Peuplier always meet a collective need, and are financed by private funds (France Bois Forêt, CODIFAB, etc.) and public funds (State, Regions) in varying proportions.

For example, an information campaign on poplar for local authorities received broad support from several regions (Centre, Grand-Est, Hauts de France, Nouvelle-Aquitaine, Pays de la Loire), which facilitated or increased the distribution of the leaflet "Le Peuplier : un atout irremplaçable" (Poplar: an irreplaceable asset) in 2020. The same applies to other information initiatives, such as the creation of video tutorials on poplar growing and poplar.

Major research initiatives (cold storage of seedlings) have been supported by both the State and local authorities (Regions), in addition to private funding.

This decentralisation is a challenge, as it means that different funders have to be sought for each action, but it is also an advantage, as it provides an optimal response to the practical and evolving needs of the industry.

Partenariat Public Privé dans la mise en place des plantations forestières : Cas du projet ECO-NZAMBA de la SNPC, en République du Congo.

by EBIO Aymar-Delmas | Ominga Maixent Raoul | MATONDO Rosalie | Coordonnateur du Projet ECO-NZAMABA de la Société Nationale des Pétroles du Congo (SNPC) | Directeur Général de la Société Nationale des Pétroles du Congo (SNPC) | Université MARIEN

ID du résumé: 140

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-POL - Policy and Livelihood

La République du Congo a mis en place un vaste programme d'Afforestation et de Reboisement depuis l'an 2011. Ce programme vise la mise en place d'Un million d'hectares de plantations et agroforestières à usages multiples dans le but de lutter contre les méfaits du dérèglement climatique, la pauvre et surtout promouvoir l'économie verte. Ce programme est mis en œuvre par trois catégories d'acteurs à savoir : les industriels privés à hauteur de 70 soit 700 000 ha l'Etat à hauteur de 20% soit 200 000 et les petits promoteurs à hauteur de 10% soit 100 000 ha. La mise en œuvre de ce programme nécessite des partenariats Public –Privé que le Congo expérimente depuis 2011. L'expérience est salutaire pour les populations riveraines des périmètres de reboisement et apporte de nombreux atouts dans le contexte du développement local. Le programme connait le développement de plus de onze (11) filières industrielles à partir du bois issu des plantations et est aujourd'hui une clé dans le développement durable. La Société Nationale des Pétroles du Congo (SNPC), une société congolaise œuvrant dans le domaine du pétrole s'engagé à diversifier ses activés en investissant sur un puits de carbone de 50 000 hectares, à bases des essences à croissance rapide, dans les Plateaux Batéké, dans le Département des Plateaux, pour une séquestration d'environ 30 millions d'équivalent tonnes Carbone à termes.

Mots clés : Partenariat Public/Privé, Plantations forestière, Développement local, puits de carbone

POSTER

WP GEN

Working Party on Genetic Resources

IPC - Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

KEY TALK

Genome-wide methylome stability and parental effects in the worldwide distributed Lombardy poplar

by Vanden Broeck A., Meese T., Verschelde P., Cox K. , Heinze B., Deforce D., De Meester E., Van Nieuwerburgh F. | Research Institute for Nature and Forest

ID du résumé: 17

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

The ability of tree species to adjust to changing environmental conditions is vital for their survival. Epigenetic mechanisms can regulate gene expression and facilitate these adaptive responses. Understanding the causes of epigenetic variation and insights into the epigenetic stability over generations is important for defining the evolutionary role of epigenetics.

The Lombardy poplar offers an ideal opportunity to investigate the impact of the environmental history on the methylome. This clonal variety of *P. nigra* L. originates from a single mutant male tree that has been distributed worldwide since the beginning of the 18th century. The Lombardy poplar is propagated by cuttings from plant material that has been grown locally, sometimes for centuries. It can be expected that the large-scale vegetative reproduction may have resulted in the accumulation of lineage-specific epimutations.

Here, we present the results of three interconnected experiments on Lombardy poplar: two observational experiments on the methylome and one study on phenotypic plasticity in a common environment experiment.

In the first methylome experiment, we investigated methylome dynamics during early plant life. We studied the variability of the methylome during a growing season and across vegetatively reproduced generations. We found that ramets collected over Europe and raised in common conditions have stable methylomes in symmetrical CG-contexts. In contrast, seasonal dynamics occurred in methylation patterns in CHH-context.

In the second experiment, we investigated whether methylome patterns of plants grown in a non-parental environment correlate with the parental climate. We did not observe a biological relevant pattern that significantly correlates with the parental climate.

Finally, we investigated phenotypic plasticity over vegetative generations. We studied whether the parental environment has persistent carry-over effects on the vegetative offspring's' phenotype in

terms of bud set. We found a statistically significant but weak short-term, parental carry-over effect on the timing of bud set. However, this effect was negligible compared to the direct effects of the offspring environment.

We concluded that methylation patterns in CG-context can be used as bio-markers to infer a common ancestor and thus to investigate the recent environmental history of a specific Lombardy poplar.

Reference

Vanden Broeck A., Meese T., Verschelde P., Cox K. , Heinze B., Deforce D., De Meester E., Van Nieuwerburgh F. 2024. Genome-wide methylome stability and parental effects in the worldwide distributed Lombardy poplar. BMC Biology, № 1. https://doi.org/10.1186/s12915-024-01816-1·

Genetic parameters estimation for adaptive foliar traits (terpenoids, spectral reflectance) in conifers.

by Dr. Ebenezer Iyiola | Dr. Julie Godbout | Mr. Loic Soumila | Dr. Melody Keena | Dr. Ilga M. Porth | Institut de Biologie Intégrative et des Systèmes, Université Laval, Québec, QC, Canada. Département des Sciences du Bois et de la Forêt, Université Laval, Québec, QC, Canada. | Ministry of Forest and Natural Resources, Quebec, QC, Canada. | Institut de Biologie Intégrative et des Systèmes, Université Laval, Québec, QC, Canada. | Department of Agriculture, Northern Research Station, US Forest Service, United States. | Institut de Biologie Intégrative et des Systèmes, Université Laval, Québec, QC, Canada.
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ID du résumé: 28
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-GEN - Genetic Resources

Despite ever decreasing costs for genotyping, the major challenge remains cost-effective and high-throughput precision phenotyping. Forest trees increasingly experience major challenges related to climate change, including phenological mismatches, physiological stress, and more severe attacks by pests and pathogens. In this context, our research aims to quickly inform the selection of genotypes in Canadian conifer breeding towards resistance and/or physiological tolerance to drought stress. For example, insect feeding experiments combined with metabolic profiling of the host tissue can provide valuable information on constitutive defenses and host preferences. Moreover, foliar spectral reflectance is widely used in determining the physiological condition of agricultural crops, but limited research has been conducted on such indices' genetics in forest trees to identify their increased stress tolerance and growth performance over a growing season. Here, we conducted two studies: first, testing the invasive *Lymantria dispar asiatica* performance on seedlings of coastal Douglas-fir and nine other equally important Canadian conifer species, along with evaluating the potential to breed for host resistance for terpenoid metabolites of interest for the B.C. F2 Douglas-fir breeding program; second, evaluating clonal heritability of foliar spectral reflectance to deduce growth performance in white spruce along the MayOctober growing season in Quebec province. Our results firstly show Douglas-fir to be susceptible, with its biochemical profile differing from unfavorable white spruce. Among 32 tested compounds, F2 families yielded promising narrow-sense heritabilities and positive genetic correlations for four terpenoids amendable to tree improvement. Secondly, there was heritable variation across the leaf spectral reflectance profile (~350 to 2500 nm) in white spruce, peaking higher for June and August. Moreover, higher genetic control was found in certain infrared spectral regions (NIR, SWIR), enabling breeders to focus on specific spectral indices as most promising for future genomic selection.

Poplar Genomics: Unlocking the Potential of a Versatile Tree

by Ilga Porth | Yousry El-Kassaby | Université Laval | The University of British Columbia

ID du résumé: 39
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-GEN - Genetic Resources

Poplar trees (genus *Populus*) are of crucial importance for some valuable forest ecosystems. They are characterized by their rapid growth and their ecological and economic benefits, including carbon sequestration, timber and bioenergy production. By decoding traits such as drought tolerance, we can create resilient tree populations that promote ecosystem stability. Poplar genomics is central to understanding the genetic basis of traits such as growth, wood formation and environmental adaptation. The importance of this field also extends to addressing environmental challenges such as climate change and reforestation. Applications of poplar genomics include sustainable agriculture, phytoremediation and the production of biofuels from lignocellulosic feedstock. Ongoing research in the field of poplar genomics promises to improve our understanding of tree biology and realize the full ecological and economic potential of poplars. High-throughput sequencing has enabled detailed mapping of several poplar genomes, facilitating the development of better tree varieties. Some of these significant advances in poplar genomics and their implications will be discussed, especially for North American species *P. trichocarpa* (the black cottonwood) and *P. tremuloides* (quaking aspen). In summary, poplar genomics is at the forefront of research on vital tree species and holds great promise for advancing sustainability and ecological health.

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Response of growth and wood property of Populus to different climate zones

by NingLiu, Jan Van den Bulcke, Liselotte De Ligne, Qinjun Huang, Joris Van Acker, | Ghent University, Woodlab

ID du résumé: 43

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Poplars (*Populus spp.*) are among the most important fast-growing timber species in temperate regions, making their climate sensitivity crucial for breeders. While breeders typically select based on genotype and environmental interactions, large-scale 'climategrowth' modeling is rarely conducted. Current research often focuses on tree species within forest ecology, which makes it challenging to achieve species-, section-, or clone-level accuracy. Our study examines artificially planted poplars in plantations, along roadsides, and in parks, allowing us to gather precise information on their age, planting spacing, management parameters, and genetic background. These data aids in understanding poplar's climate response more accurately.

The poplars in this study are distributed in typical climatic zones of China and Europe, including 14 Köppen-climate types in temperate and subtropical zones. The experimental materials were poplars of the *Sect. Aigeiros, Sect. Populus* and *Sect. Tacamahaca* that were more than 10 years old. We have been using X-ray CT techniques with equipment from UGCT of Ghent University to scan all collected samples and obtain parameters such as treering width (TRW), wood density, and vessel characteristics. And representative samples will be selected for detailed wood anatomical analysis. Our research includes examining radial growth patterns of various poplar species and sections, responses to drought and high altitude, variations in multi-site clones, juvenile and mature wood characteristics, age effects and quantitative maturity, earlywood and latewood, and predicting poplar distribution. We have collected samples from 154 trees (308 cores) across 15 sites in China (April-October 2023) and are currently sampling in Europe (Belgium, France, Spain, Hungary, Italy, etc.). Our overall objective is to uncover patterns in poplar growth responses to environmental factors to enhance future breeding and cultivation strategies.

Breeding strategies for improving poplar resistance to Woolly Poplar Aphid

by Chiara Biselli | Agostino Fricano | Andrea Carra | Lorenzo Vietto | Franco Picco | Laura Rosso | Giorgia Carletti | Veronique Jorge | Angela Teani | Filippo Maria Valentini | Luigi Cattivelli | Giuseppe Nervo |
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ID du résumé: 57
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-GEN - Genetic Resources

Climate change is expected to exacerbate the impact of pests and diseases on forest species worldwide. Woolly Poplar Aphid (WPA) is one of the major biotic threats of poplar plantations, causing up to 12% yield losses in Europe and the USA. The deployment of efficient breeding programs for high-quality WPA-resistant genotypes is pivotal to sustaining a bio-based agriculture to face future climatic scenarios. Conventional breeding programs, based on phenotypic selection, have been successful in selecting resistant *P. × canadensis* hybrids with high performance in multi-environment trials. However, poplar breeding based on truncation selection is time-consuming and cannot guarantee a prompt solution to the changing environment. Recent advances in genomics and genome-assisted breeding offer powerful tools to efficiently exploit genetic diversity for poplar improvement and reduce time and costs to deliver new clones.

In this work, linkage mapping and Genomic Prediction were applied to expand the sources of poplar resistance to WPA. Linkage mapping was pursued using two segregating F1 populations: one including 183 individuals derived from a cross between D066 (resistant *P. deltoides*) and N074 (susceptible *P.*

nigra), and another consisting of 265 individuals from a cross between two *P. nigra* clones: N355 (resistant) and N385 (susceptible). Phenotypic evaluations for WPA resistance, performed under controlled conditions, were carried out for the F1 individuals as well as for two diverse panels of 440 *P. nigra* and 88 *P. deltoides*. The entire germplasm was genotyped using the 4TREE multispecies SNP array including 13,409 poplar-specific loci covering the whole poplar genome.

Linkage mapping confirmed two QTLs associated with D066 resistance, previously mapped on chromosomes 5 and 19. A resistance new major QTL, explaining more than 60% of the phenotypic variance, was discovered for N074 on chromosome 1. Candidate genes for WPA resistance have been identified within the confidence intervals of each QTL.

Fitting genome-enabled prediction models, using 13,409 polymorphic SNPs in the two families of F1 individuals and in the two *P. nigra* and *P. deltoides* panels, showed that molecular markers explained about 50% of the phenotypic variance. Cross-validation analyses indicated that prediction accuracy varies from 0.54 for the diverse panel of *P. deltoides* to 0.86 for the collection of *P. nigra*.

The new sources of resistance, along with predictive models, developed in the present study represent valuable tools to design molecular markers to allow an efficient early selection for WPA resistance, speeding up the breeding process.

ICFRE Research Programme on Poplar and Willow Culture in North India

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ID du résumé: 101

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Poplars and willows are important plants in the landscape of northern India. This plant group is particularly prominent and economically important in the western half of its distribution range. Poplars such as *Populus ciliata, P. alba, P. nigra, P. euphratica, P. laurifolia, P. balsamifera,* etc., and willows especially *Salix alba, S. fragilis, S. babylonica,* etc. are the major plantation species in the Kashmir and Ladakh Himalayas and support numerous traditional uses while few of these species provide raw materials to a thriving cricket bat industry. They prefer moist localities; therefore, to expand planting in the cold desert – a region with very low temperatures and minuscule rainfall. Research on poplar in the Indian Council of Forestry Research and Education (ICFRE) is now focused on enhancing the availability of moisture in the rhizosphere. The plain region stretching from Punjab to western Uttar Pradesh is a zone of intensive poplar culture where *P. deltoides* plantations are managed at rotations of 4 to 6 years. Efforts are being made to further improve plantation productivity by testing new clones at three sites in Haryana, Punjab and western Uttar Pradesh.

Efforts are also underway to extend the cultivation of *P. deltoides* in eastern Uttar Pradesh and Bihar. The wood of *P. deltoides* is mainly used by the veneer and plywood industry. The limited buyer base of *P. deltoides* leads the wood producers in the hands of a monopolistic industry. New products are being made to utilise waste wood. Poplars are prone to attacks by insect pests and diseases. Few new insect pests and diseases have been identified and biocontrol measures are being developed. DNA profiles of various species and clones are being developed. *P. gamblei* is a native species of poplar in the eastern Himalayan region; the species is being tested westwards in introduction trials at similar latitudes. However, willows require greater research effort at ICFRE.

Impact of stress on the response of male and female trembling aspen in North America

by Barb Thomas | University of Alberta

ID du résumé: 107

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

400 words

North America's trembling aspen, (*Populus tremuloides*), is an extraordinary species with a myriad of strategies to survive and persist on the landscape. The distribution spans from Alaska to Newfoundland (west-east) and from the Northwest Territories to central Mexico (north-south). Since the early 90's I've worked to understand the plastic and genetic responses of aspen in Alberta, Canada, to drought, CO_2, increases in temperature (above and below ground), clonal versus seedling/family, and region and how - ultimately these stressors impact the distribution and size of male and female clones on the landscape.

With the advent of a molecular marker (Pakull et al. 2014) developed to determine sex, a new avenue of study related to sex using seedlings opened-up. Prior to this marker being available, only mature flowering trees could be identified as to their sex, requiring either rooting of suckers (stecklings) or tissue culture if studies were to be conducted on performance differences between the sexes using pre-identified clones. Furthermore, other phenotypic measures used to identify 'clones' in the field, when trees are not flowering, such as bark or timing of senescence, have been shown to be influenced by their environment and may not be a true reflection of a trees genetic, clonal or sex identify.

I will present an overview of 30-years of study on trembling aspen using a combination of field and greenhouse studies to tease out and answer questions and identify new challenges facing trembling aspen on the landscape.

Poplars facing drought: synthesis and future opportunities

by Régis FICHOT | Université d'Orléans - Laboratoire P2e (Physiologie, Ecologie, Environnement)

ID du résumé: 109

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Poplars (*Populus* spp.) represent an attractive and valuable forest resource under temperate latitudes for wood and biomass production and stand as a model organism for studying the genetics and genomics of tree physiology. The genus is genetically, morphologically and ecologically diverse, with about 30 species widely distributed over the northern hemisphere at temperate latitudes. Most of them are considered as vegetational pioneers and much of the interest in planting poplar lies in their inherently high growth rates. This is, however, typically counterbalanced by large water requirements and an overall high drought sensitivity justifying the progressive inclusion of drought response strategies in breeding programs. Here we summarize the state of the art regarding the main traits involved in drought resistance in poplar depending on drought contexts (moderate vs. potentially lethal), how these may vary between and within species including hybrids, and how these may be coordinated with other traits of interest. Potential implications and gaps in knowledge are discussed in the context of poplar cultivation, species adaptation and climate modifications. We finally expand our vision by exploring how external factors such as nutrients availability may shape drought responses and how epigenetic mechanisms such as DNA methylation might be involved in stress-induced phenotypic plasticity and stress memory under repeated drought.

Accelerating Willow Breeding and Deployment (AWBD)

by William Macalpine | Jackie Barker | Felipe Torrenti | Funmi Ladejobi | Sophie Titman | Sergio Cerezo-Medina | Andrew Mead | Steve Hanley | Ian Shield | Rothamsted Research | Rothamsted Research | Rothamsted Research | Rothamsted Research | Rothamsted Research | Rothamsted Research | Rothamsted Research | Rothamsted Research | Rothamsted Research | Rothamsted Research

ID du résumé: 131

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Rothamsted Research is developing the tools to accelerate the breeding and deployment of new and improved SRC willow varieties through Accelerating Willow Breeding and Deployment (AWBD). AWBD is funded by the Biomass Feedstocks Innovation Programme, which is a £36 million programme, funded through the UK Government Department for Energy Security & Net Zero's £1 billion Net Zero Innovation Portfolio. The Biomass Feedstocks Innovation Programme aims to increase the production of sustainable UK biomass feedstocks.

Accelerating Willow Breeding and Deployment has three main objectives:

1. Precision deployment of optimal varieties for different growing environments to maximize feedstock production.
2. Implementation of a Genomic Selection (GS) strategy that will accelerate the production, performance and security of UK SRC willow varieties for the bioenergy market.
3. Acceleration of access to new varieties by micropropagation coupled with GS for rapid multiplication of optimal genotypes.

Training Populations have been established at five different environments across the UK, each with its own environmental stressor:

Somerset Levels: Assessing flood tolerance.

Bedfordshire (sandy soils, low rainfall): Assessing drought tolerance.

Aberdeen: Assessing impact of longer day lengths and cooler growing seasons.

Northern Ireland (NI) (high humidity and disease pressure): Assessing disease tolerance.

Northumberland: A control environment, similar to those used in previous trial work.

Each trial, excluding NI, has a training population comprising 560 genotypes of which the project is generating the genome sequence of each. The trials are replicated across four blocks. In NI, 144 genotypes have been planted as a smaller test population where predictions from the other four sites will be applied and evaluated.

The purpose of these trials is to look at the field data and observable traits (phenotypes) of the SRC willows and compare with the genome sequences to identify consistent patterns for predicting biomass traits of interest. These include establishment, yield, disease and pests under the different growing conditions. Taken together this will provide the data that will inform breeding decisions for superior, new varieties, as well as information matching variety to environment.

A summary of progress of all three objectives will be presented.

TALK

Hybrid Poplar Research Program in Minnesota: A Brief History

by Andrej Pilipovic | Jeff Jackson | Bernie McMahon | Neil Nelson | Bill Berguson | John DuPlissis | Natural Resources Research Institute (NRRI), University of Minnesota Duluth, Duluth, MN, USA | Natural

ID du résumé: 7

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Early research into hybrid poplar (1920's) was for the development of conventional pulpwood. This started to change in the 1970 with the first OPEC Oil Crisis as demand for alternative energy source began to drive research from traditional pulpwood to biomass for home heating and energy production. The testing and identification of superior genotypes of Eastern Cottonwood (*Populus deltoides* Bartr.) was started by Professor Carl Mohn from the University of Minnesota followed region clonal testing performed by Hansen et al (1992 and 1994).

Shortage of aspen supply in 1990's in Minnesota increased demand for wood biomass by local pulp and paper industry initiate forming of the Minnesota Poplar Research Cooperative with Natural Resources Research Institute at the University of Minnesota Duluth (NRRI) as a lead of the hybrid poplar research within the program. This cooperative operated from 1996-2016, supported by industry and various state and federal grants and developed a total of 2419 intra- and interspecific and intra- and intersection control-pollinated crosses tested at 43 sites in seven states across the central and northeastern United States with a total area of approximately 41 ha.

Since 2020, the focus of the NRRI's hybrid poplar program focus has changed from the developed of clones toward the commercialization of superior clones which have been proven to perform well in the central and northeastern United States which resulted in the registration and patenting of the geo-robust *Populus x euramericana* Dode. Guinier clone 99059016 a.k.a. "NextGen". Concurrent with the patenting, the registration of the trademark "InnovaTree™" for this clone is also ongoing. The commercial sales of the clone started in 2023 with the signing of the license agreement with commercial nurseries in Wisconsin, Michigan and Minnesota which increased the interest for this clone both by the nursery men and customers.

Future development of the NRRI's hybrid poplar program will be directed by the contemporary trends in poplar research and sustainable development aligned with the UN SDG's and NRRI's goals and core values.

Content of eight heavy metals in poplar and willow clones cultivated in pots using soil from a landfill sites

by Lazar Kesić | Branislav Kovačević | Marina Milović | Leopold Poljaković-Pajnik | Saša Pekeč | Dragica Stanković | Goran Trivan | Ratko Ristić | Milutin Djilas | Verica Vasić | Saša Orlović | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute for Multidisciplinary Research | Institute for Multidisciplinary Research | University of Belgrade | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment

ID du résumé: 30

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

The research on poplar and willow clones for this study is particularly relevant due to the historical cultivation of these species for environmental benefits. Both poplars and willows are known for their fast growth, extensive root systems, and high tolerance to various environmental conditions, including heavy metal contamination. This study is focused on evaluation of the potential of certain poplar and willow clones in pot trial for phytoextraction of heavy metals from substrate based on soil from landfill sites near Novi Sad and Belgrade. By examining the content of nine heavy metals (Cd, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) in different clones grown in soil from the landfill, it has been aimed to identify the most suitable candidates based on their ability to thrive and accumulate heavy metals in this challenging substrate. Among the clones, the willow clone (107/65-9) in Belgrade and Eastern cottonwood clone S1-8 in Novi Sad, showed differences in zinc tolerance. The I-214 clone is notable for its copper accumulation, while the Pannonia and PE19/66 clones accumulated the highest amounts of manganese from Belgrade landfill soil. It can be recorded that the willow clone is better suited for increased watering on the heavier soil from Belgrade landfill soil, whereas the S1-8 clone performs well on the soil with higher sand content such as landfill soil from Novi Sad.

Acknowledgement

The study was supported by the Science Fund of the Republic of Serbia Green program of cooperation between science and industry „Landfill Remediation with the Use of Short Rotation Biomass Woody Crops (SRWC) Energy Plantations and Provisioning Multiple
Ecosystem Services“ (TreeRemEnergy)

Genetic linkage map and QTL identification in Populus tremula var. davidiana using GBS in South Korea

by Suvi Kim | Yang-gil Kim | Department of Agriculture, Forestry and Bioresources, Seoul National University, Seoul 88026, South Korea | Department of Agriculture, Forestry and Bioresources, Seoul National University, Seoul 88026, South Korea

ID du résumé: 35

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Genus *Populus* is a tree species that grows fast and exhibits excellent carbon absorption capacity with a large environmental purification effect. Poplar breeding can be fast and efficient if a genetic linkage map is constructed and quantitative trait loci (QTLs) are identified. In this study, a high-density genetic linkage map was constructed for the control pollinated progeny using the genotyping-by-sequencing (GBS) technique, which is a nextgeneration sequencing method. In addition, the quantitative trait genes located in the genetic linkage map were searched by examining the characteristics of the height and diameter at root collar, and the resilience to insect damage. The height and the diameter at root collar were survey, and the ability to recover after insect damage was scored in a 4year-old breeding population of aspen hybrids (Odae19 × Bonghyeon4 F1) established in the research forest of Seoul National University. After DNA extraction, paternity was confirmed using five microsatellite markers, and only the individuals identified as paternity were used as research materials. The DNA was cut using restriction enzymes, and these DNA fragments were prepared using a GBS library and sequenced. The analyzed results were sorted using *Populus trichocarpa* as a reference genome. There were a total of 58,040 aligned single nucleotide polymorphism (SNP) markers, and 17,755 SNP markers among them were used for mapping genetic linkages. The genetic linkage map was divided into 19 linkage groups, and the total length was 2,129.54cM. As a result of quantitative trait locus analysis, growth-related quantitative trait loci could not be found, but a gene presumed to be related to the recovery of insect damage could be identified on the linkage group (chromosome) 4 through the genome-wide association study (GWAS).

Black alder genotypes with high level of resistance against Phytophthora ×alni

by Novotná Kateřina | Štochlová Petra | Štochl Marek | Pecka Štěpán | Černý Karel | Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Inst.

ID du résumé: 40

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Black alder (*Alnus glutinosa*) is autochthonous woody tree in Europe. It is one of the key species of riparian and carr ecosystems. In some countries it belongs among species growing in short rotation coppice systems however in the Czech Republic it is not common. Nowadays it faces up to threat of invasive pathogen *Phytophthora ×alni*. This oomycete can rapidly cause the tree declining and breakdown whole affected ecosystems. *In vitro* testing of differences in alder resistance to *P. ×alni* started in the Czech Republic 15 years ago. The best thirteen genotypes were selected out of the 90 tested trees and vegetatively propagated. Last 6 years, these genotypes are used for controlled crossings (open pollinations are used as a control). Resistance level of obtained progenies is repeatedly tested. The higher number of highly resistant genotypes were identified in progenies of more resistant genotypes. They can serve as a reservoir of resistant genotypes for ecosystem services in changing climate as well as be used for yield testing.

Performance of experimental and commercial poplar clones in a wide-spaced field trial assessed at age 6-8 years and at 19-21 years.

by Ian McIvor | Plant & Food Research

ID du résumé: 61

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

In New Zealand, poplars are used as bioengineering tools to combat soil erosion and conserve soil on moist, unstable pastoral hill country. Four *Populus maximowiczii* × *P. nigra* experimental clones, bred for soil conservation, were trialled on pastoral land in six different climatic zones. The experimental clones (identified as NZ5033, NZ5034, NZ5035, NZ5036) were planted together with six New Zealand-bred commercially available clones (four *P. deltoides* × *P. nigra* clones, either 'Toa' (*P.* × *euramericana* × *P. yunnanensis*) or 'Kawa' (*P. deltoides* × *P. yunnanensis*), and 'Shinsei' (*P. nigra* × *P. maximowiczii*)). The clones were planted as unrooted 3-m poles on open, sloping (and often broken) terrain. Replication was 5 or 10 poles per clone/site/year subclass. Trees were planted at a spacing of 20 m x 10 m. Survival, height, and diameter at breast height (DBH) were measured six to eight years after establishment. The different clones were ranked on performance (survival, height growth, diameter growth, and wood volume) in each location and overall. The findings were published.

Questions arise about how conclusions on growth performance for young trees still hold true as the trees age and whether rankings of clonal performance, and desirable features such as narrow form change as the trees mature. Coupled with this, over time changes in environmental expectations and political directions can alter the requirements and specifications for new cultivars. In particular, canopy spread has shifted from undesirable to desirable as a response to a government scheme that rewards landowners for storing carbon.

The trials were reassessed at 19-21 years old and comparisons made with the earlier published findings. Survival, height and diameter at breast height (DBH) were again measured, together with canopy spread. Findings will be presented, together with some of the environmental and political expectations on poplar and other trees bred for erosion control that have changed since the trials were planted in 1999-2001.

Integrated assessment of late frosts and summer drought risk under climate change: Novel framework in provenance selection applied to balsam poplar in Central Canada

by Benjamin Marquis | Raju Soolanayakanahally | Canadian Forest Service, Natural Resources Canada, Great Lakes Forestry Centre, Sault Ste Marie, Ontario, Canada, P6A 2E5 | Agriculture and Agri-Food Canada, Indian Head Research Farm, Indian Head, Saskatchewan, S0G 2K0, Canada

ID du résumé: 63

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Assisted gene flow is a promising solution to agro-forest management under climate change, but provenance selection needs to be based on a framework that integrates multiple environmental risks instead of assessing tree responses to a single environmental risk. Here, we present a framework to analyze the vulnerability of balsam poplar (*Populus balsamifera* L.), a species with North American distribution, to both late frosts and summer droughts and compare the paradigm of planting locally against assisted gene flow to maximize future tree productivity. Observations of the timing of bud break were collected between 2008–2012 and 2016–2019 on 41 provenances of balsam poplar planted in a common garden established in 2005 at the southern edge of the species range in Central Canada. We calibrated 18 bud phenology models using observations from 2008–2012 and predicted the timing of the bud break in 2016–2019. The bud phenology models with the lowest root mean square error were used to predict the future timing of bud break using 12 climate models from the Canadian Downscaled Climate Scenarios (CMIP6) for two socioeconomic pathways (SSP 2.45 and 5.85) for the period 2020–2100. Exposure to late frosts was determined if the air temperature dropped below 0 °C once buds were opened, and exposure to summer droughts was determined by calculating the difference in the drought index (SPEI) between the geographic origin of the provenances and the common garden. Vulnerability was assessed by developing a two-dimensional index made of the three-level categorical score per environmental risk. We analyzed the transitions from one vulnerability state to another using generalized linear regressions and identified when provenances decrease or increase in vulnerability under climate change, which can improve plantation resilience to climate change. Under the most pessimistic climate change scenario, provenances in Central Canada decreased in vulnerability, mostly due to the decrease in risk of exposure to late frost, but under the mild climate change scenario, most provenances increased in vulnerability to climate change since the change in exposure to late frost was not sufficient to balance the increasing risk of exposure to summer droughts. Importantly, provenances near the common garden were still expected to be less vulnerable to climate change compared to provenances with geographic origins that were

far from the common garden. However, we expect that provenances could be moved farther along the longitude compared to along the latitude; hence, the expression “planting local” should be revised to “planting regionally”.

Endophytes for increasing plant resilience to climate change

by Morgan Raimondo | Andrew W. Sher | Robert Tournay | Sharon L. Doty | University of Washington Seattle | University of Washington Seattle | University of Washington Seattle | University of Washington Seattle

ID du résumé: 66

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Given urgent environmental challenges due to a changing climate, enhancing the resilience of fast-growing trees like *Populus* to elevated temperatures is critical for climate change mitigation and adaptation. Endophytes, beneficial microbes living symbiotically within plants, have been shown to support plant health, yet their role in conferring heat tolerance remains underexplored. The beneficial effects of endophytes on plant heat tolerance may be more pronounced under stress conditions compared to ambient temperatures, suggesting an adaptive response. Previous studies demonstrated that the plant microbiome of the same *Populus* species varied across different geographical locations. This variation is influenced by local environmental factors that shape the composition and function of the microbial communities, where poplar growing in the drier, hotter conditions of the east Cascade Mountain range harbor distinctly different phyllosphere microbiomes when compared to the cool, moist west-side. This study investigates endophytes derived from *P. trichocarpa* from the semi-arid Yakima River area in Washington State, USA, to enhance heat tolerance to host plants. Sterile *P. trichocarpa* Nisqually-1 were inoculated with individual endophyte strains (n=14) and assessed for key growth parameters, including biomass, chlorophyll production, and water use efficiency under simulated arid conditions using a novel screening method. Two endophyte strains improved plant growth and several enhanced chlorophyll content, indicating their potential to promote thermal stress resistance. Inoculation was confirmed using droplet-digital PCR. Whole genome sequencing of the bacterial strains was conducted to elucidate the mechanisms behind these heat stress conferring abilities. These findings offer a method for screening for beneficial endophyte strains underheat stress and highlight the potential of plant-microbe partnerships in forestry and agricultural systems to foster climate resilience and support carbon-neutral societies. This research demonstrates how endophytes can enhance the sustainability and productivity of fast-growing trees, contributing to ecosystem restoration and sustainable wood production. By improving heat tolerance capabilities of economically important species, this work addresses the critical need for climate-adaptive forestry practices in changing environments.

Black poplar and its current state in the Czech Republic

by Petra Štochlová | Kateřina Novotná | Kateřina Podrábská | Hana Drahošová | Vladimír Zýka | Daniel Zahradník | Dita Šetinová | Veronika Strnadová | Marek Štochl | Karel Černý | Silva Tarouca Research Institute for Landcape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landcape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landcape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landcape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landcape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landcape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landcape and Ornamental Gardening, Publ. Res. Inst. | Silva Tarouca Research Institute for Landcape and Ornamental Gardening, Publ. Res. Inst.

ID du résumé: 71

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Black poplar (*Populus nigra*) is an autochthonous European woody species that is endangered not only in the Czech Republic. Recently, its importance increased as it can substitute other key species of riparian stands (ash, elm, alder) that are threatened by human activity but much more by invasive pathogens that reduce their populations and change significantly composition and structure of these stands with impact on whole ecosystems.

The work focusing on black poplar started in our institute more than 30 years ago. Firstly, activity to select and conserve genetic resources (*in-situ*, *ex-situ*) had taken place. Afterwards, the selected trees were tested, their genetic diversity was studied focusing also on the level of introgression and inbreeding. The selected trees were also used in breeding programme with the main goal to obtain trees with resistance to *Melapsora larici-populina* leave rust, high biomass yield and recently although tolerant to drought and climate change.

The situation of black poplar population in the Czech Republic did not change noticeably from that time. Some of the previously selected and conserved trees already died. Demand for identification of new trees with desired characteristics emerged. Therefore, project focusing on the black poplar conservation and its application in water management and forestry was recently financially supported by the Ministry of Agriculture of the Czech Republic (project QK22010142) to make better situation of black poplar populations and the riparian stands. During the recons, mainly the residues of local populations have been found. Less than one quarter of the evaluated trees is healthy. Nearly three quarters of evaluated trees are older than recommended coppice age for poplars. In the surroundings

of majority of evaluated trees, there is presence of other poplars (mostly *P.* ×*canadensis*) and natural regeneration was recorded in surrounding of only one fifth of evaluated trees. It comes mostly from vegetative propagation. Among evaluated trees, the genotypes with desired characteristics are selected, propagated and afterwards planted in clone archive.

Alongside identification of black poplar trees and their stands, the factors to successful reintroduction of the species to riparian forests are studied. Two in-situ plantations of seedlings were established where minimal requirements of planting material are tested. Negative effect of inbreeding on seed germination and growth characteristics was observed in pre-growth of saplings.

The obtained findings have important implications for reintroduction of black poplar into riparian forests and can help to assist its self-reliant and long-term survival in landscape.

Breeding of willows in Argentina, focused on growth, adaptation and multiple uses.

by Teresa CERRILLO | Esteban THOMAS | Jorgelina GRANDE | Lucas LEVERONE | Victorio DIETA | Sabrina LOVAL | Susana TORALES | Florencia POMPONIO | Virginia LUQUEZ | INTA (National Institute for Agricultural Technology), EEA Delta, AER DF, Tigre, Argentina | INTA (National Institute for Agricultural Technology), EEA Alto Valle, Río Negro, Argentina | Central Laboratory of Woods. Papel Prensa SA. San Pedro, Argentina | Forestry Production Direction from the Ministry of Bioeconomy, Buenos Aires, Argentina | INTA (National Institute for Agricultural Technology), AER DF, Tigre, Argentina | INTA (National Institute for Agricultural Technology), EEA Delta, Campana, Argentina | INTA (National Institute for Agricultural Technology), CIRN, IRB, Castelar Argentina | INTA (National Institute for Agricultural Technology), CIRN, IRB, Castelar Argentina | INFIVE, CONICET (National Scientific and Technical Research Council), La Plata, Argentina

ID du résumé: 78

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Willows (*Salix* spp) have a wide global distribution and represent a valuable forest crop, with multiple applications. In Argentina, the genetic improvement of tree willows has been developed mainly through the introduction of genotypes, hybridization and selection. The first systematic improvement programs began in 1953, through work initiated at the National Institute of Agricultural Technology (INTA), which was followed by other developments that incorporated adjustment methodologies and protocols. These lines of work have taken into account new applications and potential through dynamic work with public-private collaboration, through INTA, CIEF (Forest Research and Experiences Center) and agreements with companies in the forestry sector. INTA´s current breeding program for willow aims to increase the diversity of productive and environmentally sustainable clones for a "multipurpose" standard, which includes sawing, paper industry (for packaging and newsprint) and environmental services (such as phytoremediation). The methodology comprises parental selection, interspecific hybridization followed by the evaluation and clonal selection on a network of trials in different environments in Argentina. The program involves germoplasm of the species: *Salix matsudana* Koidtz, *Salix alba* L., *Salix nigra* Marsh and *Salix amygdaloides* Andersson; more recently, *Salix humboldtiana* Willd. (the only willow native species) has been included in a conservation and domestication line. On the other hand, and following the same methodological strategy as for tree willows, a line of research was carried out for shrub willows, and five clones were selected for basketry (intraspecific hybrids of *Salix viminalis* and interspecific hybrids of *Salix viminalis* L x *Salix caprea* L). Due to the outstanding characteristics of growth, health, form and wood quality, between 2013 and 2022 eight improved tree willows have been released and registered at the National Seed Institute

(INASE) and there is a new set of five clones that will be released shortly. Specific analysis for pulp-paper of the most advanced genotypes carried out in the wood laboratory, simulating the industrial process, and outstanding values of wood fiber length and pulp resistance were observed in 5 released clones and 10 experimental genotypes. In April 2024, these laboratory results were satisfactorily verified for the clones released in the test carried out at the Papel Prensa company's industrial plant, following the real operational process. Furthermore, with the suitability for the sawing industry, the technological profiles of these new improved genetic materials, together with the productive and adaptive performance, show a promising horizon to improve the productive matrix of willow in Argentina.

0 words

Exploring wood anatomy plasticity in selected willow clones with differential critical flood tolerance in the Paraná Delta, Argentina

by Sabrina Loval | Teresa Cerrillo | Eleana Spavento | Silvia Monteoliva | INTA | INTA | UNLP | UNLP

ID du résumé: 100

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

This study examines the wood anatomy plasticity of willow clones (Salix spp.) in the Paraná Delta across three sites with different flood protection levels: highly protected (HP), moderately protected (MP), and unprotected (UP). The INTA´s willow genotypes analyzed were S. matsudana x S. alba hybrids: Agronales INTA-CIEF, Los Arroyos INTA-CIEF, and Tehuelche INTA and open-pollinated S. alba: Yaguareté INTA-CIEF. Measured stem variables included vessel diameter (VD), vessel frequency (VF), fiber wall thickness (FWT), and fiber lumen diameter (FLD) at juvenile (4 years) and adult (12 years) stages.

Hydraulic variables (related to vessel elements) exhibited greater plasticity than fiber variables across all clones. The VF variable showed more plasticity than VD, with plasticity ranges of CV=12-27% depending on the clone and site. Juvenile wood was always more plastic than adult wood for vessel variables, whereas the trend for fiber variables was not as clear.

Los Arroyos and Yaguareté are characterized as flood-tolerant, while Agronales and Tehuelche are not tolerant to critical flooding. VD and VF showed similar behaviors in the tolerant clones, with VD being more plastic and larger at the UP site (CV=11-16%) and VF at the HP site (20-27%), which is expected given the negative relationship between these variables. Correlations between juvenile and adult wood(J-AC) for these variables were moderate and positive (0.20-0.35), indicating early measurements could aid in selecting genetic materials with higher hydraulic efficiency.

FWT showed no significant differences between sites, but the highest values and plasticity were found at the MP site. FLD showed differences between sites, with the highest values and plasticity also at MP.

In hydraulic variables, Agronales and Tehuelche showed the highest values at the HP site, although the greatest plasticity was at UP site (8-15% for VD and 12-23% for VF). Significant J-AC were moderate and positive only for VD (0.17 in Agronales and 0.43 in Tehuelche). FWT differed significantly between sites. Agronales had the highest value at UP and greatest plasticity at HP; Tehuelche showed both at MP. For FLD, Agronales had the highest value at HP and greatest plasticity at UP; Tehuelche showed both at MP.

The tolerant clones produced wood with higher hydraulic efficiency and greater variability at the site with the most hydric content. Non-tolerant clones had higher hydraulic efficiency at the site with less water, but not always the greatest variability. These results validate previous clonal classifications of flood tolerance based on growth characteristics and wood quality.

GENETIC VARIATION AND GENOTYPIC SELECTION FOR LOW-NITROGEN TOLERANCE IN POPLAR VARIETIES AND HYBRID OFFSPRING

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ID du résumé: 103

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

It is important to investigate the adaptation of seedling traits in poplar varieties and hybrids under low nitrogen stress for genotypes selection. Using the potting method in greenhouse, a total of 87 varieties and 226 hybrids from the crossing between *P. simonigra* and *P. nigra* was used as plant material to determine growth, leaf morphology, chlorophyll fluorescence parameters and nitrogen isotope parameters traits under low nitrogen (LN) and normal nitrogen (NN) treatments. The analysis of genetic variation and the estimation of genetic parameters including in breeding values were performed using the Mixed Linear Models based on Restricted Maximum Likelihood/Best Linear Unbiased Prediction of (REML/BLUP). The multi-trait index based multi-trait genotype-ideotype distance index (MGIDI) was used to separately rank the varieties and genotypes of hybrid progeny, and to comprehensively evaluate their adaptability in the experiment. The mean values of growth and leaf morphological traits differed significantly between the two groups of N supply levels (LN<NN). For most of these above traits, the genotype effects were significant among the progeny, and the interaction effect (G × E) between genotype and nitrogen-supplying treatment environment was highly significant, whereas neither genotype effects nor G × E effects were significant for chlorophyll fluorescence parameters. The genetic parameters such as broad sense heritability (), mean heritability (), coefficient of genetic variation (CVg) were obtained respectively for the traits. The breeding values of growth and morphological traits and the observed values of nitrogen isotope parameters were used for principal component analysis (PCA). The first principal components for factor analysis (FA) were extracted with their eigenvalues above 1. The factors of FA reflected the information on growth, leaf morphology, nitrogen isotope composition and nitrogen isotope content respectively. The multi-trait index, MGIDI, was obtained to separately rank the varieties and the genotypes of the progeny. The selected 22 varieties and 42 genotypes showed dominance for growth, leaf morphology, nitrogen isotope combinations and nitrogen isotope content respectively. In conclusion, the seedling growth, leaf morphology and physiological traits of poplar varieties and hybrid progeny were significantly inhibited under low nitrogen stress. The growth traits and leaf morphological characteristics were significantly influenced by genetic factors and their interactions

with the environment. The varieties and genotypes selected by the comprehensive evaluation of multiple trait indices have strong adaptation to low nitrogen tolerance and could be used for new poplar varieties with low nitrogen tolerance.

Behavior of different clones of Populus deltoides in Rivadavia, Mendoza, Argentina.

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ID du résumé: 104

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

The objective was to study the behavior and adaptation of nine clones of *Populus deltoides* to environmental conditions and soils in the irrigated area in Mendoza. Therefore, a demonstrative trial was set up at "La Forestal" field of the INTA Junín Agricultural Experimental Station, located in the Department of Rivadavia (Lat. 33º 09 'S, Long. 68º 28' W), province of Mendoza. The trial included nine clones of *P. deltoides*: six experimental clones 'Guayracá' (2/82), 'Ñacurutú' (20 / 82), 'Paycarabí' (21 / 82), 'Nandí' (89 / 82), 'Pytá' (149 /82) and 'Hovyú' (150/82) selected within the framework of the INTA Poplar Breeding Program, and three commercial recognized clones for their performance in the Argentine Delta, 'Stoneville 67', 'Australiano 106/60' and 'Carabelas INTA'.

The planting distance was 5 meters between rows and 5 meters between plants, with ten plants per clone. Surface irrigation by furrow was used with a frequency of 15 days. Soil cultural practices, weed control and ant control were carried out. Diameter at breast height (DBH) and total height of the trees were measured, and based of these data, the wood volume produced was calculated after 13 years of cultivation.

Additionally, the phytosanitary, phenological and morphological status of each of the tested clones evaluated. As a result, it was observed that the clones showing the best performance were: 'Carabelas INTA' and 'Stoneville 67', which showed 100% survival and wood volume of 537 m3/ha and 383 m3/ha respectively. In opposition, clones that showed lower productivity were 'Pytá' and 'Hovyú' both in terms of survival and wood volume, with 134 m3/ha and 113 m3/ha respectively. The overall phytosanitary condition was good, with attacks of the wood borer *Megaplatypus mutatus* detected in larger diameter individuals.

Karyotype analysis of native and exotic male and female clones from various Poplar species in the Karaj Arboretum, IRAN.

by Seyed Mohsen Hesamzadeh Hejazi | RIFR

ID du résumé: 123

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

In this study, the number of base chromosomes (x) and (2n) of native and exotic clones, available in the arboretum of the institute's headquarters has been investigated. The studied species include males and females plants separately from: P. *euramericana (*10 different clones), *P. deltoides* (3 different clones), *P. nigra* (9 different clones), *P. alba* (6 different clones), *P. tremula* (2 different clones), *P. euphratica* (3 different clones), *P. trichocarpa*, *P. ciliata*, *P. caspica* (2 different clones each), and the Mofid variety (probably *P. euph.* x P*. alba*) and some hybrids created from past projects by other executives. The total number of clones under investigation was 50 clones. First, cuttings were prepared from the clones introduced by the Poplar Group, and they were rooted. Some of the clones, including *P. tremula*, were rooted, although the reports state that their cutting is not capable of rooting.The results of this project have shown that the species are diploid(2n=2x=38) and triploid(2n=3x=57). The number of base chromosomes (*x*) and (2n) of native or exotic clones has been investigated. All chromosomal factors were measured for each clone and their karyogram was drawn, and based on the analysis of chromosomes and the data obtained from them, all clones were clustered. A very interesting point to note in this genus is that even in the cases where the chromosomal type in two species can be crossed with a high percentage of the same, due to the fact that there is dioecy in our investigated clones, it should not be thought that it can be crossed by shifting the male and female clones as the parent of the crossbreeding, it can be Produced reproducible or fertile results.

What are Fast growing species? Some inputs from REINFFORCE Network

by Christophe Orazio | Lucas Moreews | IEFC | IEFC

ID du résumé: 137

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

The International Poplar Commission recently expanded its scope to fast growing species. A tentative definition of fast growing species is ongoing considering that when the yield of a forest stand is above 10 cubic meter per year we are dealing with species matching the definition.

In this presentation we propose to present growth rates of the 38 species tested in the trials of the REINFFORCE1 network of arboreta. This network (https://reinfforce.iefc.net) is made of the same genetic material displayed in a large range of pedo-climatic conditions from the north of the UK to Portugal.

After 10 years we can compare growth rates and climate impact on the tree species and provenances tested in the REINFFORCE network.

Analyse de la stabilité en plantation contrastée des performances de l'hybride Eucalyptus urophylla × E. grandis issues du programme d'amélioration des eucalyptus du Congo

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ID du résumé: 139

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Les espèces forestières réagissent différemment aux conditions de croissance imposées par l'environnement, comme par exemple la densité de plantation. Cette dernière a des implications économiques, sylvicoles et technologiques. Elle influence le coût de la production forestière, le taux de croissance, les pratiques forestières et la qualité du bois. La densité de plantation peut modifier les propriétés du bois en interférant avec la croissance et la morphologie des arbres, à différents stades de leur croissance. Afin d'analyser la stabilité des caractéristiques de croissance et les propriétés chimiques du bois de 55 familles de plein frères d'Eucalyptus urophylla × Eucalyptus grandis issues du schéma de sélection récurrente réciproque de l'eucalyptus au Congo, deux essais ont été mis en place avec deux densités de plantation contrastée (833 et 2500 tiges/ha). L'effet de la densité à 55 mois d'âge a été déterminé pour la hauteur, la circonférence, la lignine, la cellulose, la teneur en extrait et le rapport syringyl/gaïacyl, à l'aide d'un modèle linéaire mixte. L'analyse de la stabilité des familles a été effectuée en évaluant l'indice Pi de Lin. Les résultats montrent que la concurrence accrue entre les arbres augmente l'héritabilité des propriétés chimiques du bois, à l'exception de la teneur en extrait, et diminue l'héritabilité des caractères de croissance. Les résultats montrent également que les propriétés chimiques du bois sont relativement constantes et que la sélection impliquerait une très légère baisse des teneurs en lignine, cellulose et extrait. Pour les familles à faible indice Pi, la densité de plantation a très peu d'influence sur la qualité du bois. Cela suggère que des plantations à forte densité pourraient être établies sans impact négatif sur la qualité du bois avec ces familles.

Mots clés : Densité de plantation, propriétés chimiques du bois, gain génétique, interaction génotype-environnement, composante de variance génétique.

POSTER

Upper cut application of IBA powder formulation improve white poplar rooted cuttings' survival and growth

by Branislav Kovačević | Zoran Novčić | Marina Milović | Lazar Kesić | Saša Pekeč | Leopold Poljaković Pajnik | Milan Drekić | Vanja Vuksanović | Sreten Vasić | Igor Đukić | Saša Orlović | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Faculty of Agriculture, Novi Sad | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment | Institute of Lowland Forestry and Environment

ID du résumé: 31

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Successful rooting of hardwood cuttings is an important event in nursery production and the establishment of short rotation coppice plantation dedicated to biomass production in poplars and willows. In this study, the effect of application of powder formulation containing 0,6% indolbutiric acid and 50 μM $CoCl_2 \cdot 5H_2O$ on upper cut of hardwood cuttings of clone *Populus alba* cl. LBM, has been examined. Clone LBM is interesting in landscape architecture for its pyramidal crown and vigorous growth yet characterized by difficult-toroot hardwood cuttings. Hardwood cuttings had been prepared and treated 6 weeks (02nd March 2023) before planting (11th April 2023.), meanwhile stored in cool chamber at 2±2°C. There were three treatments concerning the place of application: B - basal cut, U – upper cut, BU – basal and upper cut, as well as C - Control treatment (no powder application).

According to the results of analysis of variance and Duncan's test, the stimulative effect of U treatment compared to the Control treatment (58.2% vs. 32.8%, respectively) on the cuttings' survival was found at the end of vegetation season (10th October 2023). At the same time, rooted cuttings in U treatment were not significantly higher than in the Control (237.8 cm vs. 206.3 cm, respectively), but were significantly higher than in those in B (156.5 cm) and BU treatment (182.5 cm), stressing better performance in U treatment than in the treatments that included application of the formulation on basal cut. These results suggest further work on this topic in white and other poplars as well as in other woody plant species.

Keywords: Rooting, *Populus alba*, Nursery, Plantation establishment

Acknowledgments

This research was supported by the Science Fund of the Republic of Serbia, *#GRANT No 5357, Landfill Remediation with the Use of Short Rotation Biomass Woody Crops (SRWC) Energy Plantations and Provisioning Multiple Ecosystem Services - TreeRemEnergy*.

APHID COLONIZATION AND THE PHYSIOLOGICAL REACTIONS OF SEVERAL POPLAR CLONES

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ID du résumé: 32

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Aphid influence on the key physiological parameters was studied on the foliage of several poplar clones. The physiological parameters under analysis are crucial indicators of the plant's physiological condition and are involved in the complex process of photosynthesis. Slight changes to some of the research parameters can have a major negative impact on the rate of photosynthesis. Random leaf samples were collected from various poplar clones with and without aphid colonies.

According to the study, aphids increase respiration by a specific proportion and reduce photosynthesis in the host plant to the same level when present. Stomata's % diffusion resistance was significantly higher in foliage that was attacked by aphids. It was clear that different clones differed in the stomata's diffusion resistance.

Although in the study clones, there was no regularity regarding the aphid influence on the content of photosynthetic pigments, it can be concluded that aphids significantly influence the content of photosynthetic pigments in the leaves. The study results indicate that the aphids on poplar foliage significantly impact the content of photosynthetic pigments in the leaves and that there are differences among the study clones.

Multiplexed genetic markers to identify black poplar (Populus nigra L.)

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ID du résumé: 54

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Black poplar (*Populus nigra* L.) is an endangered Eurasian tree species associated with riparian and alluvial forests which are dealing with habitat fragmentation and devastation. These changes prevent the regeneration of black poplar stands and cause a decrease in population size that may result in a loss of genetic diversity and consequently lead to inbreeding depression. Their populations are further at risk of gene introgression from nonnative eastern cottonwood (*Populus deltoides*) due to the long-term preference for planting their interspecific hybrids (*Populus ×canadensis*). This can result in the formation of hybrid swarms and, in extreme cases, genetic swamping, compromising the genetic integrity of rare black poplars. Identifying the residual occurrences of black poplars in the Czech Republic and restoring their populations may, in the long term, enhance the genetic diversity and integrity of the populations, leading to increased stability and biodiversity of riparian and alluvial forest ecosystems in the Czech Republic. For the recognition of selected valuable individuals from the field as source material for reintroduction into the landscape, species authenticity must be verified using DNA analyses, primarily due to the difficulty of distinguishing black poplars from Canadian poplars (*Populus ×canadensis*) or their backcross hybrids (*Populus nigra* × *Populus ×canadensis*, BC1) based on morphological traits. Two sets of genetic markers were developed to determine species authenticity. From 23 markers tested based on fragment analysis of 10 black poplars, 10 Canadian poplars, and 10 eastern cottonwoods, 6 diagnostic microsatellite markers, 1 diagnostic STS marker, and 1 informative microsatellite marker were selected and incorporated into 2 multiplexes. The results were verified on a supplementary 63 samples of black poplars, Canadian poplars, eastern cottonwoods, and BC1 hybrids. In the case of diagnostic markers, the confusion between BC1 and F2 hybrids (*Populus ×canadensis* × *Populus ×canadensis*) and pure black poplars may occur due to meiotic segregation of alleles. The probability of correctly identifying BC1 and F2 hybrids (the presence/absence of the *Populus deltoides* allele) was determined based on 6 diagnostic markers used. The probability was compared with the

observed frequencies of identified hybrids in 34 performed backcrossings (BC1). The two selected sets of markers serve to reliably distinguish black poplars from Canadian poplars and their hybrids (BC1, F2).

Nitrogen and starch stock in poplar unrooted poles

by Alain BERTHELOT | Bénédicte FABRE | FCBA | INRAE

ID du résumé: 70
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-GEN - Genetic Resources

Some unexplained diebacks of poplar clones (*P. x canadensis*) with late growth stop have been observed right after planting in numerous plantations in the North of France.

The GIS Poplar conducted a nursery experiment to recreate the effect of premature leaf fall (caused by late frost, for example) on the survival and growth of young poplar plants, for a clone with early plant growth stop (n° 661200506, *P. x canadensis* from GIS Peuplier) and a clone with late growth stop (Soligo).

Three leaf removal treatments were tested: 1) artificial leaf removal carried out in midSeptember; 2) artificial leaf removal carried out in mid-October; 3) natural leaf loss (finished by mid-November).

The 1 year-old poles were prepared and then planted in the original nursery the following spring, after being stored in water for a week. Before planting, a portion of the stem was taken from the base of the plant to analyze the sugars and nitrogen contained in the tissues.
Mortality and first-year growth were measured on all stems.

After one year of growth, we did not identify any difference in survival rate or growth between the different treatments studied, but the plantation was victim of numerous deer damage which confused the results. However, significant differences in the concentration of nitrogen, total sugars and starch were highlighted between the different dates of leaf fall and between the two clones. The difference was greater for the clone with the latest growth stop.

Thus, accidental early leaf fall (late frost) could lead to poor storage of sugars and nitrogen in the plants at the end of the growing season, especially for clones with late stop growth. In the absence of technical error during planting or external defects in the quality of the plant, this phenomenon could explain the poor survival rate observed on some clones.

Study on the genotype × spacing of large-diameter Populus × canadensis in northern China

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ID du résumé: 105

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

In response to increasing wood demands, selecting large-diameter *Populus × canadensis* genotypes and appropriate spacing for enhanced plantation productivity in Northeast China is crucial. In the Daling River Plain region, renowned for its poplar plantation industries, we assessed 12 *Populus × canadensis* genotypes across four spacings: 2 m×5 m (D1), 3 m×8 m (D2), 4 m×8 m (D3), and 4 m×10 m (D4). After evaluating genotype-environment interactions, we identified the top five genotypes: G2, G4, G11, G1, and G10. Subsequently, we conducted stem analysis and wood processing tests on these genotypes to understand their growth patterns and wood quality attributes.

Our findings reveal that denser spacing hampers growth and increases stand variability. By the 14th year, D1 had already met the large-diameter standard (24 cm) and yielded the most timber. Height-to-diameter ratio increased with denser spacing, while taper decreased. Optimal genotypes varied with spacing: wide spacing favored G4, G10, and G1, with G4 the best, exhibiting a genetic gain in survival rate of 95% and in growing stock of 105%. Conversely, dense spacing favored G2 and G11, with G2 demonstrating the highest genetic gains in survival rate (36%) and growing stock (56%). Additionally, the Periodic Annual Increment (PAI) of G4, G2, and G1 surpassed that of G10 and G11, with wider spacing resulting in higher diameter growth rates. Notably, PAI and Mean Annual Increment (MAI) trends increased with stand age, indicating sustained rapid growth by the 14th year. Predictive modeling suggests a quantitative maturity period between 15 and 19 years. The most effective combination identified was D1 × G2, reaching quantitative maturity in the 15th year with a growing stock of 34 cubic meters per hectare. Finally, our analyses revealed significant differences between heartwood and sapwood properties, with sapwood exhibiting superior characteristics. While spacing influenced the microfibril angle, it had no significant effect on basic wood density, pH, or heartwood proportion. Different genotypes exhibited varying bonding strength, bending strength, and modulus of elasticity, all of which met the Chinese national standard GB/T 9846-2015 for poplar plywood.

Keywords: *Populus × canadensis*; Genotype × spacing; Large-diameter wood; Quantitative maturity; Wood processing test

An update on the cultivar registration of Populus, Salix and other fast-growing trees.

by Julia Kuzovkina | Sara Bergante2
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Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-GEN - Genetic Resources

The International Cultivar Registration Authorities (ICRA) aim to promote stability in the naming of cultivated plants by organizing lists of authenticated and internationally recognized names in the important groups of cultivated plants. The ICRA scheme operates under the International Code of Nomenclature for Cultivated Plants (ICNCP). The ICRA system is designed to prevent the duplication in the use of cultivar epithets within a genus, and to ensure that names agree with the latest edition of the ICNCP. When breeders file the Cultivar Registration Form, the ICRA will check each new epithet to confirm that it has not been used before. The formal registration is the acceptance of an epithet and its inclusion into the Register.

The International Poplar Commission is appointed to serve as the ICRA for Populus and Salix and maintains the International Registers of Cultivars and Checklists for Cultivars for both genera. The recent decision by the IPC to incorporate additional species of fast-growing trees, launched the development of a framework for the cultivar registrations of many fast-growing trees, in addition to poplars and willows. The main registration mechanism is through the Special Commission for Cultivar Registration of the International Society for Horticultural Science (ISHS), which has already established many ICRAs. Various international organizations already support the registration of 19 genera of fast-growing species.

Mots clés : Cultivar

Unlocking the Secrets of Survival: Pioneering Strategies to Conquer Phenological Mismatch and Climate Maladaptation.

by Raju Soolanayakanahally | Robert Guy | Stephen Keller | Matthew Fitzpatrick

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Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

Climate warming poses significant ecological challenges, particularly at high latitudes, where phenological mismatches disrupt the synchronization of species' life cycles with their environments. Our research on balsam poplar (Populus balsamifera L.) examines the impact of climate warming on growth phenology and highlights the role of photoperiodic competency in driving these mismatches. To address this, we propose a novel adaptive strategy: the migration of photoperiodically appropriate trees along east-west climate clines to mitigate phenological mismatches.

Furthermore, we looked at ‘genomic offsets,’ a metric that predicts climate maladaptation by identifying genetic variations linked to climate resilience. Using the Gradient Forests method, we relate candidate loci to environmental gradients and estimate the magnitude of genetic offset —representing maladaptation— when populations are transplanted from their native environments to common garden trials. These findings offer practical applications for conservation strategies and poplar breeding programs, providing valuable insights for managing natural populations under rapid climate change.

Mots clés : Climate adaptation

Bouturage horticole des Eucalyptus sp. en République du Congo : acquis et perspectives de recherche.

by MANKESSI François | TOTO Mélanie | MATONDO Rosalie | Marien Jean Noël | MONTUUIS Olivier | Enseignant Chercheur à l'Ecole Nationale Supérieure d'Agronomie et de Foresterie (ENSAF), Université Marien NGOUABI | Technicien au Centre de Recherche sur la durabilité des plantations industrielles | Enseignant Chercheur à l'Ecole Nationale Supérieure d'Agronomie et de Foresterie (ENSAF), Université Marien NGOUABI | Chercheur Indépedant | Chercheur au CIRAD

ID du résumé: 142

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-GEN - Genetic Resources

En République du Congo, le clonage des *Eucalyptus* sp*. a* été fortement limité par l'inaptitude à la rhizogenèse adventive imputable au vieillissement des génotypes sélectionnés. La définition du procédé de rajeunissement à partir des pieds mères gérés de façon intensive en hors sol, a fortement contribué à améliorer l'aptitude au clonage conforme par bouturage. Le rajeunissement physiologique des génotypes sélectionnés au stade mature a été possible à travers la pratique des « cascades » et « réitérations » qui ont permis de mettre en évidence l'influence de l'âge physiologique sur l'aptitude à l'enracinement adventif. Les taux de réussite au bouturage et l'homogénéité du matériel issu du bouturage ont été nettement améliorés. Le dosage par HPLC du taux de cytosine méthylée dans les extrémités apicales a permis d'établir que la méthylation globale était positivement corrélée à l'âge physiologique, plus élevée chez le matériel mature que pour les plants juvéniles et rajeunis. L'immunolocalisation a montré des différences de densité de cellules méthylées ainsi que d'intensité de méthylation au sein des méristèmes primaires caulinaires ou «SAMs» en relation avec leur âge physiologique. Les investigations histocytologiques menées au niveau des «SAMs» ont permis d'établir des différences de conformation des dômes des méristèmatiques et des rapports nucléoplasmiques en fonction de l'âge physiologique du matériel étudié. Des analyses conjointes ont révélé une plus forte proportion d'hétérochromatine, transcriptionnellement moins active, chez le matériel âgé que dans les semis juvéniles ou les plants physiologiquement rajeunis. Comme perspective à ce travail, la protéomique serait le clos des précieux résultats de recherche obtenus.

Mots clés : Clonage conforme, Eucalyptus, Pieds mères hors sol, Pieds mères classiques

WP ENV

Working Party on Environmental and Ecosystem Services

IPC - Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

KEY TALK

A decade of research on the role of genotype identity vs. stand diversity in Salix biomass plantations for productivity and ecosystem function

by Martin Weih | Petra Fransson | Carolyn Glynn | Christel Baum | Swedish University of Agricultural Sciences (SLU), Department of Crop Production Ecology. Uppsala, Sweden. | SLU, Department of Forest Mycology and Plant Pathology. Uppsala, Sweden. | Swedish University of Agricultural Sciences (SLU), Department of Crop Production Ecology. Uppsala, Sweden | University of Rostock, Department of Soil Science. Rostock, Germany

ID du résumé: 81

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Salix grown in short rotation has high biomass production potential in many parts of the world, and may frequently support environmental and ecosystem services. There is evidence supporting the hypothesis that biomass production, carbon accumulation, nutrient cycling and cropping security can be increased through enhancing the number of tree species or genotypes grown in the stand; but the specific characteristics of the mixed stand components (genotypes) could also be more important than the component richness of the stand. In the ECOLINK-Salix project, we address the role of genotype identity (4 genotypes, partly belonging to different species) *vs.* stand component richness (1- to 4-mixes) in willow (*Salix* spp.) short rotation coppice plantations grown in pure and mixed culture on agricultural land in Sweden and Germany. The involved genotypes included *Salix viminalis*, *S. dasyclados* and two full-sibling hybrids of *S. dasyclados* x *S. schwerinii*. After ten years of growth, the specific characteristics of the individual genotypes included in the stands of one to four genotype richness levels affected community biomass production, nitrogen use patterns and leaf litter decomposition more than the genotype richness *per se*, but admixing effects were found for some ecosystem processes related to nutrient cycling. The absence or presence of individual genotypes strongly affected stand productivity, litter decomposition and soil carbon accumulation, and the admixing effects on tree functional traits were in most (but not all) cases explained by the trait values of the individual varieties assessed in pure cultures in combination with their relative share in the mixtures. Desirable genotype mixtures could be designed that combine, for example, the high stem productivity and nutrient conversion efficiency that certain genotypes achieve particularly in mixed stands with the high soil carbon accumulation capacity of other varieties. The role of genotype identity *vs.* species/genotype richness in willow short-rotation plantations on the stand productivity and ecosystem functions related to productivity, nutrient cycling, soil carbon accumulation and cropping security will be discussed with respect to the implications for management.

Testing of coppiced poplar and willow in agroforestry systems for erosion control

by Jan Weger | Karel Štengl | Jaroslav Bubeník | David Kincl | Jan Vopravil | The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Department of phytoenergy (VUKOZ), the Czech Republic | The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Department of phytoenergy (VUKOZ), the Czech Republic | The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Department of phytoenergy (VUKOZ), the Czech Republic | Research Institute for Soil and Water Management, Department of Pedology and Soil Conservation, the Czech Republic | Research Institute for Soil and Water Management, Department of Pedology and Soil Conservation, the Czech Republic

ID du résumé: 99

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

More than half of the agriculture land in the Czech Republic, characteristic with hilly terrains and large fields, is endangered by water erosion. This risk is expected to grow due to increased occurrence of torrential rains. The aim of our work is to evaluate production and efficiency of fast-growing trees (FGT) in silvoarable agroforestry systems (AFS) established for reduction of water erosion.

We have used experimental AFS (1 ha: 12% tree strips; 88% crop strips) established on field with declination 7-12% at research station Michovky in 2020-2022 (Picture 1). The field can be divided into three different sites according to erosion effect: erosion depression, steep slope and moderate slope (Picture 2). AFS consists of one coppiced tree belt (6.5 m wide) with triple-row of FGT: poplars Max-4 (*Populus nigra ×P. maximowiczii),* 'Kaktu' *(P. nigra ×P. simonii*) and willow 'Rokyta' (*Salix ×smithiana*), two single rows with forest/fruit trees (1.7 m wide; maple, wild cherry, chestnut, service tree, planted in 2 m) and three crop strips 26 metres wide. Contour agronomy (plowing, seeding) has been applied on whole field. Trees are planted in experimental design (factors: variety, erosion intensity, position in row). We have measured FGT growth annually and yield after 4 year rotation. In 2021-2023, we have conducted 4 simulated erosion experiments with two devices: i) field rainfall simulator and ii) overflow simulator of concentrated runoff. The simulated rain experiment (1 hour) had intensity 72 mm/m^2 and in surface runoff experiment (16 min) with overflow irrigation 625 l/min (10.42 l/s) created gully erosion from 10 m above agroforestry tree strips. The fallow land was used as a control experiment in both types of experiments.

The yields of FGT in first harvest after 4 years were relatively low between 0,2 and 2,2 t(DM)/y depending on clone and site factors and also by drier conditions of experimental field (slope with southern exposition). The best yield had poplar 'Kaktu' which was selected for drier conditions. Willow

'Rokyta' had lowest yield which can be explained by higher susceptibility to grazing by roe-buck. The yields of FGT also varied quite high between three stands on experimental site between 30% - 70% of best site (erosion depression). Both simulated rain experiments proved very good soil conservation efficiency of FGT strip and AFS: decreased soil loss by 93-99% and water runoff by 66-81% depending on width of the tree strip (1,7-6m) (Picture 3).

Research supported by project DivLand (SS02030018) by TAČR

TALK

Protection of Environment by Management of Poplar Defoliator (Clostera cuperata) through herbal approach

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ID du résumé: 34

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Introduction: In India, poplar, willows and other fast-growing species are present in large area in and outside the forest. These species are important for ecology and sustain the livelihood of millions of people. Poplar is fast growing exotic tree species which has been extensively planted in India under various afforestation/reforestation program. Poplar Timber is the backbone of vibrant plywood, board, match, paper and sports goods industries. The cultivation of poplar has generated huge employment in the rural sector in India and has overall improved the rural economy. Poplar is highly prone to insect attack, approximately, 108 insect species are causing damage. Out of these, Poplar defoliator *Clostera cuperata* (Lepidoptera: Notontidae) is one of the most damaging pest of poplar which defoliate poplar plantation and often appears in outbreaks even causes death of tree.
Therefore, a concept was developed to protect the plant by the plant.

Design and Method: Regarding this, a number of plant extracts were screened and tested against the larvicidal efficacy of *C.cuperata*. Out of four plants, leaves of *Calotropis procera* were tested for larvicidal activities against poplar defoliator. The 3rd instar larvae of C. cupreata were exposed to a wide range of concentrations (0.0625 to 2.00%). LC50 value of each sample and control was recorded simultaneously. After receiving promising results at laboratory levbel, the experiments were conducted at semi-field and field conditions as well.

Results: After repeated experiments, a herbal formulation (Biopesticide) was developed. The detailed statistical analysis of data showed almost 70% efficacies at 2% concentration of formulation against *Clostera cupreata* (poplar defoliator) at laboratory. At field 2 to 2.5% concentration of formulation showed the promising results.

Conclusions: Novel, environment friendly methods for control of plant diseases, cropdamaging pests are needed for management of insect/pest.

Keywords: Poplar, Poplar defoliator, *Clostera cuperata* (Lepidoptera: Notontidae), environment-friendly chemicals, larvicidal efficacy

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Tolerance of Hybrid Willow Clones to Aircraft De-icing Fluid

by Martin Blank | Richard Krygier | Natural Resources Canada- Canadian Forest Service | Natural Resources Canada- Canadian Forest Service

ID du résumé: 48

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Around the world, glycol-based aircraft de-icing and anti-icing fluid (ADAF) is applied to remove snow and ice, and prevent ice from reforming. Some of the fluid is collected and recycled but a significant amount is collected in runoff and stored in ponds for treatment. Extensive research has been conducted on the effective degradation of ADAF in water and soil by micro-organisms under both aerobic and anaerobic conditions. Given how willows have been proven to effectively treat nutrients and other contaminants in wastewater, land application of ADAF containing water to willow plantations could be a good low-cost alternative treatment method for many airports, provided the willows are tolerant to ADAF.

The tolerance to ADAF of seven hybrid willow clones commonly used for biomass production in Western Canada (India, Tully, Tora, Bjorn, Owasco, Olof and Preble) was tested in a randomized complete block design (n=6) greenhouse trial. One rooted cutting of each clone was transplanted into a 7-litre pot containing orthic black chernozem topsoil. Starting 26 days after transplanting, the pots were irrigated approximately every three days with RO water containing either 0 (control), 200, 400 or 800 ppm of UCAR™ Deicing ADF Concentrate (92% ethylene glycol). Thirty days after irrigation began, the length and diameter of the tallest shoot on each cutting for all blocks was measured from where the shoot emerged from the cutting to the base of the growing tip (n=168). For half the blocks, the total shoot dry weight of each cutting was determined (n=84). Forty-two days later, for the remaining three blocks, the height, diameter, and total dry weight were measured as above (n=84). Plant Products™ 20-8-20 Starter Fertilizer was applied 25, 35 and 45 days after transplanting.

No mortality, little damage (leaf edge necrosis) or signs of plant stress was observed after 75 days of irrigation with ADAF affected water. For all except India, Tora and Tully, there was no significant difference for the response variables between the control and the 200 and 400 ppm ADAF treatments. Except for Prebble and Tully, there was a significant negative effect of the 800-ppm treatment for some of the response variables and clones. The study shows that young willow plants are tolerant to ADAF impacted water in a greenhouse setting, the tolerance is clone dependent, and that irrigation of ADAF impacted water on willows could an alternative treatment method. Longer term and field trials need to be conducted.

Exploring the multifunctionality of poplar plantations through biodiversity analysis

by Nerea Oliveira | Alicia Fuertes | Isabel González | Joaquín Garnica | Fernando Montes | Isabel Cañellas | Hortensia Sixto | Institute of Forest Science, ICIFOR-INIA (CSIC), 28040 Madrid, Spain | Institute of Forest Science, ICIFOR-INIA (CSIC), 28040 Madrid, Spain | Institute of Forest Science, ICIFOR-INIA (CSIC), 28040 Madrid, Spain | Bosque y Ríos S.L. 24200, Valencia de Don Juan, León, Spain | Institute of Forest Science, ICIFOR-INIA (CSIC), 28040 Madrid, Spain | Institute of Forest Science, ICIFOR-INIA (CSIC), 28040 Madrid, Spain | Institute of Forest Science, ICIFOR-INIA (CSIC), 28040 Madrid, Spain

ID du résumé: 59

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Biodiversity is essential for ecosystem services provision. Forest plantations have increasingly demonstrated their significant role in providing ecosystem services, such as mitigating climate change through carbon sequestration. Poplar plantations for veneer production (PPV) are economically relevant in Spain. The potential of poplar for shortrotation systems (SRC) for biomass production has also been recognized, although not yet implemented commercially. Typically, PPV are established at deep root in areas with accessible groundwater tables, commonly in zones near rivers. In contrast, SRC plantations do not require proximity to rivers, as they are irrigated to ensure survival during the Mediterranean summer drought. Both plantations are established on agricultural land, integrating forested areas into agricultural landscapes.

This study aims to assess the contribution of these hybrid poplar plantations to agroforest ecosystems in terms of biodiversity, evaluating the influence of the plantation age. Flora diversity was evaluated in PPV at years 3, 9, and 12, and in SRC during their second rotation, at year 1 after coppicing, and at year 4, the final harvest year. Biodiversity was also assessed in various agricultural lands for comparison, including irrigated corn plantation (AGR-I), rainfed wheat plantation (AGR-R), and fallow (AGR-F) fields. Species richness and abundance were measured across the different plots, and the influence of plantation age on biodiversity was analyzed in both poplar plantation management. Various indices were employed to evaluate the intrinsic diversity of the forest plantations (αdiversity) and the differences between the evaluated plots (β-diversity).

Our findings reveal distinct biodiversity patterns across the sampled land-use scenarios. Specifically, we observed significantly higher flora species richness in poplar plantations (PPV and SRC) compared to agricultural land. An age effect was noted, with younger plantations showing higher individual abundance, likely due to increased light availability. Irrigated plots (SRC and AGR-I) display lower dominance (Simpson index) compared to other plots, showing a trend towards reduced dominance with age in both plantation management (PPV and SRC). Agricultural

areas exhibit lower biodiversity richness compared to poplar plantations, with SRC showing the highest values according to the Margalef index. The Shannon-Wiener index indicates similar diversity across scenarios, slightly higher in irrigated scenarios (SRC and AGR-I). A high flora complementarity (90%) suggests substantial turnover and replacement among these ecological environments.

These findings indicate that poplar plantations, both for veneer production and SRC, can enhance biodiversity in Mediterranean agroforest ecosystems. These plantations actively contribute to various provisioning ecosystem services, reflecting a multi-objective approach that extends beyond biomass production.

Harnessing wild poplar and willow microbiota for enhanced plant growth under nutrient and water limitations

by Sharon L. Doty | University of Washington, Seattle

ID du résumé: 65

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Sharon L. Doty, Andrew W. Sher, Jayde Aufrecht, Emma Gomez-Rivas, Darshi Banan, Matt Hendrickson, Sun Woo Chung, Shubroto Sarkar, Robert Tournay, Kevin C. Shaffman, Amir Ahkami, and Soo-Hyung Kim

For the success of restoration projects and plantations for carbon sequestration, it is advantageous to maximize plant health and growth with minimum inputs of nutrients and water. Wild poplar and willow harbor microbial endophytes with an array of beneficial properties that improve plant nutrient acquisition, water use efficiency, and resilience to abiotic and biotic stresses. Through multi-omics and advanced imaging approaches, we gained new insights into endophytic nitrogen fixation. NanoSIMS with 15N2 labeling and a green fluorescent protein (GFP) fusion with the nitrogenase promoter revealed that a subset of the diazotrophic bacteria were actively fixing nitrogen. When incubated with poplar in RhizoChips, a synthetic soil platform, the active bacteria were localized to novel sac-like structures within poplar root cells. In addition, we have identified bacterial partnerships that amplify nitrogen fixation. The synergistic relationships were discovered in wild poplar from different river systems, as well as in Hawaiian lava field plants, suggesting that the microbial community interactions are common to pioneering plants. Application of a consortium of specific endophyte strains to poplar under nutrient limitation increased plant growth and photosynthetic capacities. Specifically, the endophyte strains increased cell expansion rates, increasing individual leaf areas. Under water limitation, the endophytes impacted hormone and metabolic profiles, stomatal morphology and reduced stomatal conductance, resulting in improved water use efficiency of production. Endophytes also induced longer and more branching root systems. We are using chemical imaging of poplar within the RhizoChips to assess the molecular dialogue between poplar roots and key endophyte strains. Taken together, our results indicate that specific bacterial endophytes can promote biomass accumulation with reduced inputs of nutrients and water, improving the carbon sequestration ability and sustainability of plantations.

Effects of applying sewage sludge on growth performance of Populus nigra trees

By Azadeh Salehi[1], Mohsen Calagari[1], Sara Teimouri[1], Abbas Ebrahimi[2]

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ID du résumé: 67

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - [2] Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Abstract

Wastewater Treatment Plants generate a large amount of sewage sludge. Safe and sustainable disposal and management challenges of theses residues is one of the important environmental concerns. Land application of sewage sludge in short-rotation plantations can have good benefits to meet the nutrient needs of these plantations while recycling these wastes. The objective of this study was to assess the impacts of the sludge application on four-year-old poplar trees (*Populus nigra* L.). The study was established as a completely randomized block design, with three treatments of sewage sludge and three replication. Poplar trees were exposed to 0 (SS_1), 10 (SS_2), and 20 kg m^{-2} (SS_3) of sewage sludge produced by the Wastewater Treatment Plant of Tehran (Iran) under field conditions. It was observed that the application of sewage sludge increased the content of organic matter, and the concentrations of nitrogen (N), phosphorus (P), potassium (k), sulfur (S), zinc (Zn), and copper (Cu) in the soil, as well as in the plant tissues. The application of 20 kg m^{-2} sewage sludge resulted in increasing of Ni, Cr, and Pb concentrations in soil. At the end of the fourth growing year, the best growth performance and productivity of four-year old poplar trees were found in sewage sludge treatments, and there were no significant differences between SS_1 and SS_2. According to the high level of nutrients in sewage sludge, especially nitrogen and phosphorus, it seemed that the sludge-treated trees would be more susceptible to pests and diseases. However, the monitoring of *Populus nigra* trees during the growing seasons demonstrated that sewage sludge treatments did not have significant effect on pest damage of poplar trees. This study suggests that a reasonable rate of sludge application can provides soil amendment and additional nutrients for fast-growing trees without any threat to the food chain and pollution of soil by heavy metals.

Keywords: Fast-growing tree, Residues, Short-rotation plantation, Soil amendment

Distribution of above- and belowground carbon in dependence to the management system of poplar coppices grown on agricultural land in eastern Germany

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ID du résumé: 80
Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies
Topic: WP-ENV - Environmental and Ecosystem Services

Woody biomass crops can be a lucrative alternative to classic arable crops for farmers, and are an efficient solution for long-term carbon fixation on agricultural soils. Long-term experiments executed at the Leibniz Institute of Agricultural engineering and bioeconomy showed that poplar coppices can fixate up to 37.8 t/ha more belowground carbon on sandy soils than conventional crops. The sustainability of the carbon sequestered within various plant compartments and the soil, however, is not only limited to their economically profitable lifespan, but also dependent on cultivation and management factors. To find out more about how cultivation factors affect the distribution of carbon within poplar fields, four plots were studied. These were planted in 2018, but were cultivated with varying planting densities, and harvest-rotation designs. Plot one and two were initially planted with a density of 4166 trees/ha. They were partially harvested in 2023, by removing every other row, reducing to a density of 2083 trees/ha. Plot three and four are planted with a density of 8333 trees/ha. Plot 4 had been harvested fully in 2023, while plot 3 has not been harvested at all. Sequestered carbon was determined for all plots in the following fractions: crown biomass, stem biomass, coarse root biomass, fine root biomass, topsoil (0-30 cm depth) and subsoil (30-60 cm depth). Significant differences were found in aboveground as well as belowground stocks, going up to 7 t/ha biomass C between plots. In soil carbon stocks the biggest difference occurred between field 2 and 4 with a difference of over 25 t/ha. These results could be in an indicator for partial harvest system and combined use systems benefitting the purpose of belowground carbon sequestration, in comparison to conventional full harvest of the coppices. The distribution of carbon in the named fractions within the plantations will be continuously monitored in the future, to gain more insight into the long-term development. Additionally, in a previous study we investigated the development of carbon stocks belowground after LUC back to arable farming. Based on these results, possible conclusions and opportunities will be discussed to make poplar farming more impactful in terms of carbon farming and climate change mitigation in the future.

Comment: The abovementioned data and results were collected as a part of my phd research and are still in the process of being evaluated, so the values might still change a little, which is why I was reluctant to put down concrete numbers.

[4] Dynamics of carbon storage in a tropical Eucalyptus plantation over multiple rotations

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[9] *ID du résumé: 97*
[10] *Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation -*
[11] *Pathways to climate resilience and carbon neutral societies*
[12] *Topic: WP-ENV - Environmental and Ecosystem Services*

[13] Eucalyptus is the most widely planted forest hardwood genus worldwide. In Brazil, Eucalyptus plantations rank among the world's most productive forests and cover more than 7.5 Mha. Improving our understanding of the dynamics of carbon storage in these anthropized ecosystems and how management practices, especially clear-cutting, affect it is important for future land sink projections. Here, we present an unprecedented 14-years series of continuous CO_2 fluxes (net ecosystem productivity, NEP) from Eddy-covariance measurements conducted in a commercial Eucalyptus plantation in Southern Brazil (the EUCFLUX project). The measurement period encompasses 3 rotations (including a full rotation of 9 years). Clear-cutting were followed by planting after a delay of 1.5 month after the first harvest and 5 months after the second harvest. NEP data were compared to the stem biomass exported at harvest to estimate the long-term C storage of the plantation (i.e., the net ecosystem carbon balance, NECB). NEP reached a maximum value of ~2 MgC/ha/month, totaling ~86 MgC/ha in a 9-year rotation. Clear-cutting turned the plantation into a net carbon source for 7 and 12 months after the first and second harvest, corresponding to the emission of ~8 and ~11 MgC/ha, respectively. The payback period (the amount of time before the plantation recaptures as much CO_2 as was emitted after harvest) was 19 and 30 months, respectively. When using the time of planting as reference, the data was remarkably similar between rotations: the plantation turned into a net C sink 5.5 months after planting and emitted ~5MgC/ha during this period. Ten months after planting, the plantation already sequestered as much C as was emitted in the first months of the rotation. However, we found that NECB was close to zero. This suggests that despite having very high NEP, below-ground and litter C storage is low in this plantation and that the trunk export at harvest is a C flux of comparable importance as the NEP integrated between two consecutive harvests. Therefore, our

results suggest that C storage in the soil stabilizes after successive rotations in highly productive commercial Eucalyptus plantations.

Establishment of Phyto-Recurrent Selection Demonstration Projects for Phytoremediation and Phytostabilization of Ore Mining Waste in Michigan's Upper Peninsula, USA

by Ronald S. Zalesny Jr. | Erin Johnston | Elizabeth R. Rogers | Ryan A. Vinhal | Jacob Dessellier | Katherine A. Heckman | Evan S. Kane | Chung-Ho Lin | Mackenzie Russell | Karena Schmidt | Madeline Webb | James E. Anderson | Jennifer Ballinger | Zhiyong Cai | Thomas Elder | Richard A. Hallett | Deborah S. Page-Dumroese | Liza Paqueo | Max R. Piana | Nancy F. Sonti | Qiangu Yan | USDA Forest Service | Keweenaw Bay Indian Community (KBIC) | USDA Forest Service | USDA Forest Service | Keweenaw Bay Indian Community (KBIC) | USDA Forest Service | Michigan Technological University | University of Missouri | Michigan Technological University | Keweenaw Bay Indian Community (KBIC) | Michigan Technological University | USDA Forest Service | USDA Forest Service | USDA Forest Service | USDA Forest Service | USDA Forest Service | USDA Forest Service | USDA Forest Service | USDA Forest Service | USDA Forest Service | USDA Forest Service

ID du résumé: 125

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Historic copper ore mining throughout Michigan's Upper Peninsula produced mining waste containing copper, cadmium, arsenic, and other heavy metals. This waste, known as stamp sands, was distributed throughout terrestrial, coastal, and aquatic ecosystems of the Keweenaw Peninsula and Lake Superior, and today impacts human health and the environment. The Keweenaw Bay Indian Community (KBIC) conducted extensive restoration work at Sand Point, a culturally significant site in Baraga, Michigan, USA that is impacted by stamp sands and that provides beneficial uses related to subsistence, education, and recreation. To address the need for additional nature-based solutions that clean the contaminated soils and mitigate movement of the stamp sands into coastal wetlands, we established a network of phyto-recurrent selection demonstration projects to test the potential of poplars and willows to phytoremediate and phytostabilize metal-contaminated soils at Sand Point. In June 2024, we installed separate poplar and willow phytoremediation projects testing six and seven genotypes, respectively, each with three soil amendment treatments. All poplars were *Populus deltoides* Bartr. ex Marsh × *P. nigra* L. hybrids ('9732-11' '9732-24' '9732-31' '9732-36' '99059016' 'DN34'), while willows belonged to three genomic groups: *S. miyabeana* Seemen 'Sherburne' 'SX61' 'SX67'; *S. viminalis* L. × *S. miyabeana* 'Fabius' 'Preble' 'Tully Champion'; *Salix purpurea* L. × *S. miyabeana* 'Millbrook'. The first soil amendment treatment was soil mix containing two compost sources plus clean topsoil (i.e., soil mix). The remaining two treatments consisted of soil mix plus one of two different types of biochar: Wakefield Biochar (Valdosta, Georgia, USA) (i.e., soil mix + Wakefield biochar) and Restoration Fuels Biochar (John Day, Oregon, USA) (i.e., soil mix +

Restoration Fuels biochar). In addition, we established a willow phytostabilization project testing 'SX61' grown with the same three soil amendment treatments. Monthly survival and health are being inventoried, and height, diameter, and tree health will be determined at the end of the growing season. Differences in tree growth and health will be compared among genotypes, soil treatments, and their interactions for the phytoremediation projects, while variability among soil treatments will be summarized for 'SX61' in the phytostabilization plots. These first-year results will be presented for all demonstration projects. Overall, these data will provide baseline information to assess establishment success in the stamp sands impacted soils of Sand Point, guiding future management decisions for restoration of the site.

POSTER

Ectomycorrhizal community of Lombardy poplar trees on landfill near Novi Sad, Serbia

by Marina Milović | Institute of Lowland Forestry and Environment

ID du résumé: 23

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Within the project "Landfill Remediation with the Use of Short Rotation Biomass Woody Crops (SRWC) Energy Plantations and Provisioning Multiple Ecosystem Services" (TreeRemEnergy), financed by the Science Fund of the Republic of Serbia, multi-purpose phyto-buffers were established on two landfills. Mycorrhizal fungi are well known symbionts of trees which help their partners to cope with unfavorable conditions by providing them with water and nutrients.

To examine if there were any mycorrhizal fungi that can support survival and growth of poplar trees on landfill, preliminary analyses of ectomycorrhizal (ECM) fungi on 7 years old Lombardy poplar (*Populus nigra* var. *italica*) trees, already present on landfill in Novi Sad, Serbia was performed. Six soil samples were taken in January 2024 with the soil corer of 274 ml volume at distance of about 1m from the tree trunk. ECM fungi were determined by combination of morpho-anatomical characterization of ectomycorrhizas with molecular analysis based on PCR amplification of the ITS region of fungal nuclear ribosomal DNA. ECM fungi were also classified into exploration types and diversity indices were calculated. Three ECM fungal taxa were recorded: *Tuber maculatum*, *Thelephoraceae* sp., and *Geopora* sp. Diversity of ECM fungi was very low. The Species richness index and Shannon - Weaver index were 0.861 and 0.860, respectively. Short distance exploration type and medium distance exploration type - smooth subtype dominated the ECM community.

From this preliminary research can be assumed that despite unfavorable conditions on landfill some ECM fungi are well adapted and might help poplar trees to cope with contamination and other stress factors.

Keywords: *Populus nigra*, ectomycorrhizae, landfill, ITS, diversity

This research was supported by the Science Fund of the Republic of Serbia, #*GRANT No 5357, Landfill Remediation with the Use of Short Rotation Biomass Woody Crops (SRWC) Energy Plantations and Provisioning Multiple Ecosystem Services TreeRemEnergy.*

Monitoring the health status of poplar trees in Zeleznicki park in Novi Sad

by Milutin Đilas | Verica Vasic | Leopold Poljakovic Pajnik | Miroslav Markovic | Sreten Vasic | Sasa Orlovic | Institute of Lowland Forestry and Envinroment | Institute of Lowland Forestry and Envinroment | Institute of Lowland Forestry and Envinroment | Institute of Lowland Forestry and Envinroment | Institute of Lowland Forestry and Envinroment | Institute of Lowland Forestry and Envinroment

ID du résumé: 33

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

In Zeleznicki Park, dieback of *P. x euramericana* was noted in 2017. The poplar rot fungus *Cyclocybe aegerita* was observed to be developing in clusters at the bases of the trees, and in the years that followed, the dieback persisted along with the leaning of the trees. The static stability and internal structure of p*oplar* wood was checked using semi-destructive micro-drilling method and IML PD 400 resistograph and the different stages of the structural erosion of the wood were observed. From wood samples exhibiting symptoms, ophiostomatoid fungus, fusarioid fungi, and *C. aegerita* were identified. The fruiting bodies at the bases of the trees are definitely members of the species *C. aegerita*, according to molecular phylogenetic analyses. Frequent climate extremes along with other stressful factors in urban areas make poplar trees sensitive to windstorms, windbreaks, and attack of opportunistic pathogens. Therefore, it is essential to conduct intensive monitoring of health and stability of poplar trees in urban areas and this should be done using resistance measurement devices for the detection of wood decay like resistograph. This instrument provides insight into the tree structure and the possibility of timely reaction to make city parks a safe and pleasant place for people to rest and relax.

Valuing Ecosystem Services: The Role of Fast-Growing Tree Species in Sustainable Policy Frameworks

by Bill Jusu | Jallah Amos Fayiah Gbowah | Global Peace and Development Organization | Supreme Court of Liberia/Global Peace and Development Organization

ID du résumé: 44

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Introduction:

Environmental and ecosystem services represent a critical intersection of ecological health and human well-being. Despite their profound importance, these services are frequently overlooked in economic evaluations and policy decisions, leading to their degradation and loss. The focus of this study is on fast-growing tree species, aligning with the conference theme, to assess their role in providing ecosystem services and their potential for integration into policy frameworks.

Abstract:

Fast-growing tree species offer unique opportunities for carbon sequestration, biodiversity enhancement, and sustainable resource management, making them a critical component of ecosystem service valuation. This study aims to evaluate the significance of these species in providing essential ecosystem services and their integration into policy frameworks and decision-making processes.

By employing a multidisciplinary approach, the research synthesizes existing literature, case studies, and empirical data. Specific fast-growing species such as Eucalyptus, Poplar, and Acacia are examined for their rapid growth rates, high biomass production, and ability to thrive in various environments. These characteristics make them valuable for afforestation and reforestation projects, contributing significantly to carbon sequestration and soil stabilization.

Key Findings:

1. **Carbon Sequestration:** Fast-growing tree species can sequester carbon at rates significantly higher than slower-growing species, offering a viable solution for mitigating climate change.
2. **Biodiversity Enhancement:** These species can create habitats for various flora and fauna, thereby supporting biodiversity and ecosystem resilience.
3. **Economic Benefits:** Fast-growing trees can provide raw materials for timber, paper, and bioenergy industries, promoting economic development in rural areas.

Conclusions:

The study concludes that integrating fast-growing tree species into environmental policy frameworks can enhance the provision of ecosystem services. Their rapid growth and ecological benefits make them ideal candidates for reforestation and land rehabilitation projects.

Recommendations:

1. **Policy Development:** Policymakers should create incentives for planting fast-growing tree species in afforestation and reforestation initiatives.
2. **Research Investment:** Increased funding for research on the ecological and economic benefits of fast-growing species is essential to maximize their potential.
3. **Cross-Sector Collaboration:** Collaboration between government, industry, and research institutions is crucial to develop and implement effective policies.
4. **Public Awareness:** Educating the public on the benefits of fast-growing tree species can foster community support for planting initiatives.

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From waste to resource: Reusing wastewater for sustainable biomass production in short rotation coppice plantations

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ID du résumé: 58

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Biomass stands as a relevant resource for sustainable low-carbon bioeconomy development, especially through short rotation coppice plantations (SRC) capable of biomass production and carbon sequestration. However, sustaining poplar SRC in Mediterranean environments demands irrigation during summer droughts, which poses a challenge in the context of global change where water is a scarce resource. Leveraging the phytoremediation capacity of these plantations, this study explores the feasibility of reusing wastewater from an agroindustrial hydroponic red berry cultivation for biomass production in *Salicaceae* SRC plantations. Combining both aspects involves establishing wastewater-irrigated plantations, known as Vegetation Filters. The aim of this research was to assess the suitability of different poplar and willow genotypes for enhancing the efficiency of simultaneous biomass production and wastewater recycling.

To evaluate the suitability of genotypes prior to field establishment of such systems, it is advisable to test which genotypes can withstand the type of water used and which respond better in terms of production. For this purpose, a greenhouse trial was conducted testing the suitability of seven different genotypes of productive hybrid and native poplars as well as willows, with one treatment irrigated with wastewater from red berries grown in hydroponics and another with tap water as a control, using a randomized design. Biomass production (leaves, stems and roots), root:shoot ratio and tolerance index were monitored during initial growth stages. While genotype differences were observed, no significant differences between treatments were detected in yield. However, a slight increase in production was observed in the wastewater treatment for most genotypes, suggesting a potential fertilizing effect of the water used, which is rich in nitrates. The *Salix* genotype 'Levante' showed the highest production

potential in both the wastewater and control treatments, demonstrating better performance under high irrigation conditions.

These results underscore the potential of utilizing wastewater for biomass production in water-constrained short-rotation plantations, with genotype-specific responses highlighting the importance of wastewater characteristics. Vegetation Filters transform irrigation challenges into opportunities by integrating the purification and recycling of wastewater while simultaneously producing biomass, sequestering carbon, and providing other ecosystem services.

Growth responses of Populus nigra under salt stress and inoculation with arbuscular mycorrhizal fungi

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ID du résumé: 68

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

One of the limiting factors for the growth and development of plants related to the soil properties is salinity. On the other hand, *mycorrhizal* fungi as the most prominent *microorganisms* in most *natural soils* can help produce plants with higher growth performance especially under adverse environmental conditions. In this study, under controlled condition in a pot study and in an experimental randomized complete block design with two factors: inoculation status (inoculated or not inoculated with native mycorrhizal fungi) and salinity stress (0, 50, 100, 150 and 200 mM), some morphological, physiological, and biochemical responses of *Populus nigra* plants were investigated. The results showed that the poplar plants under low salt stress (50 mM) did not show significant differences with the control plants in terms of survival, growth, biomass and physiological and biochemical parameters. Under elevated levels of NaCl (100, 150 and 200 Mm), soil salinity decreased survival, growth parameters, biomass production, relative water content of leaves, the concentration of N and K in plant tissues, the concentration of Ca in root and leaf, the concentration of Mg in leaf, but increased the physiological parameters of leaf (proline and sugar contents, malondialdehyde concentration, and enzyme activities), the concentration of Na and Cl in plant tissues, the concentration of P, Fe, Zn, Mn, and Cu in root and leaf compared to those of the control treatment. In general, at high levels of salt in the soil (150 and 200 mM), a severe decrease in survival was observed along with more morphophysiological and biochemical changes in poplar plants, and poplar plants were not tolerant to these two salinity levels. On the other hand, the mycorrhizal plants in our study had higher growth and biomass under the low salt level (50 and 100 mM) and control condition, however the effect of mycorrhizae decreased with enhanced salinity stress. Decrease in survival, growth parameters and biomass production, changes in physiological parameters and absorption and accumulation of macro and micro nutrients in plant tissues, and also the higher accumulation of proline and sodium and chlorine elements in the leaf compared to salt-resistant poplar species indicate this poplar clone as a salt-sensitivite poplar. In poplar plantation programs, it is necessary to considerate of soil salinity and degree of sensitivity of this poplar

clone towards excess salt. In addition, by producing mycorrhizal plants, the resistance of this poplar clone to the low salt level can be increased.

Salix humboldtiana growing on heavy metal contaminated sediments in San Fernando, Buenos Aires, Argentina. A case study as a joint proposal for phytoremediation and environmental restoration

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ID du résumé: 77

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Fast-growing willow in hight-density stands planted on contaminated sediments may offer useful possibilities for phytoremediation. In order to explore this potential of willows a field trial was established in a contaminated site on the coast of the Luján River, San Fernando, Buenos Aires Province (-34,436809, -58.541878); a place near the Reconquista River, currently considered the second most polluted river in the country, where the variable response to the bioassays confirms that the river is used as a recipient of toxic mixtures, including heavy metals, discharged intermittently. In order to characterize the trial site, a laboratory analysis of sediments was carried out and the presence of heavy metals (Cd, Cu, Pb and Zn) was detected, with Zn being the predominant element.

Salix humboldtiana (the only native willow in South America) was the selected species for the field trial, with the complementary aim to contribute the restoration of the natural landscape. Cuttings of seven experimental genotypes were established in three blocks (from the highest part of the coast to the lowest and closest to the river), with three repetitions of each genotype per block.

At the end of the first growing season total height (Ht) and diameter at breast height (DHB) of the predominant stem of the plants were measured as general performance indicators in the experiment. The following mean values were obtained: Ht = 2.48 m; DBH = 2 cm, and 2 was the most frequent number of stems. No significant differences in growth were found between genotypes. Statistical differences were detected in terms of proximity to the river, which is explained by the longer permanence time of the water. A first laboratory analysis at 10 months of age, carried out on samples of roots, stems and leaves, showed accumulation of heavy metals that had been detected in the sediments (Cd, Cu, Pb and Zn), without any effects being observed of toxicity in plants at this young

age. In the coming years, studies will continue to be carried out to more exhaustively evaluate the accumulation mechanisms of these genotypes and the possible effects on plants, but these preliminary results of willows encourage their use in contaminated sites and, at the same time, to restore populations of *Salix humboldtiana* in riparian areas that are the natural habitat of this species.

Mapping Land cover of Riparian Ecosystem by optical and radar Sentinel Images (Case Study: Zarrineh Rood of Iran)

by Sara Teimouri | Jaafari Abolfazl | Fatemeh Ahmadloo | Jalal Henareh | Samaneh Razavi Zadeh | Mohsen Calagari | Azadeh Salehi | Assistant Professor at Research Institute of Forests and Rangelands | Assistant Professor at Research Institute of Forests and Rangelands | Assistant Professor at Research Institute of Forests and Rangelands | Assistant Professor at West Azarbaijan Agricultural and Natural Resources Research and Education Center | Assistant Professor at Research Institute of Forests and Rangelands | Associate Professor at Research Institute of Forests and Rangelands | Assistant Professor at Research Institute of Forests and Rangelands

ID du résumé: 89

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Since the riparian ecosystems of Iran are habitats of fast growing species such as *Salix sp., Populus euphratica, Tamarix sp*. and all kinds of poplars, in order to extract their area, advanced remote sensing techniques are needed. Considering the importance of investigation and monitoring riparian ecosystems, this project aimed to identify and mapping the land cover with tree and shrub species classes around the Zarrine Roud in west Azerbaijan province and Kurdistan province of IranIn this research, the land cover classes were separated during two stages. In the first stage, using the time series data of Sentinel 1 and 2, the map was included different classes of tree cover (natural, wood farming, orchard), shrub cover (natural, orchard), grass or pasture, agriculture, residential lands, soil and water bodies. For this purpose, considering that the seasonal changes of the images can provide appropriate information about the land cover classes, one-year (2021) time series images Sentinel 2 optical images and Sentinel 1 radar polarizations for 2021 in the form of median in each season, were processed on the Google Earth Engine platform. In the second stage, in order to separate the vegetation classes into *Tamarix*, willows, orchard and poplar plantation, the trend of one-year changes of normalized difference vegetation index (NDVI), normalized green red difference index (NGRD), normalized difference red edge index (NDREI) and green normalized difference vegetation index (GNDVI) combined with HV polarization of Sentinel 1 radar in the form of median in seasons, was used as input feature. The land cover map contained *Tamarix*, willows, orchard, poplar plantation, grass or pasture, agriculture, residential lands, soil and water bodies was produced. In the first stage of classification, the input feature of NDVI (Monthly)_ Radar (Seasonal)_ Sentinel 2 (Seasonal) and the random forest classifier were the best feature and the most accurate classification algorithm which separated the classes from each other with an overall accuracy and Kappa coefficient of 88% and 0.85 respectively. In the second stage of classification, the overall accuracy and Kappa coefficient obtained from the validation relying on ground samples and Google Earth images were 78% and 0.74, respectively. Among the vegetation classes, willows and agricultural lands show the best distinction. As a result, if tree and shrub stands are pure and have a different phenological behavior from their neighboring's, they can be distinguished with higher accuracy using time series of satellite images.

Ectomycorrhizal symbiosis increases NPK uptake in Populus alba seedlings under drought stress

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ID du résumé: 115

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Due to some characteristics such as rapid growth, genotypic diversity and adaptability to different environmental conditions, poplar species are among the model plants in tree species research. Since poplars are water-loving plants, global warming resulting in drought has limited their cultivation in some parts of Iran. Current research by scientists has shown that the use of ectomycorrhizal fungi increases resistance to desiccation, plants with ectomycorrhizal symbiosis show better growth properties. Ectomycorrhizae (ECM) is an association of fungi with the roots of some higher plants, with both parties equally benefiting from this association and it appears to be important for the survival of both parties and undoubtedly this association has far-reaching benefits for forests and restoration ecosystems. The most important role of ECM fungi analyzed worldwide is that they are the best biofertilizers and compatible with the environment. The underground mycelial network of ectomycorrhizal fungi absorbs large amounts of nutrients in places inaccessible to the roots and releases them to their host plants. In this study, we established an ectomycorrhizal symbiosis between poplar (*Populus alba*) seedlings and the fungus *Laccaria bicolor* (Maire) P.D.Orton under greenhouse conditions. At 14 weeks after inoculation with the ectomycorrhizal fungus, poplar seedlings were subjected to drought stress by reducing irrigation water according to the agricultural capacity of the plants. To measure the amount of nitrogen, phosphorus and potassium elements in the leaves of the tested plants, three leaves were separated from each plant and the nitrogen measurement of the whole plant was carried out after distillation using the titration method, the potassium measurement was carried out by flame emission and the phosphorus measurement was carried out using the calorimetric method. Based on the results of analysis of variance, the amount of nitrogen, phosphorus and potassium in mycorrhizal plants was significantly different from the amount of these elements in the control treatment. The amount of elements in the mycorrhizal treatment under drought stress also showed a significant difference compared to the control treatment under drought stress, while there is a

significant difference between mycorrhizal drought and the control only in the amount of potassium. The results of our study, consistent with many other studies, show that the use of ectomycorrhizal fungi even under drought stress conditions helps to better absorb the materials needed by the plant and that ectomycorrhizal symbiosis can be effective in poplar cultivation in places with limited water and mineral resources.

Physiological responses of ectomycorrhizal Populus alba L. seedlings to salt stress

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ID du résumé: 116

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Poplar species differ in salinity tolerance, *Populus euphratica* Olivier has high salinity tolerance and *P. alba* has moderate sensitivity to salinity. The results of various experiments show that ectomycorrhizal fungi increase host plant resistance to salinity by improving mineral nutrition of N and P and reducing the absorption of Na+ ions under salt stress conditions. In this study, the influence of ectomycorrhizal symbiosis on the physiological properties of poplar plants under salt stress conditions was investigated. The symbiotic fungus *Laccaria bicolor* (Maire) P.D.Orton was inoculated onto the *P.alba* seedlings. After 14 weeks, and after microscopic observation to ensure the establishment of the symbiotic fungus on the root, a salt loading of 200 milliliters of saline solution is carried out three times per week in the form of: first week 10 mM saline, second week 30 mM saline, third week and before sampling 50 mM solution was applied to half of the mycorrhizal and nonmycorrhizal pots. Measurement of traits related to plant gas exchange, including leaf photosynthetic rate, stomatal conductance, substomatal CO2 concentration, and leaf evaporation and transpiration, was carried out using the LI-COR (portable photosynthesis system) model LI-6400XT. To obtain data, five of the youngest leaves of each seedling was analyzed and all measurements were taken between 9 and 11 a.m. Based on the results of mean comparison and analysis of variance, photosynthetic rate was significantly higher in *P. alba* seedlings inoculated with ectomycorrhizal fungi than in the control (no mycorrhiza), but differences in the transpiration rate, stomatal conductance and intercellular CO2 were lower, under normal conditions. In salinity treatment, ectomycorrhized plants significantly showed higher amount of photosynthesis, stomatal conductance and transpiration than Nonectomycorrhized plants, but no significant difference in the amount of intercellular CO2 was observed between these two treatments. Although, the response of plants to ectomycorrhizal symbiosis is complex and dependent on host tree species and ectomycorrhizal fungal species, these results are in agreement with the results of those studies conducted on other plant species that show the positive effects of ectomycorrhizal symbiosis under salinity stress conditions, including the increase in photosynthetic capacity. Overall, the results indicated that the salt tolerance of *P. alba* seedlings was improved by ectomycorrhizal inoculation.

From an ecological point of view, *P. alba* in symbiosis with *L. bicolor* has the potential to be used in the development of wood production and resistance to salinity in saline soils in Iran.

Phytotechnologies to Remediate and Stabilize Stamp Sands in Michigan's Upper Peninsula, USA

by Elizabeth R. Rogers | Erin Johnston | Ronald S. Zalesny Jr. | Ryan A. Vinhal | Jacob Dessellier | Katherine A. Heckman | Evan S. Kane | Chung-Ho Lin | Mackenzie Russell | Karena Schmidt | USDA Forest Service | Keweenaw Bay Indian Community (KBIC) | USDA Forest Service | USDA Forest Service | Keweenaw Bay Indian Community (KBIC) | USDA Forest Service | Michigan Technological University | University of Missouri | Michigan Technological University | Keweenaw Bay Indian Community (KBIC)

ID du résumé: 126

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

During the 20th century, ore mining activities in the north central United States generated billions of pounds of ore processing waste, known as stamp sands. Stamp sands are small pieces of rock resembling coarse sand that result from mechanical crushing of ore-bearing rock to obtain the minerals within. In the Upper Peninsula of Michigan, where copper ore deposits are plentiful, much of these stamp sands were deposited along the shores of or directly into Lake Superior. These stamp sands are prone to erosion, and often contain elevated levels of heavy metals, posing risks to human health and the environment. One particular location in the Upper Peninsula that is currently affected by stamp sands is Sand Point, an 18.2-hectare site located within the Keweenaw Bay Indian Community (KBIC) L'Anse Indian Reservation. During the early 1900s, a nearby stamp mill dumped 2.7 million metric tons of stamp sands into Keweenaw Bay, 8 km north of Sand Point. Over time, as a result of wave action and coastal currents, nearly 344,000 cubic meters of stamp sands have been deposited at Sand Point. Sand Point and its surrounding area provide a variety of beneficial uses to the KBIC, including those related to subsistence, cultural activities, and recreation. The KBIC has led extensive restoration activities at the site, involving soil capping of stamp sands, placement of mounds and boulders to provide protection from the wind, and annual plantings of trees, shrubs, and herbaceous native plants. Despite these efforts, the stamp sands continue to impair many of the beneficial uses of Sand Point, and continue to encroach on coastal wetlands. Therefore, researchers at the USDA Forest Service, Michigan Technological University, and the University of Missouri have partnered with the KBIC to design and deploy an adaptive silvicultural system that combines specialized, fast-growing trees (hybrid poplars and willows) with biochar soil amendments to enhance stamp sands phytoremediation and phytostabilization. Priority areas for restoration were identified by the KBIC in November 2024. Cuttings were planted in June 2024 in requisite experimental designs to allow for statistical analyses

among the experimental variables (genotype; soil treatment). More information on proposed activities at Sand Point, as well as updates on project progress will be presented.

Clonal Selection of Poplars and Willows for Phytoremediation and Phytostabilization of Stamp Sands Mining Waste in Michigan, USA

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ID du résumé: 127

Event: IPC2024 : Poplars and other fast-growing trees for climate change mitigation and adaptation - Pathways to climate resilience and carbon neutral societies

Topic: WP-ENV - Environmental and Ecosystem Services

Industrial copper ore mining activities during the 20th century resulted in the processing and dumping of billions of pounds of ore processing waste, known as stamp sands, into Lake Superior and its coastal wetlands. Copper and other metals and contaminants in the stamp sands have substantially impacted waters and soils of the Keweenaw Peninsula in the Upper Peninsula of Michigan, USA, prompting a need for sustainable solutions to protect human health and mitigate the effects of these stamp sands on the environment. To address these needs, researchers at the USDA Forest Service and University of Missouri used two greenhouse phyto-recurrent selection cycles to identify poplar and willow clones to be outplanted at stamp sands phytoremediation and phytostabilization demonstration plots based on their enhanced potential to: 1) immobilize copper and other contaminants in the soil (i.e., phytostabilization), and 2) reduce the toxicity and clean the stamp sands (i.e., phytoremediation). Three soil treatments were tested in each cycle: 1) 100% stamp sands collected from Gay, Michigan, USA, 2) 50% stamp sands + 50% nursery soil (v:v), and 3) greenhouse potting soil (experimental control). In Cycle 1, 45 poplar and 21 willow clones were tested for differences in survival, height, diameter, and biomass of roots, stems, and leaves after 21 days of growth. In general, trees grown in the control soil and pure stamp sands were the largest and smallest trees, respectively. Willows had greater growth and biomass overall, yet diameter and biomass of poplars grown in the 50:50 treatment was similar to the control. In contrast, willow control trees were consistently larger than their 50:50 and pure stamp sands counterparts, indicating a greater stamp sand tolerance of poplars despite their smaller size. In Cycle 2, the best 15 poplar and 7 willow clones from Cycle 1 were tested for these parameters and physiological and health traits after 35 days of growth. Results from both selection cycles will be presented, highlighting the potential of using clones chosen from phyto-recurrent selection to remediate and stabilize lands impacted by stamp sands.