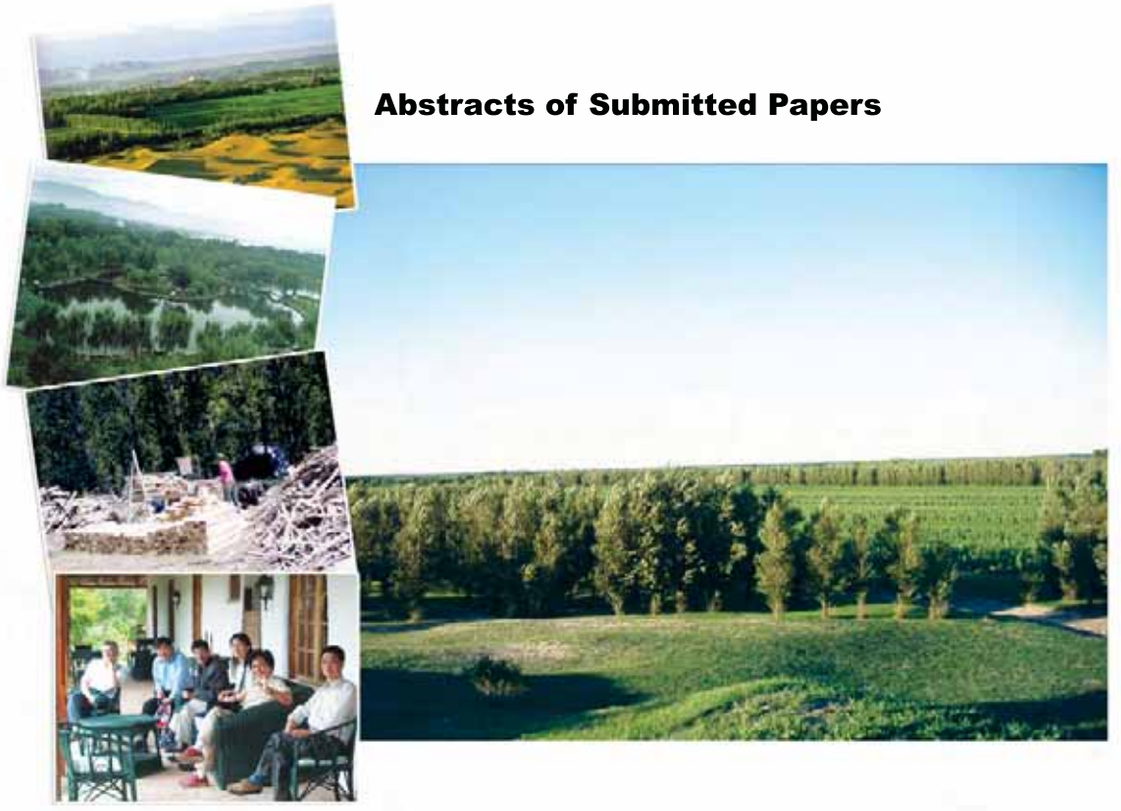
INTERNATIONAL POPLAR COMMISSION

23rd Session

Beijing, China, 27 – 30 October 2008

POPLARS, WILLOWS AND PEOPLE'S WELLBEING



Abstracts of Submitted Papers

Forest Resources Development Service
Forest Management Division
Forestry Department

Working Paper IPC/5
FAO, Rome, Italy

Disclaimer

These Abstracts of Submitted Papers do not reflect any official position of FAO but are to provide early release of information on on-going International Poplar Commission initiatives and its member country activities and programmes to stimulate dialogue between Poplar and Willow stakeholders around the globe.

Comments and feedback are welcome.

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Web references:

For details relating to the International Poplar Commission as a Technical Statutory Body of FAO including National Poplar Commissions, working parties and initiatives can be viewed on www.fao.org/forestry/ipc and highlights of the 23rd Session of the International Poplar Commission, 2008 can be viewed on www.fao.org/forestry/ipc2008.

Photo credit

Larger photo: Former desert stabilized by poplars under a State Forest Administration-FAO-Belgian Project to rehabilitate the Korqin Sandy Lands, Tong Yu District, Inner Mongolia.

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Abstracts of Submitted Papers

Organized by
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These abstracts of Submitted Papers are the product of a global team of dedicated people willingly giving their time and specific experience. It is encouraging to see the diversity of topics selected by the authors, reflecting the topical issue of 27 countries, in all temperate and boreal regions of the world. Jim Richardson (Canada), Stefano Bisoffi (Italy), Jud Isebrands (USA), Yin Weilun (China), Qiwen Zhang (China), Drusilla Riddle-Black (UK) and Jim Carle (FAO) of the Scientific Committee undertook the evaluation, review and allocation of abstracts for plenary, oral or visual presentations. The communications with authors was efficiently coordinated by the IPC administrative assistant, Graciela Andrade (FAO) and the cover design by Roberto Cenciarelli (FAO, Consultant). The computer and database expertise of Alberto Del Lungo (FAO) was critical in tracking and managing the paper summary review process in an accurate and orderly manner. Michèle Millanès (FAO) properly performed editing and formatting of the abstracts, ably supported by Jim Richardson (Canada).

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FOREWORD

Member countries of the International Poplar Commission (IPC) report that the cultivation of both naturally regenerating and planted poplar and willow species in temperate and boreal regions are increasingly being cultivated according to new methods. Poplars and willows are used more and more for new applications by not only industrial but also smallholder investors in forestry, agriculture, viticulture, horticulture and agro-forestry.

Poplars and willows contribute significantly to people, their lives, and livelihoods through the provision of wood products (industrial roundwood and poles, pulp and paper, reconstituted boards, plywood, veneer, sawn timber, packing crates, pallets, furniture etc.), non-wood products (fodder, medicines, etc.) and environmental and social services (shelter, shade and protection of soil, water, crops, livestock and dwellings). Poplars and willows play an important role in phyto-remediation of severely degraded sites, rehabilitation of fragile ecosystems, landscape restoration, sequestration of carbon and, increasingly, as a viable source of bioenergy. The environmental applications of poplars and willows are also being recognized as effective means for recreational and amenity purposes.

The International Poplar Commission strives to bring scientists, managers, policy makers, academics and other stakeholders together to bridge the science - policy - management practices gaps aimed at improving the cultivation and uses of poplars and willows and enhancing their contribution to the social, environmental and economic dimensions of development. The IPC formal Sessions are held every four years in different regions of the world to address topical issues and demonstrate unique applications of poplar and willow culture and management reflecting local contexts.

The 23rd Session of the International Poplar Commission will bring stakeholders together to address topical issues related to the theme ***"Poplars, Willows and People's Wellbeing"*** hosted by China, in the heart of the Asian region. China has a rich past and exciting future in poplar and willow cultivation for a large number of poplar and willow applications, from beautification of cities, rehabilitation of degraded lands, combating desertification, fast-growing commercial plantations and agroforestry systems, investment by large companies and smallholder farmers growing a great number of forest products and provision of a wide range of social, environmental and economic goods and services. China has also become a world leader in poplar genomics, genetic transformation and development of genetic tools to improve resistance to biotic agents, improve wood quality and increase productivity.

The 250 paper abstracts from 27 countries contained in this working paper demonstrate the increasing diversity in users and uses of poplar and willow culture, but also highlight the expanding knowledge and rapid development of new technical innovations (both growing and using) of poplars and willows around the globe. The papers range across all working parties: genetics, tree improvement and conservation; production systems; environmental applications; harvesting and utilization; invasive insects, and diseases. This also embraces the application of poplars and willows in multi-disciplinary and inter-sectoral land-uses. It is also a feature that there are paper abstracts from not only industrialized countries, but also from those with economies in transition and developing countries.

This Book of Abstracts will help to facilitate fruitful discussions between stakeholders at the 23rd Session and will also provide participants with author coordinates for follow up beyond the Session. It is hoped that this Book of Abstracts will facilitate stimulating dialogue between stakeholders to enhance the contribution of poplars and willows to peoples' well-being.

Best wishes for a fruitful Session in transferring poplar and willow knowledge and technology effectively between different stakeholder groups regardless of socio-economic contexts.

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(BY SUBJECTS)

WORKING PARTY ON PRODUCTION SYSTEMS

WORKING PARTY ON HARVESTING AND UTILIZATION OF POPLAR AND WILLOW WOOD

Abstracts marked with an asterisk have been presented to the "Engineered Wood Products Based on Poplar/Willow Wood" held in Nanjing, China, from 21 to 24 October 2008

WORKING PARTY ON ENVIRONMENTAL APPLICATIONS OF POPLARS AND WILLOWS

WORKING PARTY ON POPLAR AND WILLOW DISEASES

WORKING PARTY ON POPLAR AND WILLOW INSECTS AND OTHER ANIMAL PESTS

IN VITRO REGENERATION OF *POPULUS DELTOIDES* CV. AUSTRALIA 129-60

W. Abedini, M. Adema, R. Amado Cattaneo, A. De Francesco, H. Ciccioni and S. Sharry[1]

The genus *Populus* (Fam. Salicaceae) has a prominent role within the forestry industry in Argentina and has an estimated planted area of 63,500 hectares. The cultivation of poplar is not merely regarded as a form of forest land use but is increasingly also used for landscape restoration, rehabilitation of degraded land and combating desertification.

The *Populus deltoides* clone 'Australia 129-60' is resistant to rust and canker disease and has excellent size, performance and wood quality. Many countries have improvement programs using genetically modified (GM) poplars and recently the complete genome of *Populus trichocarpa* was achieved. However, for genetic transformation of poplars it is necessary to develop an efficient protocol for tissue culture and whole plant recovery.

While GM poplars have been obtained with different characteristics (resistance to pests and diseases, wood properties, growth and yield, herbicide tolerance), the genotype *P. deltoide*s is considered recalcitrant, since calluses have been successfully transformed, but its regeneration of stable transformed plants has not been possible. Therefore the objective of this research was the establishment of a mechanism for *in vitro* regeneration of *Populus deltoides* cv. Australia 129-60 for later genetic transformation.

We used embryos from immature fruit of *Populus deltoides* cv. Australia 129-60, surface-disinfected with 5% sodium hypochlorite using 2 drops of Tween 20 for 10 minutes and then washed twice with sterile water. The embryos were grown in the base medium of Murashige Skoog (MS) supplemented with α-naphthalenacetic acid (1 and 2 mg/l) for callus formation. To induce bud proliferation, the calluses were subcultured on three different culture media: (1) woody plant medium (WPM) with addition of 40 mg/l adenine, 0.5 mg/l 6-benzylaminopurine (BAP) and 0.1 mg/l α-naphthalenacetic acid (NAA); 2) ¾-strength MS macronutrients plus 1 mg/l indole-3-butyric acid (IBA) and 0.5 mg/l kinetin; or 3) MS supplemented with BAP 1 mg/l and NAA 0.5mg/l. For elongation of budsMS was used with added BAP 1 mg/l, NAA 1 mg/l and giberellic acid 5 mg/l. Rooting was achieved in WPM with 0.1 mg/l IBA. Acclimatization and gardening was obtained on a soil-perlite-vermiculite (6:3.5:0.5) mix.

The embryos formed organogenic calli on MS supplemented with NAA 2 mg/l (64%). The average callus size was 1.13 cm. The best way to proliferate buds was MS with BAP 1 mg/l and NAA 0.5 mg/l. The culture media tested for bud elongation and rooting were adequate. It was possible to develop an efficient regeneration system for the recalcitrant genotype *Populus deltoides*, thus allowing testing of genetic transformation to start.

Key words: micropropagation, poplar, tissue culture, embryo rescue.

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WATER AVAILABILITY LIMITS EARLY GROWTH OF POPLAR (*POPULUS* SPP.) IN THE PLANE PAMPAS OF CENTRAL ARGENTINA

Fabio G. Achinelli[1,2,3], Sebastian P. Angelinetti[1], Maximiano R. Delgado[1], Eduardo Skorupski[4] and Virginia M.C. Luquez[2]

In Argentina, most poplar (*Populus* spp.) plantations are located in the Paraná River Delta, an area where episodes of flooding frequently lead to disruptions in wood supply. This prompted the development of poplar plantations in agricultural soils on the Plane Pampas of central Argentina (33° to 36° S Lat., 57° to 63° W Long.). In this area, annual rainfall ranges from 700 to 1000 mm, and the distribution of the rainfall during the growing season may be uneven. Dry periods occur particularly in summer, when lack of rainfall is combined with high evaporative demand, which could limit growth since commercial plantations are not irrigated. It has been shown that there is variation in water stress tolerance between *P. deltoides* Marsh. and *P.* × *canadensis* Moench clones, but a systematic evaluation of drought tolerance in clones planted in Argentina has not been carried out. The aim of this study was to determine which clones are most sensitive to naturally occurring drought episodes during the growing season.

A field experiment was carried out at El Gazapo (34º 12´ S Lat.; 61º 43´ W Long.; 90 m elevation) where nine clones were planted in August 2007 on a typical hapludoll. The experimental design was a split-plot, with 54-plant main plots replicated in three randomized complete blocks. Main plots were established with and without irrigation, and clones were planted in 6-plant subplots. The irrigation treatments were applied from November 2007 to April 2008 and consisted of: (i) plants receiving only natural rainfall (515 mm in total), (ii) plants watered weekly with the equivalent of 36 mm of rainfall when natural precipitation did not reach a minimum of 45 mm in the previous week. Measurements were taken four times: 15 November and 13 December 2007, and 11 February and 20 April 2008. At the last date, all clones had set terminal buds. The variables measured were: basal diameter (mm), total height (m), individual leaf area of the last expanded leaf (ILA, cm^2) and leaf area (LA, cm^2) of leaves formed between each period of sampling. Clonal responses to irrigation were significantly different. The ILA and the LA produced between measurements were higher in the irrigated plants, but there were differences in the clones as well, with significant clone × irrigation interactions. Cumulative growth at the end of the season, expressed as volume index (VI, dm^3 = [(basal diameter)^2] · total height), was always lower in the non-irrigated treatment, but the intensity of response varied between clones. To quantify drought susceptibility, we calculated growth increases due to irrigation, by taking non-irrigated plots as reference growth levels. The extreme responses were found in *P. deltoides* 'Catfish 2' clone which grew 11.3 times more in watered plots than in the non-irrigated treatment, while in clone *P.* × *canadensis* `Guardi´ the difference was only 3.5 times. Using VI data, we made a ranking of clone responses to drought, taking 'Catfish 2' as the most sensitive and `Guardi´ as the least sensitive, the others being in intermediate positions. This study shows that water availability can limit early growth in poplar plantations on the Argentinean Plane Pampas, and that some poplar genotypes perform better than others under this adverse condition.

Key words: *Populus* spp., Plane pampas, early growth, water availability, volume index, Argentina.

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DENDROCHRONOLOGICAL METHODS APPLIED TO STUDY AMBROSIA BEETLE (*MEGAPLATYPUS MUTATUS* (CHAPUIS)) POPULATION DYNAMICS IN POPLAR (*POPULUS* SPP.) PLANTATIONS OF ARGENTINA

Fabio G. Achinelli[1,2], Maximiano R. Delgado[1], Marcos Jouanny[1] and Gerardo Liljesthröm[3]

Ambrosia beetle (*Megaplatypus mutatus* (Chapuis)) is the most important insect pest in poplar plantations (*Populus* spp.) of Argentina, producing losses both in wood yield and quality. Despite the various research projects being carried out on the biology of this beetle, some aspects of its population dynamics are still unclear. Field work needed to monitor the density and dynamics of the insect is time- and labour-consuming, and the results we have obtained to date showed marked fluctuations from year to year in relative density for unknown reasons.

In order to reconstruct in time the previous density of this beetle in a poplar plantation, we applied dendrochronological techniques to 208 trees from 16 permanent sample plots (PSP), located in a commercial poplar plantation at Alberti, Buenos Aires, Argentina (34° 50' S Lat; 60° 30' W Long; 55 m elevation). Dendrochronological techniques may be applied in this situation as these poplar clones produce wood rings which can be dated, and also stand ages are recorded in each case. This 1 945 ha plantation can be considered an isolated forest situation, because it is completely surrounded by agricultural crops such as cereals and soybeans. The PSPs were representative of intermediate (9-10 years old; eight PSPs) and mature (11-12 years old; eight PSPs) stands.

Selected trees were felled to obtain four logs from each main stem: a basal log 2.6 m long, and second, third and fourth logs 2.2 m long each. This permitted study of the first 9.2 m of trunk of each tree. Logs were then split lengthwise with an axe into two approximately equal parts to expose the interior of the wood. The pieces were carefully examined in the field to mark all beetle galleries present, and then disks of wood were obtained with a chainsaw for each marked gallery. Wood discs were processed in the laboratory to determine: number and dating of tree rings, age of section, type of gallery (imaginal gallery, made by male individuals; larval gallery, a nest that reached reproductive state), and year of formation of the gallery (season when the attack was produced).

First attacks were found very early in some cases, when stands were three years old, but in other plots initial attacks occurred one to four years later. Relative density of the beetle, expressed as the cumulative number of imaginal galleries · ha^{-1} during the rotation varied between 3 710 and 8 584 galleries · ha^{-1}, but was not related to the age of the stand. The presence of the beetle in all mature PSPs was characterized by density peaks at 9-10 years old, followed by pronounced declines at the end of the rotation. Most importantly, this pattern determined that plantations with the highest average diameter at breast height (DBH) had minimal ambrosia beetle activity prior to harvest. This behavior could be related to the possible detrimental influence of natural enemies on the population growth rate of the beetle.

Key words: ambrosia beetle, *Megaplatypus mutatus*, population dynamics, relative density, dendrochronology**,** *Populus*, Argentina.

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ID-103

A STUDY ON DETERMINATION OF PLANTING MATERIAL USED FOR POPLAR PLANTATIONS IN TURKEY

Selda Akgul[1]

In Turkey, the total production of poplar planting material is around 6.2 million saplings per year. Approximately 1.9 million of these saplings are I-214 and Samsun clones. It is known that planting material is very important for successful plantation establishment. In Turkey, poplar plantations are generally established by using one- and two-year-old rooted seedlings.

In this study, the growth and survival of different planting materials were compared - 20, 35, 50 and 65 cm length cutting, one-year-old unrooted saplings and two-year-old saplings - to find out the most economic cultivation method for I-214 and Samsun poplar clones in plantations. The experimental design was a factorial randomized block design replicated twice with six different planting materials for both I-214 and Samsun clones planted in 1998 at 5m × 5m spacing at Izmit. Diameter and height measurements were made every year from 1999 to 2006. At the end of the second year, unit times for a pruning operation were determined.

In the Samsun clone, analysis of variance of annual diameter and height growth showed no significant differences between treatments after one year of growth. In the I-214 clone, according to analysis of variance of annual diameter and height growth showed no significant differences between treatments after two years' growth. Analysis of variance of survival rates for both clones showed no significant differences between treatments.

As a result, owing to the lower cost of production and advantages in transportation and planting, cuttings can be suggested as the best planting material for places with similar growing conditions to Izmit in Turkey.

Key words: planting material, I-214 and Samsun clones, poplar plantations.

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OCCURRENCE OF HERMAPHRODITISM IN *POPULUS ALBA* L., A MOSTLY DIOECIOUS RIPARIAN TREE

N. Alba[1], D. Macaya[1], C. Maestro[2], J. Climent[1] and S. C. González-Martínez[1]

The *Populus* genus is considered dioecious, although hermaphrodite and bisexual individuals occasionally occur in some species. The existence of these hermaphrodite individuals has generally been treated as anecdotic. However, the need for further research into hermaphroditism and its implications for evolution have returned to the agenda since the recent identification of the genes which determine the sex of *Populus.* Due to the importance of *Populus alba* and its wide area of distribution in Spain, studies are currently being undertaken to investigate aspects related to the structure of genetic diversity in natural populations and the characterization of its reproductive system.

In this study, we present the characterization of eight individuals (4 hermaphrodite, 2 female and 2 male) from the same natural *P. alba* stand in the south of Spain. The genetic analyses carried out using molecular markers (nuSSRs) to study clonality in natural stands have revealed that the individuals characterized in the study are different from each other.

A methodology has been established to carry out a quantitative evaluation of the level of hermaphroditism in each individual as well as an analysis of germination to evaluate the efficiency of each sexual morphotype as a mother plant.

The phenomenon of hermaphroditism has only been observed in individuals with aments composed of flowers which are not exclusively female. Furthermore, the results indicate that the hermaphrodite inflorescences originate from male inflorescences which develop a variable number of pistils (1-4) (probably due to mutation), and not from female inflorescences which develop stamens. The female flowers of the hermaphrodite individuals have multiple pistils, whereas those of the female individuals only have one. In all cases, the level of hermaphroditism was higher in the basal third of the ament, varying from one clone to another between 5 and 80, 0 being male and 100 female.

The germination percentage varied from 10 to 50 in the case of the hermaphrodites and from 30 to 90 for female individuals. The germination analysis trials revealed variations in the germination potential of the different mother plants (female trees and hermaphrodite trees), hence definitive conclusions cannot be drawn regarding the reproductive efficiency of hermaphrodite mother plants.

Key words: *Populus alba*, hermaphroditism, natural stands.

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EVALUATION OF *POPULUS ALBA* L. CLONES FOR BIOMASS PRODUCTION FOR ENERGY

N. Alba[1] and H. Sixto[1]

The species *Populus alba* is considered one of the most resilient to conditions of water and salt stress. The identification of clones of this species, which could be used in short rotation coppice to produce biomass under conditions of limited water supply, is proposed to provide possible alternatives to the clones currently used.

The objective of this research is to evaluate different clones of *Populus alba* for use as biomass producers in high-density plantations. The characteristics to be evaluated relate initially to the growth and production of these clones.

An initial selection was made from a collection of more than 400 clones (i = 10 %; 40 clones), attempting to encompass part of the morphological variation of the species: the different phenologies and architectures had been evaluated in previous trials. Once the selection had been made, the trial was installed in 2002 at high density (0.4 m × 1 m), and results were obtained for growth and survival, on the basis of which a second selection was made (i = 10%, 5 clones) based on the survival rate and basal area.

In 2006 a further trial was set up with the five selected clones and data were recorded on growth and phenology. Data were also gathered from the 2002 trial for dry weight of stem and branches (separately) as well as an estimation of the approximate calorific value of the species in 3-year-old plants.

An analysis of the different data obtained allows us to identify the potential of some of the *P. alba* clones for use in SRC and to determine which should be included in trials to evaluate their performance under different cultivation conditions.

Key words: *Populus alba*, SRC.

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USING MORPHOLOGICAL TRAITS FOR IDENTIFICATION OF *POPULUS NIGRA* CLONES

A. Alimohammadi[1], F. Asadi, E. Adeli, S.R. Tabaie-Aghdaei[2] and A. Mataji[3]

Genetic diversity of *Populus nigra* has been endangered by vegetative propagation. In order to adopt strategies for conservation and development, it is necessary to estimate the amount and distribution of genetic diversity in existing populations of poplar in Iran.

In this study, for estimating genetic diversity among and within 12 stands of *Populus nigra* established in Kermanshah and Zanjan provinces of Iran, poplar cuttings were planted in a randomized complete block design with three replications. In the middle of the growing season, 22 morphological traits (leaf length, leaf width, leaf length/leaf width, petiole length, petiole ratio, junction shape, basal shape, tip shape, angle between midrib and second lowest lateral vein, angle between midrib and lowest lateral vein, base angle, apex angle, angle at 10% of blade length, angle at 25% of blade length, blade width at 90% of blade length, blade width at 50% of blade length, leaf blade width at 1cm from leaf tip, distance between widest leaf part and leaf base, number of teeth, depth of teeth, number of veins, leaf area and undulation of edges of leaf blade) were measured and data were analyzed using analysis of variance, cluster and principal component analysis.

Results showed significant differences within stands and between provinces, but no significant differences among stands. Principal component analysis introduced traits with high weight in components. Finally, by using cluster analysis, stands were classified into two groups by province. Results showed that in homogeneous environmental conditions, morphological traits could reveal diversity and similarity in poplar stands.

Key words: *Populus nigra*, morphological traits, genetic diversity.

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ID-030

HEDGEROW INTERCROPPING OF *POPULUS NIGRA BETULIFOLIA* WITH ALFALFA IN IRAN

F. Asadi[1] and M. Calagari

Iran is characterized by widely varying climatic and topographic conditions which result in a broad diversity of forest ecosystems and species variations. *Populus nigra* has a wide distribution in Iran and has been cultivated by farmers on private lands for centuries. Poplar seedlings in many areas of Iran are traditionally planted at low spacing which produces large-dimension trees suitable for industrial utilization. Thus, hedgerow intercropping has ecological and economic benefits for farmers and industries from the annual income produced by agricultural crops between trees for land owners and large-dimension trees for industry.

In this study, *Populus nigra betulifolia* seedlings were planted in a randomized complete block design with three replications and foiur mixed poplar and alfalfa treatments with tree spacings of 3×4, 3×6.66, 3×8, and 3×10 m, as well as two control treatments with only alfalfa or only trees (planted at 3×4m). Plot size was 1 200 m^2. Irrigation was applied during the growing seasons. We investigated some important attributes during the years 1999-2007. Ten distinctive growth attributes for poplar and alfalfa were recorded in the treated plots at different stages and times during the study period. The data were analyzed using univariate and multivariate statistical methods. The study aims to evaluate the performance of poplar intercropped with alfalfa.

Results showed that most tree height growth occurred in mixed treatments at spacings of 3×4, 3×8 and 3×6.66 m with 159, 158 and 142 cm height respectively. The greatest wood volume growth per hectare belonged to the same treatments: 18.4, 11.1 and 10.99 m^3 respectively. The greatest dry weight production of alfalfa was found in the alfalfa alone, 3×10 and 3×8 m treatments with 7 507, 4 788 and 4 265 kg per hectare, respectively. All of the results that showed differences among treatments were significantly different at the 5% level of probability. After nine years of intercropping, there were no significant differences among the spacings for branch diameter or annual tree diameter growth. As a final result at this stage the recommended planting spacing for trees in the poplar/alfalfa intercropping system is 3×6.66 m, depending on the site conditions. Meanwhile, for some attributes, we observed significant differences among years and interaction between treatments and years.

Key words: *Populus*, hedgerow intercropping, alfalfa.

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PATH ANALYSIS OF POPLAR DIFFERENT ATTRIBUTES IN EARLY STAGES OF GROWTH

F. Asadi and H. Mirzaie-Nadoushan[1]

Direct selection of superior poplar clones for cultivation has been based on the evaluation of yield. Using this method is sometimes not possible, due to limiting site characteristics causing unsuitable yields. Therefore, indirect selection based on other attributes correlated with yield could be useful. In this study, path analysis was applied to some morphological and growth characteristics recorded from field studies of poplar clones. The characteristics recorded for five individual plants in each experimental unit were: leaf number, leaf area, total leaf area, length of blade, maximum leaf width, leaf width/length ratio, petiole length, depth of leaf midrib, number of veins, number of branches, branch length, branch diameter, stem diameter, stem diameter/ branch diameter ratio, branch angle, height, number of roots, root length, number of new leaves and survival. Analysis of variance showed differences between the species and their clones for these characters, and then path analysis was performed on the data.

Analysis of height characters revealed that branch numbers and branch angle had a strong direct effect on the dependent variable, height. Branch numbers showed a strong negative direct effect but a strong positive indirect effect through other independent variables on the dependent variable, resulting in a negative total effect of -0.554 on height. Leaf numbers had the greatest direct effect on height. Branch diameter/stem diameter ratio had the greatest negative total effect on height and consequently stem diameter had a strong positive direct effect on height. Survival had a strong positive indirect effect on height through independent variables, counterbalancing the negative direct effects to produce a positive effect of 0.667. However, total leaf area, with positive direct and indirect effects on height, is the most influential character on height and would be the best indicator of height in the poplar species studied. This would be of high value, particularly when a great number of clones are under investigation in the early stages of a poplar cultivation programme.

Key words: poplar, path analysis, morphological attributes, direct and indirect effects.

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ID-067

INDUCTION OF CALLI AND ESTABLISHMENT OF SUSPENSION CULTURES IN *POPULUS ALBA* L. VAR. *PYRAMIDALIS*

Shan-shan Bai, Xiang-yang Kang and Yan-chun Jing[1]

In this research, the induction of calli from blades and stems of sterile seedlings and the establishment of suspension cultures of *Populus alba* L. var. *pyramidalis* were investigated. The main results were as follows:

There was almost no difference in the ratios of callus induction among different sites of materials used in the experiments. The optimal callus-induction medium was 3.0 mg/l of 1/2MS + 2,4-D, for which the induction ratio was 100%. The calli were vivid light yellow granules and grew quickly after 2~4 subculture periods, which was ideal to establish suspension culture.

It was found that plant hormone levels, initial inoculation capacity and subculture periods influenced the results of *P. alba* L. var. *pyramidalis* suspension culture. The optimal medium was MS + 1.5 mg/l 2,4-D + 1.0 mg/l ZT + 0.02 mg/l NAA + 600 mg/l MES + 500 mg/l CH + 200 mg/l L-Glutamine + 150 mg/l L-Aspartic acid, with an initial density of 2 g of embryonic calli in 30 ml of liquid medium, initial inoculation density of 1 ml suspension cells in 30 ml liquid medium, and a subculturing period of 8~10 days.

Factors influencing protoplast culture and cell fusion were studied.

Key words: suspension, calli, *Populus alba* L. var. *pyramidalis.*

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ID-135

AN OVERVIEW OF POPLARS IN BOSNIA AND HERZEGOVINA

Dalibor Ballian[1]

The distribution of native poplars *(Populus nigra*, *Populus alba*) in Bosnia and Herzegovina is associated with large rivers and some of their smaller tributaries.

With the arrival of the Austro-Hungarian Monarchy to Bosnia and Herzegovina, the first introduction of exotic species of poplars happened when introduced species were planted near railway stations. Our country was also not spared the introduction, although largely unsuccessful, of the cultivars of Canadian poplars (*P.* × *canadensis* Moench). Apart from Canadian poplars, only balsam poplars have been introduced, in minor quantities, and are being used only for urban plantings. Nevertheless, we can consider the genetic resource of native poplars in Bosnia and Herzegovina to be in good health and one of the best preserved in Europe. Thus it represents a real treasure. This status is primarily due to the fact that intense production of woods trees has never taken place in Bosnia and Herzegovina.

The lack of management of human activity in riparian areas, arbitrary and unplanned regulation of water flows, opening of gravel production plants, deposition of garbage, and absence of any legal regulations that would protect the current status of the black poplar genetic resource, all these factors represent basic threats to the native genetic resource of black poplars. Compared to other tree species, much has been done to protect native species of poplar, and in co-operation with colleagues from Croatia, previously included in the programme of network research and preservation of the genetic resources of European forest tree species (EUFORGEN), around 70 trees of black poplars were successfully vegetatively reproduced and placed in the clone archives in neighboring Croatia. Based on this experience with our Croatian colleagues, a clone archive of black poplars in Bosnia and Herzegovina with around 165 clones of native black poplars has been initiated in 2006.

Currently, poplars are considered marginal species the country, but this situation will most likely change entirely in the near future, with the increasing of ecological consciousness of the people, and because of the need to meet the demand for economic resources. Additionally, black poplar is a species that can play a very significant role in the remediation of polluted rivers and soils in the industrial zones, as well as in securing larger quantities of biomass for energy needs.

Key words: native poplars, Bosnia and Herzegovina, protected.

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ID-011

THE CLONE ARCHIVE OF BLACK POPLAR *(POPULUS NIGRA* L.*)* IN ŽEPČE, BOSNIA AND HERZEGOVINA

Dalibor Ballian and Faruk Mekić[1]

The case we present regards the establishment of the clone archive of black poplars in the seed orchard of "Lugovi", near Žepče. To create the archive, we used 26 natural populations of black poplar (*Populus nigra* L.) from Bosnia and Herzegovina, 11 hybrid poplars and three exotic species of poplars. We planted a total of 6,885 cuttings: after one month, 4,270 (or 62.02%) were still alive, while there were 3,480 surviving cuttings (50.54%) after the second month, and 3,427 (49.77%) after the third month.

The greatest mortality was noted during the first and the second months, even though we applied every agro means to ensure survival. However, excluding the hybrid poplars, the success was even lower, which can be explained by the age of the planting material and non-use of rooting stimulants. Nevertheless, the results are encouraging, and after the rooted plants grow beyond the juvenile stage, it will be possible to use them in the production of reproductive material.

Until we have the necessary results at the molecular-genetic level, or at the level of provenance testing, we will have to use the material only for local needs, without mixing it with other materials. Thus, the clones from Sarajevo will be used in the area of Sarajevo, and the clones from Banja Luka only in the Banja Luka region. We might eventually perform cautious mixing in the river basins, but with the greatest vigilance, and only in zones which are intermediate between the archived populations. We cannot even consider the possibility of random mixing until we obtain the molecular genetic results.

The material coming from the Rudnik population is a special case as it represents the pioneer population on the Vrtilište mine waste deposits near Kakanj. This material should be used in the treatment of the mine waste deposit site in Kakanj, as it quickly stabilizes the soil and creates conditions suitable for the growth of native vegetation.

Key words: black poplar (*Populus nigra* L.), clone, archive.

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ID-010

GROWTH PERFORMANCE OF *POPULUS DELTOIDES* CLONES IN SALT-AFFECTED AND NORMAL SOILS OF ARID INDIA

Kulvir S. Bangarwa[1]

Sixty clones of *Populus deltoides* obtained from WIMCO Seedlings Ltd, Rudarpur and the State Forest Department, Lal Kuan, Uttaranchal, were transplanted in early March 2001 in the germplasm area of the Department of Forestry, CCS Haryana Agricultural University, Hisar, India. Clone 57 ranked first with diameter at breast height of 30.47 cm, and clone 183 ranked second with diameter at breast height of 30.04 cm at the age of seven years after transplanting. Clones 189, 139, 191, 172, 143, 28, and 165 were also found promising and significantly superior than controls (G3 and G48) for diameter at breast height at the age of seven years after transplanting. Clones 57, 189, 139 and 143 were among the top ten for total height.

Twenty-seven clones of *Populus deltoides* found promising under nursery testing were transplanted in early March 2002 in the salt-affected field [pH (1:2) 8.75, EC (1:2) 1.90dSm^{1})] of the Department of Forestry, CCS Haryana Agricultural University, Hisar, India. Clone 187 ranked first with diameter at breast height of 20.83 cm and clone 156 ranked second with diameter at breast height of 19.93 cm at the age of six years after transplanting. Clones 165 and 188 from WIMCO and clone L52 from UP Forest Department along with G3 were also found promising on the salt-affected soils at the age of six years after transplanting. Clones 187, 156 and 165 were found among the top ranks for total height. The rate of growth of all the clones was slower on salt-affected soils than on normal soils.

Key words: *Populus deltoides*, growth performance, clone, arid, diameter.

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ID-017

PRODUCTION POTENTIAL, MARKET FLUCTUATIONS AND PRESENT STATUS OF EXOTIC POPLAR IN INDIA

Kulvir S. Bangarwa[1]

Agroforestry is being promoted and popularized in India by the Government and wood-based industries so that the requirements for fuelwood, fodder and timber for industries can be met from farms and the pressure on forests reduced. Selection of trees for agroforestry is of paramount importance in promoting tree cultivation on farmers' fields.

Poplar (*Populus deltoides*), a native tree of the USA introduced to India in 1950, is widely grown in northern India as an agroforestry tree because of its fast growth, straight-growing stem, short rotation, quality wood production and less adverse effect on agricultural crops. Commercial-scale plantations of poplar have been expanding since the WIMCO-sponsored Farm Forestry Project was launched in 1984. The maximum production potential of a poplar plantation is 50 m^3/ha per year and the average potential of a poplar plantation is 20 m^3/ha per year. Poplar replaced *Eucalyptus tereticornis* when the latter's market prices declined in the 1990s. Ten million trees used to be planted annually on 0.02 million ha with an average density of 400-500 trees per ha. Market prices for poplar wood reached their highest levels in 1994-95 and started declining in 1996. Poplar growers suffered a lot in 2002-03 when they had to sell their poplar crops at throwaway prices: Rs 1 250-2 000 per ton as compared to Rs 4 500-5 000 per ton before 1996. Presently the sale price of poplar wood is again more than Rs 5 000 per ton. The poplar wood can be sold in Yamunanagar (Northern part of Haryana state) and other parts of Haryana, Punjab and Uttar Pradesh. Now, farmers are again attracted to poplar plantations. The tree attains a girth of 1 m at breast height at an average age of 6-7 years and such a tree fetches an average of Rs.1 500. The net income from poplar plantations would be more than Rs.75 000 per hectare per year (three times greater than agricultural crops alone). The income from crops grown in association with poplar is additional.

Key words: production, market, exotic poplar**,** agroforestry.

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STUDIES OF POPLAR AND WILLOW SHORT ROTATION COPPICE ESTABLISHMENT

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and Manuela Annunziati[1]

The establishment of short rotation coppice (SRC) plantations is a cultural operation that requires a high level of mechanization to reduce the production costs. In this paper results are reported on the influence of different planting materials and transplanting machines on biomass production. Three trials were carried out in the Mezzi experimental farm of CRA-PLF at Casale Monferrato (AL), Italy. In the first trial, two methods of cutting preparation were compared: a quick and an accurate method. In the second trial, three transplanting machines were tested. In the third trial, mechanical establishment with and without plastic mulch were compared.

The fields were ploughed to 30-40 cm depth and harrowed before planting. Unrooted cuttings of different clones of poplar and willow were utilized. After establishment and after every coppicing, chemical herbicide was sprayed on the rows. During the summer of the first year, three or four harrowings were carried out between the rows. Repeated treatments against *Crisomela populi* were necessary during spring and summer of the first year of every rotation. During the second year, cultural practices were reduced: weed control by disc harrowing was done only once in late spring. The plots were irrigated by sprinkler once or twice per year. All the plots were harvested at the end of the second and fourth year. At the end of each vegetative season, in all the trials, survival %, number of living shoots with height more 150 cm, diameter at breast height (D130) (mm), and total height (cm) were recorded. The total green weights of stem and branches were measured on a sub-sample of 10-30 trees per clone on each site at the end of each rotation. To obtain dry weight, the stem and branch samples were dried to constant weight in an oven at 105°C. Biomass production values were estimated by a potential regression. Analysis of variance (ANOVA) of the data recorded in each trial was performed.

The transplanting machines had an important influence on rooting, but tests are continuing for two harvest cycles to determine the productivity of the clones utilized. There were no statistically significant differences between the accurate and the quick cutting preparation methods, for rooting, stump survival or production. The interaction between species and transplanting machines had a highly significant influence on production in the first year. Plastic mulching, which eliminates the problem of chemical weed control, can be used only if the cuttings are planted 4-5 cm above the ground. Planting machines did not have a strong influence on production, but differences among species and clones were significant in the first year and highly significant at the end of the cycle. The willow clones utilized had greater productivity than the poplars.

Key words: poplar, willow, short rotation coppice.

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ID-085

RESEARCH ON NATIVE SPECIES OF FAST-GROWING TREES (POPLAR AND WILLOWS) FOR SHORT ROTATION COPPICE

Vojtěch Benetka and Jan Weger[1]

Since the 1990s, we have been testing selected native tree species for short rotation coppice at our institute. These include willow and poplar clones from domestic collections and natural populations – especially *Populus nigra, Salix viminalis*, *S. alba* and their natural hybrids. One of the reasons for testing native species is that the Czech nature protection legislation forbids the growing of allochtonous (non-native) species and their hybrids in specially protected areas. These areas make up quite a large proportion of the agricultural land suitable for growing short rotation coppice. Our task was therefore to select poplar and willow clones suitable primarily for these areas. Another reason for our research was to contribute to increasing the biodiversity of the agricultural landscape by introducing new permanent and "low-input" crops selected from autochthonous (native) species.

There are some problems when using native tree species. We can expect lower gains in productivity (yield) from intra-specific breeding in comparison with inter-specific hybridization where heterosis may occur. Another difficulty is the lack of knowledge about the behavior of these species and clones in agriculture.

Our first results confirmed that black poplar can be successfully grown in short rotation. There are no problems with diseases and it does not suffer from insufficient light in dense plantations (SRC). The first selected clones of black poplar had 10-15% lower yields than some older poplar hybrids (e.g. NE-42) in locations with climate and soil conditions where SRC is supposed to be grown in the Czech Republic (e.g. sub-montane regions).

From our results it is possible to say that selected clones of *Salix ×smithiana* (a natural hybrid taxon of domestic willows – *S. caprea* × *viminalis*) showed very good potential for biomass production in SRC. Selected clones of *S. alba*, *S. viminalis* and their natural hybrids (some from native populations or selections) also performed very well. The best four "native" willow clones have average annual yields of 12.5–13.5 o.d.t./ha/year after 9 years of growth (three harvests) and they can achieve yields up to 22 o.d.t./ha/year in individual harvests on suitable sites.

Key words: poplar, willow, domestic species, biomass production, short rotation coppice (SRC).

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WASTEWATER POLISHING USING RENEWABLE ENERGY CROPS: LIFE CYCLE ASSESSMENT

Victoria Benson and Barbara Hudec[1]

Water Renew is an EU-funded project demonstrating the commercial application of combining short rotation energy forestry with wastewater management. Scientific and technical know-how is brought in by the partners: Queens University, Northern Ireland, and Cranfield University, England, led by WRc plc, England.

Extensive research conducted across the European Union and further afield has proven the theory of wastewater polishing using renewable energy crops and commercial sites are operational in several countries. The project investigates and demonstrates the applicability and commercial viability of this technology under UK conditions.

The objective for the life cycle assessment (LCA) is to compare greenhouse gas emissions and energy use when bioenergy production and wastewater polishing are carried out separately and in combination to demonstrate the indirect environmental benefits of Water Renew.

The Water Renew system that has been chosen as a test case for a life cycle assessment is a 1 ha willow coppice plantation in Kent, England, alongside a small water treatment plant that serves about 200 people. The scope of the Water Renew LCA consists of three main stages: installation, site operation and decommissioning.

The main inputs and outputs that are described are greenhouse gases (GHG) and energy. Each stage has its own boundaries and limitations and each stage is looked at in detail in respect to all energy and GHG inputs and outputs. The scope was decided carefully as too wide a scope would take too long and be too complex to complete accurately and efficiently, whereas too narrow a scope would not correctly assess the life-cycle of the system.

Preliminary work has indicated that significantly lower GHG emissions can be associated with this type of wastewater management system compared with more highly-engineered alternatives during both installation and operational phases, but that good system management is necessary to maximise the benefits and minimise methane or nitrous oxide formation.

Key words: wastewater, wastewater polishing, wastewater treatment, wastewater management, renewable energy crops, life cycle assessment, biomass, short rotation coppice, greenhouse gas emissions, willow.

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POTENTIAL OF POPLAR BUDS AS A SOURCE OF BIOACTIVE COMPOUNDS: ANTIOXIDANT ACTIVITY OF SUPERCRITICAL EXTRACTS

B. Berrueco[1], E. Langa[1], C. Maestro[2], J.S. Urieta[1]
and A.M. Mainar[1]

Poplar can be an interesting source of biologically active compounds. In the research reported here, the antioxidant activity of different extracts of poplar buds was studied. These extracts were obtained by a conventional liquid-solid extraction (Soxhlet) using organic solvents, and by an advanced extraction technique using supercritical CO_2 as solvent. The latter, used in 'Green Chemistry', is environmentally friendly and avoids thermal degradation of the extracted compounds.

The research was carried out with buds of native *Populus nigra* from the Ebro valley and the widely cultivated *Populus ×euramericana* clone MC. Dormant buds were harvested at the end of the winter from one-year-old shoots from stool-beds of the *Populus* spp. gene bank mantained at CITA (Zaragoza).

Before the extraction, a pre-treatment consisting of crushing the dried vegetable material was carried out. Two Soxhlet extractions (with ethanol and hexane as solvents) and two supercritical extractions (with and without ethanol as entrainer) were done. These supercritical extractions were done in the pilot plant built by the GATHERS Group. The extraction conditions were 180 bars and 50 ºC in the extractor, and the separation process involved two steps at different P-T conditions. The chemical composition of the extracts was determined using GC-MS (gas chromatography coupled with mass spectrometry), 1-(2,6-dihydroxy-4-methoxyphenyl)-3-phenyl-(E)-2-propen-1-one being the main component in all of them.

The antioxidant activity of the extracts obtained was evaluated by UV-Vis spectroscopy using the method of the DPPH radical. The results of these experiments were shown as EC_{50} (efficient concentration) which is the amount of antioxidant needed to decrease the initial concentration of DPPH·by 50%. The *Populus nigra* extracts showed an antioxidant activity greater than the MC ones (Trolox, a tested pure commercial antioxidant just doubles the activity of the most active extract).

Key words: *Populus nigra*, *Populus ×euramericana*, bud extracts, antioxidant, supercritical fluids.

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GENETIC TRANSFORMATION OF POPLAR (*POPULUS TREMULA* × *P. TREMULOIDES* CV. T89) USING STRESS-RESISTANCE GENES

Yufang Bi, Mingyan Qin and Qiang Zhuge[1]

Drought, extreme temperatures and salinity are critical environmental factors which limit forest growth and development. Stresses such as drought, extreme temperatures and salinity cause a series of morphological, physiological, biochemical, and molecular changes in forest plants. SRK2C is a member of the SnRK2 gene family within the SnRK2a subfamily and has been annotated as a putative serine/threonine protein kinase. Research in *Arabidopsis* suggested that SRK2C was a positive regulator of drought tolerance in *Arabidopsis* and the drought tolerance coincided with up-regulation of many stress-responsive genes.

In this study, stem sections of *Populus tremula* × *P. tremuloides* cv. T89 were used as materials for genetic transformation. The expression vector was constructed by use of Invitrogen Corporation's gateway recombination system and an over-expression vector pH35GS with the homologous gene of SRK2C cloned from the poplar was established. Three over-expression vectors pH35GS with three homologous genes of SRK2C were used for genetic transformation of *Populus tremula* × *P. tremuloides* T89 mediated by the *Agrobacterium* method. Sixty hyg resistant plants with the pH35GS::PtSRK2C-1 gene were obtained by a selection medium with concentration of 25 mg/l hyg. Forty hyg resistant plants with the pH35GS::PtSRK2C-2 gene and 30 hyg resistant plants with the pH35GS::PtSRK2C-3 gene were also obtained. The resistant plants were determined by PCR analysis which showed there were 80%, 73% and 70% positive respectively, and it proved that the three genes were integrated into the genome of *Populus tremula* × *P. tremuloides* T89. The resistance testing of transgenic poplars will be done in the near future.

Key words: genetic transformation, SRK2C, stress resistance, *Populus tremula* × *P. tremuloides* T89.

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LIVELIHOOD STUDIES OF WILLOW-DEPENDENT COMMUNITIES OF THE INDIAN TRANS-HIMALAYAN REGION WITH EMPHASIS ON SUSTAINABLE MANAGEMENT OF THE BIORESOURCE AND IMPROVED WELL-BEING

Sas Biswas and S. Showkat Hussain[1]

Willow (*Salix*) in India is represented by about 27 species out of the 300 species found globally. The Himalayan region is endowed with 24 indigenous species distributed in bioclimatic zones from tropical to cold desert at high altitude in Ladakh. Tree species of willow are hardy, and can survive the sub-zero temperatures and extreme wind conditions. The region has some monumental trees growing in the rural areas measuring respectively 9m15 and 10m25 breast-height girth in Chok-Than village, Ladakh and Puyan village, Kargil. Several different forms in terms of habit, utilization properties and value addition for *Salix* in the Himalayan region are the result of natural hybridization. The economic benefits of this diversity have been well understood by the dependent communities of the region in terms of gains through marketing and continual improvement in quality, aesthetics and design. A traditional method for the development of this resource through conscious and sub-conscious selection of material for small-scale planting and utilization exists in the region despite the introduction of exotic willow (*Salix alba* cv *calve* = *S. caerulea* Smith) during the early decades of the last century in the Kashmir Himalayas. Lesser known uses of willows in the Trans-Himalayan region are for making charcoal and Kangri (fire pot) from twigs, chips etc. to overcome severe winter conditions, as cattle feed from foliage during lean seasons and wickerwork for the manufacture of baskets, flower vases, trays, chairs and other novelty items. The willow-dependent communities carry out weaving jobs about six days a week, 25 days a month and 300 days a year. In the rural/forest villages of the region, *viz*. Hakimgund and Kachen in Srinagar District of Kashmir, 33 out of a total of 95 family members, are workers. Studies indicate that the income from the weaving per family ranges from Indian Rupees 4,000 to Rs. 17,513,125 (US$ 100 to 438,000 - at Rs. 40 per US$) and the total income of as many as 14 families reaches US$ 513,134 (i.e. Rs. 20,525,375). Thus the willow bioresource provides a sustainable livelihood. Some of the families have been involved in weaving for over six decades and are recognized for their traits and grass-root innovation.

The paper highlights comprehensively the need and priorities for conservation and management of the willow diversity and genetic resource through an integrated approach involving the participation of communities, transfer of technology, capacity building on value addition and marketability of products for higher income generation, safeguarding the property rights to indigenous traditional knowledge and strategies for sustainable livelihood.

Key words: cold desert, willow genetic resource**,** Kangri (fire pot), integrated approach, indigenous traditional knowledge, property rights.

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ID-013

CULTIVATION OF POPLARS FOR BIOMASS PRODUCTION IN MENDOZA: FIRST-YEAR RESULTS

J. Bustamante, S. Pérez, D. Funes and P. Zanetti[1]

Within the Bioenergy Program 2007/2010 of the Universidad Nacional de Cuyo, there is a series of initiatives intended to develop biofuels and their participation in the Argentinian sustainable energy matrix. Forest trees, and especially Salicaceae, are the crops selected to produce solid biofuels with subsequent transformation into bioenergy.

The aim of the present project is to select, from among the best poplar clones, those producing the greatest quantity of biomass per unit area, while simultaneously making efficient use of water resources because these trees are cultivated under irrigation in Mendoza. The suitability of clones was evaluated on the basis of survival (expressed in percentage), diameter, length and number of shoots per cutting.

The experimental plot was located on a farm irrigated with treated wastewater in the Restricted Crops Area of Mendoza, in the district of El Pastal, Las Heras (approximately 20 km from Mendoza city). One-year-old 30-cm-long woody cuttings of *Populus* × *canadensis* `Conti-12´ and *Populus deltoides* `Harvard´ were planted in two plantation frames: (1) double rows spaced alternately 75 and 150 cm apart and 90 cm between cuttings in rows, for a density of 10,000 plants/ha; (2) double rows spaced alternatively 60 and 120 cm apart and 55 cm between cuttings in rows, for a density of 20,000 plants/ha. A randomized block design was used with three replications of two clones for each density. Individual plots were 9 m × 11.5 m and 5.5 m × 9 m respectively, each with 10 rows of 10 trees and a double row of border trees. Data were taken from the 36 centre trees.

After the first period of vegetative growth, the survival percentage was determined and stems produced by each cutting were cut at 10 cm from soil, to measure diameter and total length of shoots. Statistical analysis included analysis of variance and Tukey's test to compare treatment means. Correlations were determined by means of simple linear correlation analysis.

The average results were: `Harvard` 18.5% survival, 219 cm shoot length, 1.11 shoot per cutting and 19.24 mm diameter average of shoots: diameter average of shoots; `Conti 12` 43.5% survival, 143 cm shoot length, 2.11 shoots per cutting and 12.35 mm diameter average of shoots.

Key words: poplars, production, bioenergy, short rotation forestry.

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ID-061

CULTIVATION OF *SALIX* FOR BIOMASS PRODUCTION IN MENDOZA: FIRST-YEAR RESULTS

J. Bustamante, S. Pérez, D. Funes and P. Zanetti[1]

Within the Bioenergy Program 2007/2010 of the Universidad Nacional de Cuyo, there is a series of initiatives intended to develop biofuels and their participation in the Argentinian sustainable energy matrix. Forest trees, and especially Salicaceae, are the crops selected to produce solid biofuels for subsequent transformation into bioenergy.

The aim of the present project is to select, from among the best poplar clones, those able to produce the greatest quantity of biomass per unit area, while simultaneously making efficient use of water resources because these trees are cultivated under irrigation in Mendoza. The suitability of clones was evaluated on the basis of survival (expressed in percentage), diameter, length and number of shoots per cutting.

The experimental plot was located on a farm irrigated with treated wastewater in the Restricted Crops Area of Mendoza, in the district of El Pastal, Las Heras (approximately 20 km from Mendoza city). One-year-old 30-cm-long woody cuttings of *Salix babilónica* × *Salix alba* hybrid 'A-131-27' and *Salix babilónica* var. *Sacramenta Hortus*, 'American willow' were planted in two plantation arrangements: (1) double rows spaced alternately 75 and 150 cm apart and 90 cm between cuttings within rows for a density of 10,000 plants/ha; (2) double rows spaced alternately 60 and 120 cm apart and 55 cm between cuttings within rows for a density of 20,000 plants/ha.

A randomized block design was used with three replications of two clones for each density. Individual plots were 9 m × 11.5 m and 5.5 m × 9 m respectively, each with 10 rows of 10 trees and a double row of border trees. Data were taken from the 36 centre plants.

After the first period of vegetative growth, the survival percentage was determined and stems produced by each cutting were cut at 10 cm from the soil, to measure diameter and total length of shoots. Statistical analysis included analysis of variance and Tukey's test to compare treatment means. Correlations were determined by mean of simple linear correlation analysis.

The average results were: hybrid `A 131-27` had 43.5% survival, 213 cm shoot length, 1.75 shoot per cutting and 14.53 mm diameter average of shoots; `American willow` had 26% survival, 214 cm shoot length, 2.77 shoots per cutting and 14.32 mm diameter average of shoots.

Key words: *Salix*, production short rotation forestry, bioenergy.

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ID-062

ISOLATION AND PURIFICATION OF MESOPHYLL PROTOPLASTS FROM *POPULUS PSEUDO-SIMONII* KITAG.

Xiao Cai[1] and Xiangyang Kang[1]

A protocol is presented for isolating and purifying the protoplasts from leaves of shoot cultures of *Populus pseudo-simonii* Kitag., resulting in a procedure that should be useful for somatic hybridization studies. The yield of protoplasts depends on factors such as enzyme concentration, osmoticum concentration and the age of leaves. The results are shown below:

An enzyme solution containing 1.0%-3.0% (w/v) cellulase R-10, 0.5-1.5% (w/v) macerozyme R-10 and 0.1%-0.9% (w/v) pectolyase Y-23 was tested using an orthogonal design. The enzyme solutions were supplemented with CPW salts and 0.6M mannitol as osmoticum. The most effective digesting enzymes tested for production of viable protoplasts were obtained with 3% cellulase R-10, 1.0% macerozyme R-10 and 0.1% pectolyase Y-23. Protoplast yields were 2.26×10^7.gfw $^{-1}$ and the viability was 75%.The concentration of mannitol in the enzyme solution was from 0.3M to 0.8M. As the concentration of mannitol increased, the yield and viability of protoplasts first increased and then decreased. When the mannitol was 0.6M, both the yield and the viability were highest. The optimal concentration of mannitol was 0.6M. The age of leaves determines tissue physiology and affects the release of viable protoplasts. Leaves aged 20d-60d were chosen as materials from which to isolate protoplasts. Good results were obtained from 30d-40d leaves. Leaves that were too young or too old were unsuitable for isolating viable protoplasts. Leaf tissues were sliced into pieces and placed either directly in enzyme, or plasmolysed prior to enzyme digestion. Plasmolysis before enzyme incubation of leaf tissues in 0.7M mannitol for 1-2 hours promoted the viability of protoplasts and reduced damage. The yield and viability of protoplasts were increased by 10.1% and 7.7% respectively. In order to separate the debris from the intact protoplasts, the protoplast-enzyme mixture was filtered through 200- and 400-mesh stainless steel sieves and collected by centrifugation. Protoplast preparations were purified by sedimentation over 21% (w/v) sucrose (100×g for 10 min), for collecting viable protoplasts at the interface using a Pasteur pipette.

Key words: *Populus pseudo-simonii* Kitag., protoplast, isolation.

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ID-078

GROWTH COMPARISON OF SIXTEEN *POPULUS EUPHRATICA* PROVENANCES AT THE RESEARCH STATION OF KARADJ, IRAN

M. Calagari[1]

In early 2002, cuttings of *Populus euphratica* were collected from 16 natural populations in 11 provenances in Iran. These populations cover much of the geographic distribution of this species in Iran. From each population location, 30 cuttings (three cuttings from each mother tree) were planted in a field experiment conducted from 15 March 2006 to 1 October 2007. At the end of each growing season (2006 and 2007), survival percentage, tree height and diameter at 0.5 m height were measured. Data of two years' diameter and height growth were analyzed by one-way ANOVA and Duncan's multiple range test ($P<0.05$).

Survival varied among *P. euphratica* provenances. Survival at the end of the first growing season was greatest for the Tafresh (92%), Kerman (90%) and Dezful (85%) provenances. The poorest survival was for the Gherekhlar (20%) and Mahneshan (36%) provenances. The best three provenances at the end of the first growing season (Hamidiyeh, Ramhormoz, Tafresh) had average diameters of 1.24, 1.22 and 1.20 cm and average heights of 2.00, 1.97 and 1.75 m, respectively, while the three best provenances after the second growing season (Ramhormoz, Gotvand, Tafresh) had average diameters of 2.62, 2.37 and 2.26 cm and average heights of 2.51, 2.76 and 2.43 m, respectively. Mahneshan and Gherekhlar provenances had the lowest average diameter (0.62 and 0.69 cm respectively after the first growing season, and 1.14 and 1.12 cm respectively after the second) and average height (0.75 and 0.93 m after the first growing season, and 1.36 and 1.35 m respectively after the second).

The results show the effect of different geographic origins on growth. Further research could be conducted on the introduction and development of suitable clones for wider use and better growth in arid and semi-arid regions with alkaline and salinity soils, as a source of wood production for local people.

Key words: *Populus euphratica*, height growth, diameter growth, survival, Iran.

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VARIATION IN LEAF ANATOMY AMONG NINE PROVENANCES OF *POPULUS EUPHRATICA* IN IRAN

M. Calagari[1] and R. Abbas-Azimi

Populus euphratica is a native species in Iran. It grows in arid, semi-arid and desert areas with salt and alkaline soils. Nine *P. euphratica* provenances from different geographic origins were studied for four growing seasons in the experimental field of Karadj Research Station. Mature leaves were examined from all provenances (four trees from each provenance). The objective was to study the relationship between geographical origin and variations in leaf anatomical characteristics (i.e. density and length of stomata, thickness of palisade parenchyma and number of palisade parenchyma layers).

The abaxial stomatal density varied from 72 to 117 no.mm-2 and adaxial stomatal density ranged from 68 to 113 no.mm-2. The abaxial stomatal length varied from 25.3 to 31.1 µm and adaxial stomatal length from 25.7 to 31.8 µm. The stomatal density and stomatal length differed significantly ($P<0.01$) among provenances with different origins. Total thickness of leaf cross-section varied from 392 to 432 µm. This included cuticle (<0.01%), epidermis (6-9%), hypodermis (19-21%), palisade parenchyma (58-69%) and spongy parenchyma (7-13%).

Key words: *Populus euphratica*, leaf anatomy, stomatal density and length, Iran.

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ID-034

BEHAVIOR OF *POPULUS* SPP. IN LOW FERTILITY SOIL IN JUNÍN, MENDOZA, ARGENTINA

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The choice of a clone must always be based on local experience. In countries with an extensive experience of growing poplars, observing the behavior of new clones has given good results in populeta created with this aim. Because of this and in order to study different clones on different sites of the west-central region of Argentina, the Instituto Forestal (Forestry Institute) of the Facultad de Ciencias Agrarias installed a network of trials, of which one was located in Junín, Mendoza, with 13 *Populus* clones: 6 clones of *P.* ×*euramericana*: Luisa Avanzo, BL Constanzo, Neva, NNDV, Boccalari and Guardi, and 7 clones of *P. deltoides*: Catfish 2, Alton, Lux, Dvina, INTA 69/69, INTA 41/71 and Harvard.

The main data for the site are: 653 m height above sea level, absolute maximum temperature 40.2ºC, absolute minimum temperature -8ºC, soil texture sandy-loam pH 7–7.5, soil depth >1.5 m. Low fertility is another soil characteristic, especially in relation to nitrogen, for which values are less than 220 ppm, indicating very poor content of this element. In relation to cultivation activities, weed control was undertaken twice or three times in the first three years and once after four years. Pruning to train stems and obtain knot-free wood was undertaken up to a full 6 meters of height. Furrow irrigation was used every 14 to 21 days. No fertilizers were used.

The design used for statistical analysis was randomized blocks with four replications. Planting distance was 5 m between rows and 4 m between plants.

Annual measurements were made of diameter at breast height and height of trees. From these data, wood volume was expressed in cubic meters per hectare. At the same time, the phytosanitary status of every one of the tested clones was observed.

Results at eight years showed very low values of wood volume, between 84 and 117 m^3/ha for the four best clones: NNDV, Guardi, Luisa Avanzo y Harvard.

In conclusion, the poor growth could be due to low soil fertility and the low water level with respect to *Populus* requirements. The phytosanitary status is in general very good with no important pests or diseases at present.

Key words: poplar, clones, behaviour, fertility.

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BEHAVIOR OF CHINESE CLONES OF *POPULUS* SPP. IN LAVALLE, MENDOZA, ARGENTINA

A. Calderón, J. Bustamante, S. Perez and P. Zanetti[1]

The Instituto Forestal (Forestry Institute) of the Facultad de Ciencias Agrarias installed a trial network, of which one trial was established in 2003 in Lavalle, Mendoza, with the objective of studying the behavior of different clones on different sites of the west-central region of Argentina. In this trial the behavior of three Chinese clones of *Populus* × *canadiensis*: 'Zhongling 28', 'Zhongling 23' and 'Zhongling 46', was compared with that of the control clone *Populus deltoides* 'Harvard'. The plantation was irrigated with domestic wastewater.

The main data for the site are: height above sea level 653 m, absolute maximum temperature 41.2ºC, absolute minimum temperature -9.4ºC. Soil and irrigation water characteristics were measured. Soil management and pruning of trees were as normal.

The statistical design used was randomized blocks with four replications. Each plot contained 9 plants. Plantation spacing was 4 meters between rows and 4 meters between plants.

Annual measurements were made of breast-height diameter and height of the trees, from which the volume of wood was calculated in cubic meters per hectare. At the same time, the phytosanitary status of each clone was observed.

There were no significant differences in wood volume at four years between the clones 'Harvard', 'Zhongling 28' and 'Zhongling 23'. These clones produced wood volumes between 148.82 and 137.91 m^3/ha, but there was a significant difference between these and the clone 'Zhongling 46' which produced only 74.22 m^3/ha. The phytosanitary status was very good, with no significant pests or diseases presently found in the test plants.

Key words: poplar, clones, behaviour, wastewater.

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ID-063

GENETIC TRANSFORMATION OF ELITE POPLAR CLONES FOR USEFUL TRAITS

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and Giuseppe Nervo[1]

Poplars represent an important wood resource in the temperate regions of the world. In Italy, poplar plantations are the major source of domestic roundwood and also have significant potential for paper, biomass energy production, cleaning up environmental pollution, phytoremediation and enhanced amenity and landscape restoration value. Interspecific *Populus euramericana* hybrids (*P.deltoides* × *P.nigra*) still represent the bulk of European intensive poplar cultivation and most of them have been selected at the CRA Research Unit of Casale Monferrato. The introduction of new desirable traits into these hybrids by classical breeding has been delayed because of the large size of plants, the long sexual generation cycles and the prolonged period required in order to evaluate adult traits. The use of genetic engineering could allow the resolution of these problems and shorten the length of breeding programmes. Applications of genetic modification include improved resistance to pests and diseases, altered wood properties and composition, herbicide tolerance and growth rate. Plant transformation vectors and methodologies have been improved to increase the efficiency of plant transformation protocols for *P. ×canadensis* clones, generally considered recalcitrant.

Transgenic poplar plants carrying the *bar* gene, encoding the phosphinotricin acetyltransferase enzyme which confers tolerance or resistance to the non-selective herbicide "Basta", were successfully obtained at the CRA Research Unit. Other plants with improved useful traits such as durable resistance to pests were produced by using vectors containing proteinase inhibitor genes (*Atcys* genes) and poplar clones expressing the *StSy* gene which is involved in the production of different phytoalexins with antimicrobial activity were transferred to greenhouse in order to study the resistance to disease and the stability of resveratrol compounds, produced under different growth conditions. Significant progress has been also observed in developing transgenic plants with sexual sterility and without antibiotic marker genes, for a possible use in open field, in compliance to the current UE biosafety law.

Key words: *Populus x canadensis* , genetic transformation, transgenic clones, useful traits.

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GENETIC TRANSFORMATION OF POPLAR STERILE GENE CONSTRUCTS IN TOBACCO AND POPLAR

Guanlin Cao, Xinmin An, Dongmei Wang, Wenhao Bo
and Zhiyi Zhang[1]

To control flowering of poplar, the sterile gene expression vectors *PTAG-IR::PTLF-IR, PTLF-PTAG-IR, AG-m2* and *AG-m3* were transformed into *Agrobacterium tumefaciens* GV3101, and then introduced into *Populus tomentosa* LM50 (male) and 5082 (female) cultivars and tobacco plants using the *Agrobacterium*-mediated method with leaf-explant regeneration medium MS + 6-BA 2.0 mg/l + NAA 0.1 mg/l + sugar 30 g/l + agar 5.5 g/l, and rooting media MS + IBA 0.2 mg/l + sugar 20 g/l + agar 4.5 g/l.

The optimal concentration of kanamycin for preliminary selection was 20 mg/l. The generated transgenic tobacco plants were preliminarily verified by PCR. Additional molecular detection and analysis will be done subsequently. This work would be useful for further investigation of flowering mechanisms in poplars.

Key words: poplars, sterile gene, transformation, flowering.

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ID-187

EFFECT OF HEAT TREATMENT ON PROPERTIES OF CHINESE WHITE POPLAR

Yongjian Cao, Jianxiong Lv and Rongfeng Huang[1]

Steam heat treatment has been known for long time as one of a number of effective methods to improve the dimensional stability and durability of wood. Unfortunately, undesired side effects, in particular the loss of strength and increased brittleness of the heat-treated wood, have prevented the commercial utilization of thermal modification. In order to expand the industrial applicability of heat-treated wood, it is important to study the reasons for the adverse effects and devise methods to control mechanical strength loss and the property changes of heat-treated wood during the heating process.

Temperature and time are two crucial factors affecting the final quality of heat-treated wood, with temperature having a greater effect than time. Holocellulose and hemicellulose contents of heat-treated Chinese White Poplar decreased by 2.52% and 0.94% at 170°C for 1 hour, and by 23.72% and 41.44% at 230°C for 5 hours. However, the lignin content of heat-treated Chinese White Poplar increased by 9.06% at 170°C for 1 hour, and by 123.64% at 230°C for 5 hours. The dimensional stability was improved along with the increase of temperature and time during the heat treatment process. The highest improving ratio was 70.71%. Heat treatment enhanced the decay resistance of Chinese White Poplar from Grade 4 which belongs to strong resistance decay, to Grade 1 which belongs to non-resistance decay. The bending strength and the modulus of elasticity were improved with treatment below 200°C for about 2 hours. The highest improving ratios of bending strength and modulus of elasticity were 11.28% and 15.80% respectively. When the temperature was above 200°C, thermal degradation of cellulose and hemicellulose was the main reaction in which the fiber chains became increasingly shorter and shorter in step with the increase in temperature and time during the heat-treatment process. The loss ratios of bending strength and modulus of elasticity at 230°C for 5 hours were 54.20% and -2.73% respectively.

In this study, $\hat{y}$ means loss ratio of bending strength of heat-treated wood, x_1 means treatment temperature, x_2 means treatment time, so the regression model of bending strength, x_1 and x_2 was is $\hat{y} = 0.961x_1 + 4.218x_2 + 183.832$ (R^2=0.953). If $\hat{y}$ means the modulus of elasticity, the regression model of the modulus of elasticity, x_1 and x_2 was $\hat{y} = 0.089x_1 + 1.544x_2 + 32.172$ (R^2=0.777). Using these mathematical regression models, the loss ratios of bending strength and modulus of elasticity of heat-treated wood can be predicted under different treatment temperatures and times.

The temperature should be controlled to below 200°C so that there is no or minimal loss in the mechanical strength of the wood, with an enhancement of hardness, bending strength and modulus of elasticity properties of the heat-treated wood within a short time. With the correlative mathematic regression models, the optimum temperature and time used in the heat treatment can be determined in accordance with the final use of the heat-treated wood.

Key words: heat treatment, *Populus tomentosa* Carr, physical properties, chemical properties, mechanical strength, loss ratio, regression model, control theory.

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ID-207

DASOMETRIC RESPONSE OF *POPULUS DELTOIDES* 'AUSTRALIA 106/60' TO DIFFERENT PROPAGATION MATERIALS FOR PLANTATIONS IN THE DELTA OF THE PARANÁ RIVER, ARGENTINA

E.A. Casaubon[1], G.R. Cueto[2], P.L. Peri[3] and A.C. González[1]

The planting materials used to establish poplar in silvopastoral systems (SSP) in the Delta of the Paraná River are cuttings (E), one-year-old (G1) and two-year-old (G2) unrooted pole cuttings. When using E, the cost of planting is lower and income from animals grazing in SSP can start at the 4th or 5th year after planting. In contrast, when G1 and G2 are planted, the cost of establishment increases and cattle grazing can start earlier (one or two years after plantings).

The aim of this study was to evaluate the dasometric response of E, G1 and G2 of *Populus deltoides* 'Australia 106/60' in the fifth year after planting. A total of five replications of 25 plants of each of the three planting materials E, G1 and G2 were included. For each plant, diameter at breast height (DBH) and total height where recorded annually from 2002 to 2007. Analysis of variance was performed for the trees variables (DBH and total height) over time (years). Trees originating from G2 had the highest DBH values followed by G1, with treatment E showing the lowest values ($P < 0.01$). These differences were recorded in each year ($P > 0.1$). There was significant interaction between planting material and year for total height ($P < 0.01$). This was because there were differences among the heights of planting materials in the years 2003 and 2005 ($P < 0.01$), whereas in 2007, although there were differences among the materials ($P < 0.01$), there were no significant differences between E and G1 ($P > 0.05$). Trees originating from G2 remained significantly taller than other planting materials (E and G1). In *Populus deltoides* 'Australia 106/60' two-year-old poplar pole cuttings are excellent propagation material for silvopastoral plantations in the Paraná River Delta.

Key words: *Populus deltoides* Marsh., poplar, Lower Delta, Argentina.

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ID-127

SILVOPASTORAL SYSTEMS WITH POPLAR IN THE LOWER DELTA OF THE PARANÁ RIVER, ARGENTINA

Edgardo Casaubon[1] and Adrian González[1]

Beef cattle have always been a good partner with forestry in the lower Delta of the Paraná River, by minimizing the high volumes of spontaneous natural grasses that grow beneath the young plantations of *Populus deltoides* Batr., and reducing the possibility of occurrence of wildfires during the autumn-winter season, especially in periods of prolonged droughts. Currently silvopastoral systems (SSP) are an increasingly productive alternative in the region due to the expansion of soybean cultivation (*Glycine max*) to regions of the country traditionally used for cattle raising. The SSP are being designed with the aim of producing quality wood for veneer, sawing and to a lesser extent for crush and cellulosic paper industry, in addition to providing shade, shelter and fodder for cattle, and producing beef to meet the demands of national and international standard markets. This form of diversification is a good production alternative for small, medium and large producers in the region.

The increasing presence of cattle in the Delta determines the need to change from traditional forestry to a more intensive forestry aimed at the simultaneous production of timber, grass and meat. From the point of view of forestry, there is a change in the use of new planting materials (one- and two-year-old unrooted pole cuttings, deep planted) produced in nurseries with large distances between mothers strains (1×1 m), and greater distances in planting these new materials in field (5×5 and 6×6 m). This is intended to control the depth of the water table and to keep the drainage networks clean, avoiding the presence of stagnant water, favouring the discharge of rainwater in periods of intense rainfall (such as in 2007) and the entry of water from the river in times of intense drought (such as in 2008), and maintaining a good quality of water for the animals to drink and for good growth of pastures and trees. This new silviculture allows the entry of animals to the plantation in the second year, diminishing the loss of benefits between planting and the entry of cattle to the system.

The new forestry facilitates early use of natural pastures and quality meat production simultaneously with the collection of wood for various uses. In addition, there is greater individual plant growth, greater uniformity of the crop, a higher percentage of cylindrical stems, a longer planting period (May-August), greater plant rooting per hectare, better contact of plant roots with the water table, increased spontaneous forage beneath plantations, giving better management of the groundwater, and a lower percentage of losses of plants due to late frost. Less stagnant water means better wood quality in relation to stain, fewer dead standing trees, less weed competition and a reduced risk of occurrence of forest fires because the volume of dry grass is decreased. Also, water is present in all the drainage networks and available for livestock. At the same time, the new system increases animal and plant biodiversity, associated with the constant availability of water in the system.

Key words: *Populus deltoides* Batr., poplar, silvopastoral systems, low delta.

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POPLAR CULTIVATION IN ITALY: HISTORY, STATE-OF-THE-ART, PERSPECTIVES

Gaetano Castro[1] and Roberto Zanuttini[2]

Specialized poplar plantations have existed in Italy for more than a century and remain a characteristic feature of extensive areas of both uplands and lowlands. The timber produced is an important raw material, in particular for the local primary timber industry with a focus on the plywood sector.

Even though the area under poplar cultivation is only 83,000 hectares, equivalent to less than 1% of the total forest area, it contributes more than a third of the annual national production of industrial roundwood, with a total volume of about 1 Mt of timber.

This article provides a general overview of this industrial chain, which is much appreciated and taken as an example on an international level. It describes particularities and its development over time with reference to the economic operators involved, i.e. the poplar growers, the harvesting companies and the industries which process the timber. The most important technological and economic issues, harvesting methods, final destinations and derived products, and report on recent trends as well as prospects in the medium term are also analysed.

Key words: poplar, wood, wood-based panels, industry, poplar cultivation, harvesting.

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ID-212

WILLOW BREEDING FOR INDUSTRIAL USES IN ARGENTINA

Teresa Cerrillo[1]

In Argentina, willows are mainly cultivated in the region of the Delta of the Paraná River, an extended area located between 32°5′ - 34°29′S and 58° 22′- 60°45′ W, that presents excellent conditions, mainly because of the soils which are rich in organic matter, abundant water, a warm-temperate climate and a location near the centers of consumption. Traditionally, tree willows are used in the pulp and paper industry and for production of particleboard and, secondarily, for saw-timber. However, it is well known that the quality of willow wood is also appropriate for several other uses, including furniture components and veneer for plywood.

In the last four years, the industrial demand for willow wood has increased in Argentina, but the availability of plantations, considering both the total area planted and the quality, is not enough to meet this demand. This situation has emphasised the need to increase the potential of willow plantations by means of genetic improvement. To address that, a breeding programme was started in 2003, capitalizing on the results of a research project started in 1986 (but discontinued) which was based on introduction of species and clones, and inter- and intra-specific hybridisation, with the fundamental aim of providing a range of genotypes of greater variability. The programme has reached an advanced phase of selection with 200 experimental hybrids. Selection criteria include fast growth, stem form, apical dominance and wood quality.

The most promising clones are hybrids between *S. matsudana* and *S. alba*; other species under consideration in the programme are *S. nigra*, *S, humboldtiana* and *S. babylonica*. Future generations of breeding using these favourable genetic combinations will be produced in new steps of the programme.

Preliminary studies of the main wood characteristics for some of the clones in the advanced stage of selection were carried out. Some of these clones have paper evaluations, showing good mechanical resistance; complementary evaluations are necessary in order to have a complete characterization of the selected genotypes.

Finally, some more recent breeding activities with shrub willow and osier, focused particularly on production systems for small farmers, will be reported.

Key words: willow, *Salix*, breeding programme, selected clones, Argentina.

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BIOMASS PRODUCTION OF WILLOW CLONES FROM DIFFERENT SPECIES COMBINATIONS - PRELIMINARY RESULTS

Teresa Cerrillo[1], Gianni Facciotto[2] and Lorenzo Vietto[2]

The use of renewable energy, and particularly bioenergy, has become very important in order to secure energy supplies for future generations and to reduce global atmospheric changes due to high greenhouse gas (GHG) emissions. Biomass is the largest renewable source for energy production and represents a substantial opportunity not only to reduce GHG but also to increase internal energy supplies and for environmental and energy- independence reasons. Biomass, and particularly woody biomass, can be produced with dedicated crops such as short rotation coppice of fast-growing species. The genus *Salix*, with more than 300 species, has a very wide range, from maritime zones, some characterized by salty soils, to high mountain zones, and particularly on flood-prone lowlands. It is an extremely versatile genus showing relevant adaptability to different ecological environments. Willow species are widely used all over the world in biomass production for energy use.

The main purpose of this paper is to present an evaluation of different combinations of tree willow species with the aim of identifying elements useful in the selection of proper genotypes for biomass production.

Salix alba, S. amygdaloides, S. babylonica, S. fragilis, S. jessoensis, S. matsudana and *S. nigra* were the species utilized to produce progenies. Italy, Spain, Canada, the United States and New Zealand are the parental countries of origin. Controlled crossing (intra- and inter-specific) and open pollination, using as progenitors clones of the different species combinations, were carried out in Argentina and Italy. Clones obtained were planted at two locations in the Delta del Paraná, Argentina and in the experimental Mezzi Farm at Casale Monferrato, Italy. On each site, complete randomized experimental designs with 2-4 replications were established. For every species combination, growth data were collected and dry biomass production was estimated. The basal density of selected genotypes among the best species combinations have shown values ranging from 0.327 to 0.455 g/cm^3. Some of the best clones could have important applications in energy biomass production.

Based on the preliminary results, clones of the species combinations *S. matsudana* × *S. alba*, *S. matsudana* × *S. nigra* and *S. amygdaloides* × polycross had the best performances. These preliminary results will be the basis for the creation of future productivity evaluations for short rotations coppice (SRC).

Key words: willow, *Salix*, short, biomass production, species combinations, clones.

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ID-099

GENOME-WIDE SEARCH AND EXPRESSION ANALYSIS OF POPLAR DREB2 TRANSCRIPTION FACTOR GENES

Jinhuan Chen, Xinli Xia[1] and Weilun Yin[1]

The dehydration responsive element-binding proteins (DREBs) that can recognize and bind to DRE *cis*-acting elements are characterized as a gene family in plants. Most of the members of this family act as transcriptional regulators involved in response to various stresses. To comprehensively understand the DREB transcription factor family in poplar, a database search was performed.

The result was that 73 homologues were identified, annotated and assigned to six groups (A-F) based on phylogenetic relationship with some related DREBs from *Arabidopsis* and rice (*Oryza sativa* L.). As for each group, the strict conservation of essential structural features suggests the mode of action and physiological function of these proteins. Detailed analysis of gene pairs and intron distribution indicates multiple modes of gene evolution including insertions/deletions, repeats and duplications. Furthermore, we investigated the transcript profile and tissue specificity of four DREB2 paralogues identified from salt-treated leaves of *Populus euphratica* (Oliv.). The stress-responsive pathway conserved in poplar demonstrates that poplar utilizes a DREB2-based response to abiotic stresses such as salt, cold, and dehydration. The differential induction kinetics also suggest perennial-driven evolution of environmental dormancy may have given rise to specific roles for these transcription factors.

Key words: DRE-binding protein, *Populus euphratica*, quantitative real-time PCR, salt stress, transcription factor.

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ID-166

BIOMASS PRODUCTION AND CARBON STORAGE IN DIFFERENT POPLAR AGROFORESTRY SCHEMES IN JIANGSU PROVINCE

Lebei Chen, Hailing Li and Shengzuo Fang[1]

Poplars are widely planted in the northern area of Jiangsu Province and many kinds of agroforestry management schemes have been developed. However, little research has been conducted on the carbon reserves of ecosystems, and the function of carbon sources and sinks is still not clear, especially for the different agroforestry management schemes. In order to evaluate the function of poplar-agroforestry systems in carbon sequestration, a case study was conducted to compare the differences in carbon reserves and carbon productivity among three poplar-agroforestry schemes in Jiangsu Province.

By means of the relative growth method, biomass production models of *Populus deltoides* cv. '35' were developed. Using these models, biomass and carbon reserves were estimated and compared among three poplar-agroforestry schemes. Crop biomass and net carbon productivity as well as soil carbon reserves were also measured and discussed for the different schemes. The main results were as follows:

1. The fitted biomass production models and their correlation coefficients for various components of clone 35 were: $W_{leaf}=0.0350589 \times (D^2H)^{0.682092882}$ ($r^2=0.878$); $W_{branch}=0.043008 \times (D^2H)^{0.7182796}$ ($r^2=0.879$); $W_{stem}=0.037269 \times (D^2H)^{0.862924257}$ ($r^2=0.994$); $W_{bark}=0.033552829 \times D^{1.925782104}$ ($r^2=0.968$); $W_{root}=0.010009097 \times D^{2.349796761}$ ($r^2=0.899$); $W_{total}=0.123611 \times (D^2H)^{0.804004574}$ ($r^2=0.957$), where D is a diameter at breast height, and H is the tree height.
2. There was a significant difference in poplar biomass production among three different poplar-agroforestry schemes. Aboveground biomass production of poplar plantations in the different agroforestry schemes was: K (12.49 t/ha), P (12.25 t/ha), W (7.75 t/ha). Below-ground biomass production was: P (2.27 t/ha), K (2.22 t/ha), W (1.45 t/ha).
3. There was also a significant difference in crop biomass production among three different agroforestry schemes. Biomass production for different crops in the different schemes was: W (16.58 t/ha), K (15.24 t/ha), P (13.48 t/ha) for wheat; W (11.65 t/ha), P (11.21 t/ha), K (10.53 t/ha) for rice; W (13.79 t/ha), K (9.79 t/ha), P (8.26 t/ha) for maize; and P (5.81 t/ha), W (4.74 t/ha), K (4.69 t/ha) for soybean.
4. A significant difference in carbon reserves was observed among three poplar-agroforestry schemes, which was in the order of K (7.37 t/ha), P (7.27 t/ha) and W (4.60 t/ha).
5. From the viewpoint of the ecosystem, the largest reserves in total carbon (poplar + soil + wheat + corn) were measured in K, reaching 92.31 t/ha, and the smallest were observed in W at, only 56.45 t/ha.

Key words: poplar plantations, biomass, carbon reserves, carbon net productivity.

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ID-040

STUDY ON THE PROPERTIES OF COMPRESSED POPLAR VENEER

Min Chen[1], Hao Huang[1] and Yuhe Deng[1]

This paper describes the ratio of veneer compression and recovery by different experimental factors as well as the properties of veneer with different compression set. Test results revealed that the major factor that works on compression set is the pressing pressure. The higher the pressure, the greater veneer's compression set will be. When the pressure was 4MPa and 2MPa, the compression set reached 56% and 36%, respectively.

Pressing temperature is a secondary influencing factor. The compression set of veneer was 49% when the temperature was 180°C. Pressing time shows the lowest impact.

The pressing temperature and pressure also affected the recovery set of veneer. When the temperature and pressure were 180°C and 4MPa, the recovery set and actual compression ratio measured were 8.26% and 22.74%, respectively, and compared to those veneers had not been dealt with, the compressed veneer's properties such as modulus of elasticity (MOE), modulus of rupture (MOR) were 4762.32MPa and 47.85MPa, both improved by 120% and 60%. The untreated veneers and compressed ones were made into plywood, and the results confirmed that the adhesive shear strength of the latter plywood was 0.72MPa, increased by 112%.

Key words: poplar veneer, compression ratio, recovery set, veneer properties.

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ENHANCEMENT BY HYDROGEL POLYMERS OF SALT RESISTANCE IN POPLAR

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The effects of hydrogel on salt resistance of a salt-sensitive woody species, *Populus popularis*, were investigated under saline conditions. The hydrogel used was Stocksorb 500 XL (crosslinked poly potassium-co-(acrylic resin polymer)-co-polyacrylamide hydrogel) manufactured by Stockhausen GmbH Krefeld, Germany. The amendment of saline soil with 0.5% (dry weight) Stocksorb 500 XL enhanced salt tolerance of the tested poplar genotype. Hydrogel treatment markedly limited the buildup of salt ions (Na^+ and Cl^-) in leaves of *P. popularis* but increased stomatal conductance (Cs), transpiration rate (TRN) and net photosynthetic rate (Pn) of the genotype. Moreover, the application of hydrogel assisted the salt-sensitive genotype *P. popularis* to maintain the activity of superoxide dismutase (SOD) and peroxidase (POD) isoenzymes, thus retaining the capacity to eliminate salt-induced reactive oxygen species (ROS) under salt stress. NaCl-treated *P. popularis* plants exhibited leaf necrosis after 25 days of salt stress, whereas the hydrogel amendment delayed the occurrence of leaf injury for 20 days. The reduction of salt uptake by hydrogel amendment was the result of its salt-buffering and ion-selective uptake capacity: (i) Stocksorb 500 XL diluted Na^+ and Cl^- concentration in the gel matrix due to the water-holding capacity of hydrogel, allowing roots to grow in an environment of lower salinity; (ii) the enrichment of nutrients Ca^{2+} and Mg^{2+}, instead of Na^+, was accounted for by the cation-exchange character of Stocksorb 500 XL. Furthermore, Stocksorb 500 XL contains K^+ that can be taken up by plant roots. Collectively, root aggregation in hydrogel allows good contact with a source of lower salinity but with higher K^+, therefore, the uptake, transport and accumulation of salt ions in plant tissues was reduced, but the uptake of nutrients was increased; as a result, the salt resistance of the plants was increased.

Key words: antioxidant enzymes, growth, hydrogel, ion relations, NaCl, polymers, *Populus popularis.*

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ID-139

STUDY OF THE RESIN IMPREGNATION PROCESS OF POPLAR VENEERS AND ITS EFFECT ON THE WEIGHT PERCENTAGE GAIN (WPG) OF IMPREGNATED RESIN

Yong-ping Chen and Jin-lin Wang[1]

In this paper, poplar (*Populus ×canadensis* cv. 'Sacrou 79') was selected as the raw material, and melamine-formaldehyde resin (MF) as the adhesive, taking veneer texture, veneer thickness, solid content of resin, impregnation time and roller gap as variables. Resin impregnation techniques for poplar veneer under atmospheric pressure and the pressure-rolling process were used.

The results show that the weight percentage gain (WPG) of wood veneer was not found to increase during the impregnation process. For wood veneers (85mm×55mm and 360mm×180mm wide, and 0.7-1.9mm in thickness), the WPG remained constant after 3 hours of impregnation. The WPG of veneers tended to increase with decrease in the roller gap. More specifically for the veneers of poplar, a maximum WPG of 89.15% was obtained for the process of atmospheric pressure impregnation, while a maximum WPG of 110.79% was obtained for the process of roll-pressure-based impregnation. Roll pressure was found to facilitate resin impregnation into the wood faster and more conveniently than under atmospheric pressure.

Key words: melamine-formaldehyde resin, pressure-rolling, impregnation, poplar veneer, weight percentage gain.

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ID-209

ISOLATION AND CHARACTERIZATION OF TWO POLYGALACTURONASE-INHIBITING PROTEIN GENES FROM *POPULUS DELTOIDES*

Qiang Cheng, Youzhi Cao, Huixin Pan, Mingxiu Wang and Minren Huang[1]

Polygalacturonase-inhibiting proteins (PGIPs) are extracellular proteins that belong to the leucine-rich repeat (LRR) protein superfamily. PGIPs inhibit fungal polygalacturonases (PGs) and favour the accumulation of oligogalacturonides, which activate plant defense responses. PGIPs play important roles in defense against pathogens.

In this study, RT-PCR and RLM-RACE were used to isolate the full-length *PGIP* cDNA from *Populus deltoides* (*PdPGIP2* and *PdPGIP4* GenBank accession no. EF684913 and EF684912). Domain analysis revealed that the derived amino acid sequences of *PdPGIP2* and *PdPGIP4* have the typical PGIPs topology. Phylogenetic analysis of the known PGIPs revealed the two PdPGIPs belong to the defense-related PGIP clade. Using real-time RT-PCR, the expression patterns of the two *PdPGIPs* following treatment with a fungal pathogen and defense-related signaling molecules were studied. Both the *PdPGIP2* and *PdPGIP4* expression levels were up-regulated following induction by the fungal pathogen *Marssonina brunnea*. We propose that the two novel PGIPs may be involved in poplar defense against phytopathogenic fungi.

Key words: polygalacturonase-inhibiting protein, real-time RT-PCR, *Populus deltoids.*

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ID-144

POPLAR STANDS vs. AGRICULTURAL CROPS: ENVIRONMENTAL IMPLICATIONS

Pier Mario Chiarabaglio[1], Gianni Allegro[1], Gianni Facciotto[1],
Tiziana Incitti[1], Andrea Edmondo Rossi[1], Marco Isaia[2] and Alberto Chiarle[2]

Intensively managed poplar plantations are grown in rotation with agricultural crops, frequently along rivers on environmentally sensitive land and sometimes in areas included in natural parks where cultivation practices are subject to several restrictions. Therefore, an ecological study of the environmental impact of poplar cultivation as compared to the impact caused by another typical crop (maize) in rotation with poplar was carried out, using as a control the ecological parameters of natural forests present on the same sites.

The study was carried out using bio-indicators such as *Coleoptera carabidae, Aranea* and a Soil Quality Index for two different cultivation models: the "traditional" model, characterized by intensive cultivation and frequent treatments with phyto-sanitary products, and a "controlled" model, with little use of phyto-sanitary products and low-impact cultivation practices. A soil nitrogen balance estimation was also carried out in both models.

The results of two years of surveys in the experimental trials showed that poplar stands have a lower environmental impact than maize, both in the case of "traditional" and of "controlled" cultivation. Regarding the nitrogen balance, the results indicated that maize cultivated with "traditional" techniques, particularly when ferit-irrigation with livestock sewage is provided, can cause pollution of a high water table. In conclusion, the "controlled*"* cultivation model, which is the basis of sustainable forest management applicable to poplar stands, can reduce both the environmental impact of poplar culture and the costs of production, thus making cultivation more sustainable.

Key words: poplar, environmental impact, bio-indicators, nitrogen balance.

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ID-133

FOREST CERTIFICATION FOR POPLAR PLANTATIONS: A NEW MARKET OPPORTUNITY

Domenico Coaloa[1] and Lorenzo Vietto[1]

Two forest certification schemes for poplar cultivation are operating presently in Italy: the Forest Stewardship Council (FSC, www.fsc.org) scheme and the Programme for Endorsement of Forest Certification (PEFC, www.pefc.it) scheme, both of which are based on internationally-recognised requirements. These certification systems use an evaluation approach that takes place at a single company level (each forest company is inspected by a certifier on at least an annual basis), but in order to also provide the possibility of cost-effective certification to private smallholders, the instrument of group certification has also been developed.

Sustainable poplar plantation management consists mainly of the implementation of a management plan and of an environmental monitoring system, i.e. safe harvesting methods, water-course protection, irrigation-water management and control, implementation of measures to mitigate negative impacts of chemical product applications (disease control, nutrient supply). All this results in a reduction of cultivation practices and costs without affecting the wood quality. The main advantages obtained by forest enterprises with certification are: documentation of internationally-recognised ecological and social standards, safeguarding of existing market shares and customers, access to new markets, improvement of the company's image and marketing advantages in general.

There is a growing trend in business to grow and use certified wood from sustainably-managed forests at a European level. In Italy more than 40% of the domestic timber production comes from poplar plantations, and there is a strong demand for certified poplar wood from domestic industries; at present, at least 10% of the certified poplar wood is utilized by industry for plywood production and the market forecast suggests the trend is increasing.

The CRA-PLF, in cooperation with the Piedmont Region, has recently developed a web-portal to provide efficient technical support for the implementation of the environmentally-sustainable management practices required by the above-mentioned certification schemes. This integrated information system allows sharing of information and strategies on poplar certification schemes, as well as providing access to a database of certified plantations in Italy.

Key words: poplar, forest certification, FSC, PEFC, poplar wood market.

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ID-134

A NEW CLONE OF *POPULUS DELTOIDES* RECENTLY RELEASED IN ARGENTINA

S. Cortizo[1,2], J. Bozzi[1] and V. Mema[1,2]

In the Paraná River Delta area, there are 14,000 hectares of poplar plantations. *Populus deltoides* showed better adaptation to our ecological conditions than other species and hybrids, and is the main species planted in this region.

Argentina does not have any native population of poplars. For this reason, the Delta del Paraná Experimental Station (INTA) has introduced seed collected from trees of the Mississippi region to select new clones for commercial plantations. Presently, 32 clones that were selected from this population are being tested in 18 comparative field trials. The aim of this paper is to present the results obtained from one of these trials that let us to release a new clone of *Populus deltoides.*

The trial with 14 clones (10 of *P. deltoides* and 4 of *P. ×canadensis*) was planted in 1997 in a field protected against floods by a dike, using a completely randomized design with five replications of 9 plants per plot and spacing of 4 × 4 m. Height, diameter at 1.30 m above ground and resistance to diseases were evaluated at the end of each growing season for eight years. Wood density was estimated at the end of the seventh growing season.

The clone *P. deltoides* 'Carabelas INTA' grew more than two of the four local control clones included in the trial and was tolerant to the most important diseases in the region (rust caused by *Melampsora* species and canker caused by *Septoria* species). The wood density was similar to that of one of the local clones but lower than that of the other local clones. The performance of this clone was verified in two other comparative field trials.

Key words: *Populus deltoides*, field trial, clonal selection.

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IMPACT OF POPLAR RUST ON FOLIAGE DEVELOPMENT, PHOTOSYNTHESIS AND GROWTH IN STOOLBEDS

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Different kinds of rust are among the most harmful phytopathological organisms. They parasitize a wide range of species producing important losses in various crops, and poplars are not an exception. Two important epidemics were reported in the Paraná River Delta area, Argentina. The first one was caused by *Melampsora medusae* which forced farmers to replace stands of *Populus deltoides* subsp. *angulata* cv *carolinensis* with *Populus nigra* cv *italica* in 1920. But this clone was decimated by *Melampsora larici-populina* in the '40s. Thereafter rust was not a problem in commercial plantations, because trees were only infected towards the end of the growing season. However, in 1994, *P. deltoides* 'Catfish 2'was attacked in the middle of the growing season by a new pathogenic strain of *M. medusae*.

To assess the effects of this disease on poplar foliage, photosynthesis and growth responses in stoolbed plants, we established a factorial experiment, with two clones (*Populus deltoides* 'Australiano 106/60' and *Populus deltoides* 'Onda') and two levels of disease (without rust, sprayed with 25,8 g ai/ha of tebuconazole; and with rust, not sprayed). There were 24 plants per plot, in a completely randomized design with three replications.

The evolution of the disease was monitored every fifteen days throughout the entire growing season by counting the number of uredia per square centimeter on a random sample of ten heavily infected leaves per plot. The number of new leaves, the number of fallen leaves and total leaf area were evaluated periodically during the growing season. The growth (height, diameter and stem biomass) was evaluated at the end of the two growing seasons and just before a new rust attack during the second year. Photosynthesis was evaluated during the peak of the rust attack.

All variables were negatively affected by rust attack in *Populus deltoides* 'Onda', while in *Populus deltoides* 'Australiano 106/60' only the growth during the beginning of the second year and the number of leaves were reduced.

Our results show that the losses produced by the disease are related to the genotype, and that growth reduction is only partially explained by the leaf damage. The implications of carbohydrate reserves on stool sprouting are discussed.

Key words: *Populus deltoides*, *Melampsora medusae*, growth, defoliation, photosynthesis.

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ID-123

DYNAMIC WETTABILITY OF PRE-COMPRESSED POPLAR

Juqing Cui[1], Zhaobing Zhaou[1] and Yang Zhang[1]

Wettability is an important interface characteristic of wood-based materials to describe what happens on a wood surface when it comes into contact with an adhesive. A wetting model describing the dynamic contact angle (θ) process at the wood-based material surface was developed. The K-value was used to evaluate the kinitics of wetting during the adhesive wetting process. Applying the wetting model, urea formaldehyde resin (UF) and phenol formaldehyde resin (PF) wetting of pre-compressed poplar at different compressing process conditions were investigated. Moreover, the parameters of poplar pre-compressing such as compression ratio, the platen temperature and the pressing time, on the dynamic wettability were also compared.

These results showed that the wetting model can accurately describe the dynamic adhesive wetting process on pre-compressed poplar surface. The contribution of compression ratios to the K value is the most significant of the studied parameters of pre-compressed poplar. This means that most attention should go to the compression ratio when processing poplar.

Key words: dynamic wettability, UF, PF, poplar, compressing process.

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ID-211

VISUAL AND MECHANICAL GRADING OF POPLAR WOOD FOR GLUED LAMINATED BEAMS

Lieven De Boever[1] and Joris Van Acker[2]

Woody biomass from poplar plantations remains one of the most important resources for the wood processing industry market in several countries. As a fast-growing species, poplar enhances the possibility to cover increasing wood demands. Changing industrial requirements and the introduction of new poplar clones necessitates a continuous monitoring of wood quality in respect of possible end-uses. Wood is formed by a living tree with an annual growth-cycle, resulting in an annually fluctuating growth in width and height, which is dependent on site conditions and influenced by age. Consequently, wood properties can show a large variation between and even within the individuals of the same clone. This may affect the overall wood quality and its final utilisation.

The produced poplar wood is light, usually with a density between 360 and 540 kg/m³ and quite strong, resulting in a high strength-density ratio. This provides poplar sawn wood with some specific technical advantages in light construction applications.

In this study the potential of two poplar clones 'Ogy' and 'Gaver' (both *P. deltoides x nigra* crossings) was evaluated envisaging the production of glued laminated beams. All lamella were graded, both visually and mechanically in at least 3 grades. Laminated beams were produced using three different types of glue in three different lay-out types for the five lamellae counting laminated beams. 'Ogy' and 'Gaver' have very similar average wood density. The visual grades are mainly based on the presence of knots. For both clones no significant correlation could be detected between the visual grade and the Modulus of Elasticity (MOE) determined in four-point bending test. Even when density was added to the correlation matrix, no trends were discerned. This limits the use of visual grades for poplar wood, especially when aiming at higher strength grades, which can only be retrieved by mechanical testing. The mean MOE is higher for 'Ogy' but the standard deviation is lower for 'Gaver'.

Beams glued with an isocyanate adhesive showed significant lower bending strength in comparison to the poly-urethane and phenol-resorcinol-formaldehyde bonded beams. The strength evaluation of the beams resulted in higher values than could be predicted, based on the individual properties of the lamellae.

The absence of a useful correlation between density, MOE and the bending strength will also limit the possibilities of an optimal mechanical grading. Secondary effects as local slope of grain or fibre length variation (e.g. linked to juvenile or tension wood) will need to be included in the grading of poplars when an efficient use of these fast growing species in load bearing applications is envisaged.

Key words: visual grading, mechanical grading, poplar wood, laminated beams, EN14081.

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ID-239

STEM FORM AND INTERNAL WOOD QUALITY OF SELECTED WILLOW CLONES

Lieven De Boever[1], Jan Van den Bulcke[2], Dries Vansteenkiste[3] and Joris Van Acker[4]

Willow wood could form an additional or alternative source for current poplar wood harvests. The Flemish region (northern part of Belgium) has a large local genetic pool of willows. The selection process for willow clones has intensified in the last decade. Previous studies proved that early selection of willow clones could be done based on minimum requirements for physical-mechanical properties, disregarding the species genetic background. As such, it is possible to find different willow clones with similar growth and wood characteristics to use in multiclonal stands. Now, the first studies are being conducted to evaluate the wood processing potential of full-grown willow trees. Poplar processing industries in Belgium are still reluctant to process willows for two main reasons. Current resources of full-grown trees show very poor stem form and quality as they were never managed properly. Secondly, it remains unclear how the availability of this additional wood resource could evolve in the future.

For this study, two trees of each of six clones were felled within a multiclonal stand. The selection was mainly based on growth vigour, final stem form and disease resistance. The aim was to model these trees to enable the running of virtual sawing or peeling processes. As such, the potential of these willow clones can be evaluated for different processing strategies. Using photographs of the standing trees from different angles, it was possible to reconstruct a three-dimensional representation. This image can be used for the determination of the stem form and present lean of the stem. Subsequently, all stems were sawn into stem discs of 5-7 centimetres, except for one 50 cm block taken at breast height which was intended to be used for mechanical testing. All discs were photographed in a chamber designed with standardized light conditions. Features such as position of the core, actual stem contour, presence of heartwood or wood defects were detected using semi-automated image processing. Because all the positions of the stem discs were known they can be fitted into the three-dimensional representation of the standing tree. Every two meters a disc was also used to determine density and dimensional stability.

Using interpolation techniques spatial distributions of these features can be presented. All trees had, to some extent, an eccentric form and this eccentricity is not always constant along the stem. This methodology is mainly used to evaluate the willow clones under virtual peeling and sawing processes.

Key words: willow wood, stem form, wood processing potential, internal wood defects.

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ID-182

PROCEDURES FOR EVALUATING OCCURRENCE OF TENSION WOOD IN RELATION TO THE INDUSTRIAL PROCESSING OF POPLAR AND WILLOW WOOD

Lieven De Boever[1], Dries Vansteenkiste[2] and Joris Van Acker[3]

The formation of tension wood is induced by a gravitational stimulus. Different patterns of tension wood distribution between poplar clones have been reported in the literature, pointing out a partly genetic influence. It has also been stated that the extent of tension wood is greatest at the tree base. The amount of tension wood fibres can vary by as much as 22% to 63%. Tension wood can be visualized using different techniques depending on the level of evaluation envisaged (micro *vs* macro). Several staining techniques have been described for the differentiation of tension wood fibres within microscopic slides. These procedures have been proven to be very accurate. However, this approach is very time-consuming and as such less suitable for the evaluation of tension wood occurrence within logs, trees or whole poplar stands. The latter is done using Cl-Zn-I-solutions on fresh sawn cross-sectional discs at representative heights (i.e. every two meters). The total area of tension wood is determined on each disc and subsequently extrapolated to a volume percentage. This approach provides only indicative values and allows ranking of clones according to the likelihood of tension wood occurring. As such, the consequences for further processing can be assessed. So far, no publication has reported on the potential to predict tension wood using the latter technique.

To be able to give a more sophisticated image of tension wood occurrence in relation to the end-use at hand, new evaluation methods are suggested. First, to extract more information from the existing data, distributions can be fitted based on the size and surface proportions of the individual detected tension wood zones. These distributions can differentiate whether the tension wood is occurring diffuse or more concentrated. Especially when drying veneers or solid wood a more diffuse distribution is preferred as this limit induced distortions. The question still remains on how many discs should be stained and be taken randomly or systematically along the trunk. For these reasons three willow trees of the same clone on the same site were fully subdivided into stem discs of 5-7 centimetres and all discs were stained and evaluated. Simulations are performed to determine if tension wood occurrence ranges the same amount when calculations are based on different sub samples of all discs,. These calculations can be made systematically (i.e. every meter or two meters) as well as randomly (different number of discs).

Finally, it is also important to be able to predict this partly genetically influenced tension wood occurrence at an early stage. Therefore, sixty willow clones (two trees per clone) were evaluated for tension wood occurrence at the age of seven. Tension wood was measured on two cross-sectional discs thirty centimetres apart and located in the middle of the part of the stem formed during the first growing season (first 0.5 to 1.5 meter). The stem part between these discs was sawn into planks corresponding to the North-South direction. These planks were also evaluated for tension wood occurrence (radial-tangential plane). Results were analysed to see if willow clones could be separated at this early stage. Also, the prediction based on the cross-sectional discs could be compared with the vertically-detected tension wood zones and the potential to predict them.

Keywords: tension wood, poplar and willow, stem disc staining, probability of tension wood occurrence.

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POTENTIAL OF NEW SELECTED BELGIAN POPLAR CLONES FOR THE PRODUCTION OF PLYWOOD AND LAMINATED VENEER LUMBER BASED ON *P. DELTOIDES* X (*TRICHOCARPA* X *MAXIMOWICZII*) AND *P. DELTOIDES* X *MAXIMOWICZII*

Lieven De Boever[1], Dries Vansteenkiste[2] and Joris Van Acker[3]

In the Northern part of Belgium (Flemish region) poplar stands account for almost 25% of the afforested land area (35 000 ha). Yearly around 350 000 m³ round wood of divers quality are harvested from these stands. The poplar cultivation in Flanders is aiming at producing large dimension trees using wide planting distances (10 m x 10 m). To acquire high quality logs an intensified management is required (especially pruning). Last century these stems were peeled for the production of matches. However this production has disappeared and the high quality trees are now mainly used for poplar veneer based products as plywood.

From the beginning of the nineties up till now, the use of monoclonal large scaled plantations is under discussion from an environmental point of view. This pressure was mainly due to the fact of severe poplar rust disease, spreading easily once adapted to the new planted clones. A number of measures are intended to counteract this trend. Several new poplar clones (continuing selection) are planted in mixed stands for better sanitation. In addition, poplar wood is searched for to be applied in higher value added products. Local products with a prolonged lifetime (LCA) have a significant better environmental balance.

This paper discusses the use of poplar wood from new selected Belgian poplar clones for veneer based construction materials, i.e. plywood and Laminated Veneer Lumber (LVL). A sampling of clones was made within mixed stands of DM clones (*deltoides* x *maximowiczii*) and DTM clones (*deltoides* x (*trichocarpa* x *maximowiczii)*) on two different sites. The sampling was using 3 to 5 trees per clone-site combination. By planting different clones - having similar growth characteristics and disease resistance – in mixed stands, a higher degree of variability in physical and mechanical wood properties can be introduced when these stands are finally used as raw material. Determination of allowable distribution characteristics of the input material is needed in relation to the production of an end-product with standard features (limited variation). Distributions for false heartwood and tension wood, but also of drying quality were drawn and are related to distributions of the physical and mechanical properties of the produced plywood, respectively LVL. Both products are also evaluated in relation to the European standards for CE marked load bearing constructive products.

Key words: poplar wood, plywood, LVL, physical and mechanical properties, *P. deltoides*, *P. trichocarpa* and *P. maximowiczii*.

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POTENTIAL OF WOOD COLOUR MEASUREMENTS AS A TOOL FOR EARLY SELECTION OF GENETICALLY-RELATED WILLOW CLONES

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and Joris Van Acker[4]

At the Institute for Forestry and Game Management, 100 willow clones representing *Salix alba*, *Salix fragilis* and their crossing *S.* ×*rubens*, were selected at the age of 7 to 8 years based on criteria of phenology and disease resistance. For each clone, two trees were felled and the stems were analysed at breast height. The approximately 1-meter logs were each subdivided into two stem discs and two blocks of 30 cm. One block was sawn into samples for mechanical testing according to EN 408. The second block was subdivided in a north-south direction into planks of 5 mm thickness. These planks were air- dried and subsequently measured to determine the colour characteristics in a CIELAB colour space.

Properties such as density, moisture content, dimensional stability, amount of tension wood, modulus of elasticity in bending and static bending strength were determined. The parameters were statistically tested to determine differences between trees, clones and species.

Taking into account the rather large variation in wood properties, a principal component analysis was performed including the most significant characteristics (MOE, MOR, density, dimensional stability and the ratio of sap- and heartwood density). The PCA plots show, contrary to a previous ANOVA analysis, that the division into groups does not match the boundaries of the willow species. For instance, some *S. alba* and *S.* ×*rubens* clones are obviously matching the values of the best *S. fragilis* clones. The selection of willow clones can be done based on minimum requirements for physical-mechanical properties, disregarding the species genetic background.

After natural drying the willow planks showed a large variation in colour. Some of the veneers clearly showed a more reddish accent. The colour was determined on each plank at ten randomly selected positions, using a spectral analyser. The colour differences could be due to differences in chemical composition or anatomical features and as such be linked to the earlier-determined physical and mechanical features. Data were analysed to determine if the same selection could be made within these genetically closely-related willow clones based on colour measurements as they were detected by physical-mechanical properties.

Key words: willow clones, wood colour, early selection, CIELAB colour space.

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ID-183

EVOLUTION OF POPLAR-BASED AGROFORESTRY IN INDIA

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Approximately 95 per cent of poplar in India are planted in association with agricultural crops on farm land in the states of Punjab, Haryana, Western Uttar Pradesh, the Tarai Region of Uttrakhand, and parts of the remaining 5 per cent are planted on forest land in the Himalayan states of Himachal Pradesh, Jammu and Kashmir, Uttrakhand and Arunachal Pradesh. Approximately two dozens in number of *P. deltoides* clones form the bulk of planted poplar, followed by *P. ciliata, P. alba, P. gamblei* and *P. nigra.* The main clones of *P. deltoides* planted are G-48, Udai, Wimco-22, Wimco-39, Wimco-32, S7C15, S7C8, Kranti, L-34, St-121 and a few others. Of late, a very high fluctuation in annual planting of poplar has been experienced, yet, over 10-year period, approximately 20 million poplar saplings have been planted annually and harvested after 5-12 years, producing approximately 7.5 million tonnes of green timber, 1.8 million tonnes of pulpwood and 3.5 million tonnes of firewood each year, besides generating employment to the tune of 100 million man/days *per annum* in poplar-related activities.

The practice of planting poplars on farm land in the hilly states, especially in the Kashmir valley, has been carried on for centuries with farmers planting the trees on bunds on their farm land and on homesteads to meet needs for firewood and small timber. The commercial version of poplar-based agroforestry has been promoted by a match company - Wimco Ltd. - in a few north-western states since the early 1980s to secure a wood availability for its match manufacturing unit in Uttar Pradesh. Planting poplar as compact blocks within agricultural fields at a variety of spacings including 5m x 5m, 5m x 4m, 6m x 4m, 7m x 3m and others is the most dominant form of agroforestry followed by line planting within fields and bund planting on the periphery of fields. Growing agricultural crops in association with poplar is routine practice and the best crop combinations have been sugarcane in the first two years, wheat during the winter season thereafter and turmeric during the late-stage of poplar growth when trees grow in age and size. Almost all traditional and a few high value crops, including medicinal herbs, can be successfully grown within poplar plantations during the winter season throughout the poplar rotation, but farmers grow only those crops which provide them with higher economic returns from the combination of farm crops and tree harvests.

Presently, poplar-based agroforestry is supporting approximately 1 000 wood-based industrial units by supplying wood raw material for manufacturing around three dozens products and is essential for plywood, veneer, match, sporting goods, artificial limbs and packing industries at least within the poplar growing region.

Key words: poplar, agroforestry, crop combinations.

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REDUCING ENVIRONMENTAL IMPACTS OF SHORT ROTATION COPPICE THROUGH EVIDENCE-BASED INTEGRATED DECISION SUPPORT TOOLS

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A rapid increase in the area of agricultural land cultivated with short rotation coppice (SRC) with willow and poplar for production of biomass for heat and/or electricity is projected in the short-term in a range of European countries. This will have implications for various environmental issues. As a perennial crop, SRC differs from arable crops in physical traits and management practices. Results so far imply many positive environmental benefits due to SRC implementation, but SRC is in some cases faced with reservations concerning its environmental impact since it is a new crop and gaps in knowledge might exist.

A full-scale evaluation of the environmental impact of SRC at the micro-scale (in and near the SRC field) but also at macro-scale (regional) is currently missing. "Reducing environmental impact of SRC through evidence-based integrated decision support tools" (RATING-SRC) is a European Union research project funded by ERA-NET Bioenergy. It will provide scientific evidence to evaluate the impacts of SRC on soil, water, biodiversity and landscape issues and will also propose ways to mitigate negative and increase positive impacts. Moreover, factors strengthening SRC as a sustainable energy generation system, such as the recycling of by-products back to SRC, will be considered in the general evaluation. Research activities will be conducted by the five partners of the consortium from Sweden and Germany.

The main aim of the project is to provide decision-makers of different levels such as policy makers at the local and government level, commercial actors, environmental and bioenergy agencies, farmers, landscape planners and other stakeholders with decision-making support tools to assess the sustainability of SRC as an agricultural crop for the production of biomass for energy. These tools will be produced by research experiments conducted within the project, but also by combining previous and current research results obtained by the consortium members.

Key words: decision tools, environmental impact, poplar, short rotation coppice, sustainability framework, willow.

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ANALYSIS OF SNPS LINKED TO WOOD PROPERTIES OF *POPULUS NIGRA* L. GENE RESOURCES

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In this study, 115 *Populus nigra* L. collected from Europe were used as materials. They were studied for SNPs of genes linked to lignin and holocellulose (4*CL*, *PAL* and *CesA2*) using TaqMan technology and correlations between SNPs and wood properties (wood specific gravity, fiber length, fiber width, microfibre angle, lignin content, holocellulose content and α-cellulose content) were also studied.

Results showed that 27 SNPs were obtained in the genes, including 4*CL*, *PAL* and *CesA2* associated with lignin synthesis. Among these, 17 SNPs were transition (A-G, C-T) and 10 SNPs were transversion (A-C, G-C, G-T, and A-T). Three of the SNPs were discriminated. A significant negative correlation between holocellulose content of four-year old *P. nigra* and SNP1 was detected, with a contribution ratio of 11.11%. SNP2 and SNP3 had no significant correlation with wood properties. Wood properties of various genotypes of SNP1 were significantly different. The *CC* and *CT* genotypes had greater holocellulose content than the *TT* genotype. SNP1 would be an efficient marker for *P. nigra* gene resources with greater holocellulose content.

Key words: *Populus nigra* L., wood properties, single nucleotide polymorphisms.

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ENHANCING PHYTOREMEDIATION AND PLANT GROWTH IN POPLAR AND WILLOW

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Halogenated hydrocarbons, such as trichloroethylene (TCE), are serious environmental contaminants of soil, groundwater, and air. Studies of the metabolism of this class of pollutants by poplar trees, a genus widely used in phytoremediation applications, has demonstrated that cytochrome P450 enzymes are involved in the early steps of TCE metabolism. Using microarrays of poplar and *Arabidopsis*, we have determined a number of genes that are differentially regulated in response to TCE. Through expression of candidate genes in yeast, we hope to elucidate which of these genes may be directly involved in TCE metabolism. Transgenic plants that highly express the genes necessary to metabolize pollutants could lead to profound enhancements in phytoremediation. We have developed transgenic poplar plants with greatly increased rates of metabolism and removal of these pollutants through the overexpression of cytochrome P450 2E1. These transgenic poplars may provide the means to effectively remediate sites contaminated with a variety of pollutants at much faster rates and at lower costs than can be achieved with current conventional techniques.

The interior of plants provides habitat for a wide range of bacteria and fungi, both termed endophytes, which benefit the plant host. Nitrogen fixed biologically by plant-symbiotic bacteria is more ecologically friendly than chemical fertilizers. We have isolated a variety of micro-organisms able to grow under nitrogen-limitation from the stems of native poplar (*Populus trichocarpa*) and willow (*Salix sitchensis*) in a riverine system in western Washington State (USA). The presence of these diazotrophic micro-organisms may help explain the ability of these pioneering tree species to grow under nitrogen-limiting conditions.

Key words: pollutants, *Arabidopsis*, TCE metabolism, bacteria.

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ID-009

ROLE OF *ARBORKNOX2* IN REGULATING SECONDARY GROWTH IN *POPULUS*

Juan Du and Andrew Groover[1]

Secondary growth is a developmental process supported by division of meristematic cells within the vascular cambium. We have cloned *ARBORKNOX2* (*ARK2*), a *Populus* ortholog of *Arabidopsis brevipedicellus (*also known as *knati). ARK2* is expressed in both the shoot apical meristem and vascular tissues. Whole mount *in situ* hybridizations of cultured *Populus* plants show that *ARK2* is expressed in the procambium in the first elongating internode during primary growth. During the transition to secondary growth in internodes 3, 5, and 7, *ARK2* expression is associated with cambium cells, as well as secondary phloem fibers and secondary xylem cells. In the bottommost internode, where phloem fibers and secondary xylem cells have matured, *ARK2* is only expressed in the cambium region.

To further explore the regulation of *ARK2* in secondary growth, we transformed *Populus* with *ARK2* RNAi, artificial micro-RNA (amiRNA) and overexpression constructs. Real-Time PCR data showed that *ARK2* is only partially down-regulated in recovered RNAi and amiRNA transgenics, and no plants were recovered with severe knockdown of *ARK2* expression. Compared with the wild type, *ARK2* knockdown *Populus* precociously formed secondary phloem fibers and xylem tissue during the transition to secondary growth, had more secondary xylem tissue in the bottommost internode, and had thicker secondary cell walls in phloem fibers and secondary xylem cells. In *ARK2*-overexpressing *Populus*, the shape of the procambium in the first internode was altered, and was associated with an early formation of cambium. The cambium cells showed more periclinal divisions, but daughter cell differentiation was inhibited, leading to a wider cambium region tissue and less phloem fibers and secondary xylem tissues. The regulation of secondary growth by *ARK2* was further demonstrated by microarray data analysis, which showed that secondary growth-related genes were down-regulated in overexpression transgenics, and up-regulated in knockdown transgenics.

In summary, our preliminary data indicate that *ARK2* acts in regulating cambium function, as well as differentiation and secondary cell wall formation of secondary phloem fibers and xylem cells.

Key words: *ARBORKNOX2 (ARK2), Populus,* meristem, secondary growth, lignin.

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ID-158

RENEWABLE ENERGY FROM SUSTAINABLE POPLAR TREE FARMS

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GreenWood Resources (GWR) manages 14,000 hectares of poplar farms in the Pacific Northwest region of the United States and is developing nurseries and short-rotation high-yield poplar plantations in China and South America. The US farms are managed on 12-15-year rotations for multiple products including sawlogs, chips, and residuals for bioenergy. GWR intends to certify all the tree farms to the Forest Stewardship Council (FSC) standard. In addition to the sawlog production business, GreenWood Resources is fully committed to the goal of developing renewable sources of energy. To this end, GreenWood is refining agronomic technologies that will optimize the production systems for poplar energy farms. Poplar feedstock will be used for cogeneration, pellet production, and it will become a feedstock of choice for cellulosic ethanol. Over the next 3-5 years it is GWR's goal to be a leader in the development of sustainable poplar energy plantations in North America, South America, and China. GreenWood is well positioned to play a valuable role in bringing all of the essential elements together for successful commercialization of poplar tree farms for renewable energy. GWR is a global leader in the development of elite poplar germplasm as well as the production systems to optimize poplar energy farm operation. Further, the company has the ability to develop sound financial structures to access the capital that is required for large-scale project financing. GWR is currently working with developers to use poplar feedstock for combined heat and power generation in South America. In the US, Greenwood will provide poplar feedstock for pilot-scale cellulosic ethanol conversion as a first step towards large-scale development that integrates the energy farm with the conversion facility.

Key words: poplar, tree improvement, production systems, cellulosic ethanol, sustainability.

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ID-086

NEW POPLAR AND WILLOW CLONES SELECTED FOR SHORT ROTATION COPPICE IN ITALY

Gianni Facciotto, Giuseppe Nervo, Sara Bergante and Cesare Lioia[1]

In recent years, increasing energy demands, due to fast economic growth in Asia and to the uncertainty of the political situation, have caused an increase in the price of fossil fuels. The use of renewable energy, and particularly bioenergy, has become very important in order to secure energy supplies for future generations and to reduce global catastrophic atmospheric changes due to high greenhouse gas (GHG) emissions. Biomass, including forestry and agricultural crop residues and waste, is the largest source material for renewable energy production and provides a substantial opportunity not only to reduce GHG but also to increase internal energy supplies. In the short term, the use of biomass residues will allow bioenergy production in Italy to increase up to 8-10 Mtoe per year without reducing food production while maintaining soil fertility. In the longer term, biomass could provide 15-20% of the total energy production according to the target of the European Union (EU). To reach this level, it will be necessary to establish energy crops that are characterized by high production per hectare and low environmental pressure. Among dedicated woody crops grown on short rotations, good results are obtained with *Salicaceae*, specifically poplar and willow clones.

This paper reports performance (survival and biomass production) of new poplar and willow clones, selected by the Wood Production Outside Forest Research Unit at Casale Monferrato (AL), Italy. The trials were established on different sites all over Italy. New clones are grown in a short rotation coppice (SRC) system (density of 8,000 – 10,000 plants per hectare, harvest every 2-3 years). The clones used are characterized by good rooting capacity, fast growth, resistance to diseases and good re-sprouting capacity after harvesting.

Dry biomass production can exceed 20 odt per ha per year in fertile soil with good water availability in North Italy. In particular, the clones *P.* ×*canadensis* 'Orion', *P. deltoides* 'Baldo', *Salix* spp 'Levante' and *Salix* spp 'Drago', recently patented in the EU, are able to produce from 30 to 60% more than old clones such as *P.* ×*canadensis* 'I-214' used in traditional poplar plantations (10 year rotation). They are also partially resistant to water shortages

By using new clones, it will be possible to reduce the economic and energy costs of SRC, making cultivation more profitable.

Key words: poplar, willow, short rotation coppice, productivity.

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ID-104

EVALUATION OF PROPERTIES OF *POPULUS ×EURAMERICANA* CV. '74/76' FOR BLEACHING CHEMI-MECHANICAL PULPS

Guigan Fang and Yongjun Deng[1]

Populus ×euramericana cv. '74/76', a new fast-growing hardwood cultivar planted widely in Central China, was used as a raw material in this study. Wood characteristics of this cultivar were determined and its P-RC APMP pulping properties were evaluated by testing specific energy consumption, strength properties and optical properties.

The results of this study showed that the wood of *Populus ×euramericana* cv. '74/76' is a good resource for bleaching chemi-mechanical pulps. Under pulping conditions involving lower dosages of H_2O_2 (ranging from 3.0% to 4.0%) and NaOH (ranging from 2.0% to 4.5%), pulping yields ranged from 85.6% to 88.5% on an oven-dry basis, the pulp brightness ranged from 80% to 85.7% ISO, and, at the Canadian Standard Freeness of 150 ml, tensile index of pulps ranged from 28 N.m/g to 50 N.m/g.

Key words: *Populus ×euramericana* cv. '74/76', wood characteristics, P-RC APMP process.

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RELATIONSHIPS OF BENDING PROPERTIES OF POPLAR CLONES WITH KNOTS

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In Hungary the importance of forestry and wood industry of poplars is considered to be quite significant, its area ratio is over 10% and gross yield ratios is 16%. According to this fact, it is one of the most important fields of wood industry research in Hungary. The value of wood materials of different poplars and hybrid poplars is lower than for pines, depending on several reasons such as the structure of tissue, low density etc. Certain hybrid poplars clones have higher density ρ>0,400 g/cm^3, and because of their certain properties they can be used in utilizations which are similar to utilizations of pines, such as structural wood materials.

The utilization of wood materials is limited significantly by wood defects. The most important of these is the presence of knots that has a strong influence on the mechanical properties of the material. In terms of structural wood, knots are considered the most critical type of defect. Increasing knot area ratios and knot diameter ratios result in decreasing bending strength (MOR) and modulus of elasticity (MOE) values. This decrease may amount to as much as 40-50%. The aim of the research is to reveal the effects of knots on bending qualities of certain poplar clones such as bending strength and modulus of elasticity similarly to the characteristics of Scots pine.

Key words: wood industry, Hungary, bending quality.

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ID-236

ACTIVATION TAGGING IN ASPEN USING AN INDUCIBLE TWO COMPONENT *Ac*/DS-ENHANCER ELEMENT SYSTEM

Matthias Fladung and Fadia El-Sherif[1]

Based on the *Ac*/Ds two-element transposition system from maize, an activation tagging approach was suggested for the hybrid aspen (*Populus tremula* × *tremuloides*) line 'Esch5'. The proposed approach is based on results obtained from our earlier work on the genetic transfer of the maize transposable element *Ac* and its functional analysis in hybrid and pure aspen lines.

Two different inducible *Ac*/ATDs element systems were used to induce activation-tagged variants following two independent transformation steps. The transposase was induced following glucocorticoid and/or heat-shock treatment.

In combination with a 35S enhancer tetramer and outward facing two CaMV 35S promoters located near both ends of the ATDs element, expression of genes which are located adjacent to the new integration site of the element can be elevated. As selective markers for ATDs transposition, both knocking-out the expression of a phenotypic marker (*rolC* gene) and a negative selection marker gene (*tms*) are considered. The state of this study is as following:

- Constructs were made carrying (i) the transposase gene under control of either a glucocorticoid or heat-shock-inducible promoter, and (ii) an ATDs element with either *rolC* or *tms* as a phenotypic selectable marker.
- Transgenic poplar plants were obtained carrying either one or two of the above mentioned constructs.
- Transgenic status of the transgenic plants was confirmed by PCR- and Southern blot experiments.
- Following induction of the GIP promoter only a weak transposase signal could be detected in RT-PCR experiments. Mobility of the ATDs activation construct could not be confirmed in the GIP system so far.
- The induction of the heat-shock promoter could be confirmed in RT-PCR experiments. Out of eight HSP-transposase transgenic lines, seven lines showed transposase induction following heat shock. Mobility of the ATDs element could be demonstrated.

Key words: genome analysis, transgenic poplar, transposase, transposition.

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FASTER EVALUATION OF INDUCED FLORAL STERILITY IN TRANSGENIC EARLY FLOWERING POPLAR

Matthias Fladung and Hans Hoenicka[1]

A major concern over the use of transgenic trees is the potential for extensive transgene dispersal through pollen and seeds. The incorporation of sterility genes into transgenic lines of trees has been proposed to reduce or even avoid gene flow of transgenes into non-transgenic relatives, which is one of the main ecological concerns with respect to commercial use of transgenic plants. The evaluation of strategies for the induction of sterility in transgenic forest tree species has been hindered by their long vegetative periods. In our study early flowering transgenic poplar lines carrying 35S::*Leafy* and Hsp::*FT* were used to evaluate several sterility constructs.

So far, in CGPDHC::*Vst1*- and TA29::*mPdH*-transgenic aspen, no formation of pollen could be detected in anthers while early flowering genotypes without the sterility construct were fertile. In MALE::*STS* transgenic aspen, pollen was formed, however, with deformed shape. In further analyses pollen germination tests will be initiated.

The combination of two transgenic approaches, one to induce early flowering and a second for the induction of sterility, allowed evaluation of both sterility strategies two years after transformation. This is a very short period of time considering the long vegetative period of up to ten to twenty years common in forest tree species. This approach opens new opportunities for the assessment of mechanisms for this plant group.

Key words: biosafety, avoidance of pollen dispersal, vertical gene transfer.

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ID-172

ELIMINATION OF MARKER GENES AND TARGETED INTEGRATION OF TRANSGENES VIA THE FLP/*FRT*-RECOMBINATION SYSTEM

Matthias Fladung[1], Tobias Schenk[2], Horst Lörz[2] and Dirk Becker[2]

After December 31, 2008, release of transgenic plants with antibiotic resistance genes will no longer be allowed in the EU-countries. These selections of marker genes are needed to control the success of the transformation process, but become useless during later stages of development. Further, the problem of expression variability is more crucial for trees with long vegetative cycles compared to annual plants. To address the issue of expression variability, single-copy transgenes need to be placed precisely into the pre-defined genomic loci already characterized for stable expression.

Site-specific recombination (SSR) systems can be used both to eliminate the antibiotic marker gene and to place a recognition target (reporter gene) within the genome so that the "gene-of-interest" (GOI) can be precisely placed into the target. The aim of this project is to test the usability of the FLP/*FRT*-recombination system from yeast in transgenic poplar.

In our experiments the activity of the FLP-recombinase is controlled by a soybean (*Glycine max*) heat-shock promoter. After the activation of the FLP-recombinase by heat, this enzyme will recombine two collateral orientated *FRT*-sites leading to excision of the antibiotic marker gene in between. To control success of the recombination process a promoterless *uidA* reporter gene gets under the control of the CaMV35S-promoter and GUS staining tests verify the recombination events.

In the next step of our "proof-of-concept" study we have replaced the selection marker *nptII* with a promoterless *bar* gene located on a second T-DNA. Following heat-shock-induced recombination, the *nptII* gene disappeared and the *bar* gene integrated exactly at this position, thus becoming active under control of the 35S-promoter. Targeted events could therefore easily be detected in BASTA resistance tests. Southern blot experiments and sequencing analyses have confirmed successful targeting of the *bar* gene.

Key words: antibiotic-free transgenic, expression variability, targeted gene transfer.

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ID-171

GROWTH PERFORMANCE OF POPLAR ENERGY PLANTATIONS ON TWO DIFFERENT SITES IN CENTRAL CHILE

Alejandro Fraga[1]

The Maule Region is an area of 800,000 ha located in the arid interior of central Chile with low precipitation and absence of frost. The presence of vineyards with drip irrigation has increased in the last decade. Clay soil types predominate. The trial was established cooperatively by GWR (GreenWood Resources), CONAF (National Forest Service) and CORESPO. The BioBio Region is an area located in the irrigated lands of the central valley of Chile. The precipitation reaches around 1,000 mm per year and there are frost events in winter and mid spring. The trial was established by GWR at its own propagation center.

The aim of the study was to assess the growth of poplars for energy biomass production in a way that demonstrates the potential of five selected *Populus ×generosa* hybrids for development of a renewable energy program in Chile.

The two trials were established in the spring of 2007. One trial had drip irrigation and the other surface irrigation. The experimental design is a spit-plot treatment arrangement with two stocking levels (5,500 and 1,800 trees x ha^{-1}) assigned to whole plots and hybrids (5) to sub-plots. There are three replications of each factorial combination of clone and density. Each high density plot contains 290 trees and each low density plot has 88 trees. The total area is about 1.9 ha for each site. An inventory plot was established within each sub-plot for the annual measurement of height and diameter growth. Yield will be measured at rotation. Measurement of yield will be by destructive sampling and development of yield equations.

Assessment data are being collected in 2008 and results will be available after statistical analysis.

Key words: energy plantations, *Populus ×generosa,* poplar hybrids, poplar biomass, biomass.

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ID-174

EX SITU GENE BANK ESTABLISHMENT OF *POPULUS SIMONII* AND BIOLOGICAL FEATURE ANALYSIS OF ITS SEEDLINGS

Gui-Sheng Fu[1]

Populus simonii is a native species in China and grows in Northeast, Northwest and North China. The range extends from Jilin and Liaoling through Inner Mongolia, Hebei, Shanxi, Henan, Shandong to Gansu and Qinghai province. Its beneficial characteristics, such as drought resistance, cold hardiness, high quality timber and ability to grow in poor sandy soil, make it an important genetic resource in China.

This presentation summarises the work of FAO/GCP/CPR/009/BEL on the investigation of the range of *P. simonii*, collection of provenance material, and the establishment of an *ex situ* gene bank, as well as observation and analysis of seedling growth, phenology, morphological characteristics and isoenzyme charts. The main results were as follows:

1. *P. simonii* cutting bank was established, includes 303 clones and has an area of 1.18 ha.
2. *P. simonii* seedling bank was established, includes 195 families and has an area of 2.45 ha.
3. There were no significant differences in height growth and phenological phase among the different provenances of *P. simonii*.
4. There were no unique isoenzyme loci to distinguish the *P. simonii* from different provenances.
5. There were no obvious differences in morphological traits of trunk, lenticels, branches or buds among the trees from three regions of Northeast, Northwest and North China.
6. The leaves of *P. simonii* from North China were found to be larger than those from Northeast and Northwest China.

This research has important implications for the forestry ecological construction activity in the sandy area of north China.

Key words: *Populus simonii, ex situ* gene bank, biological characteristics.

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ID-175

RESULTS FROM A DEEP PLANTING TECHNIQUE USING AN ELECTRIC AUGER

Gui-Sheng Fu[1]

A new deep planting auger (Mobile Electric Deep Planting Auger), which is unlimited by site topography, is suitable for planting operations on undulating sand dunes. This paper details systematically the key technical aspects of the new planting technique and its use in planting operations.

Compared to traditional planting techniques, the new planting technique has a number of advantages:

1. Working on difficult, undulating planting sites is possible since the new machine has a mobile auger.
2. Greater planting depth, 1.6 m, allows the cuttings to reach the water table in sandy soil.
3. Faster planting speed: the planting speed of the new technique is six times as fast as that with the normal auger.
4. Lower planting costs since the new technique does not require watering after planting while the traditional method requires watering three times after planting. Thus, the new technique enhances the survival rate and increment of the plantations.

With over 0.2 million mu (1/15 hm^2) of large-scale experimental plantations, the planting new technique has solved the issue of planting in winter.

Key words: planting auger, deep planting, sandy soil.

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TANDEM REPEATS IN A GROUP II INTRON PROVIDE RESOLUTION IN PHYLOGENETIC AND PHYLOGEOGRAPHIC STUDIES OF THE GENUS *POPULUS*

Barbara Fussi, Jelena Aleksic and Berthold Heinze[1]

We detected a variable region in a chloroplast group II intron. A large portion of this variation is made up of complex tandem repeat structures, thus the region proved useful in inter- and intraspecific phylogenetic analysis. We use indel/gap coding to establish a phylogeny of 46 poplar accessions.

Additionally we investigated the secondary structure of the intron. Particularly interesting is the finding that one of the tandem repeats is not forming a hairpin itself, nor in a repeated state. Rather the folding suggests that repeats are involved in attracting inversed structures along the 5' direction of the sequence, thus shortening the distance between conserved regions of certain domains. Furthermore, the variable region is found in domain IV. On the one hand, this domain has lost its maturase function, so it evolves fast and nucleotide composition is no longer important. On the other hand, domain IV is reported to be highly specific due to high variability regarding additional splicing factors. In the folding of the rpl16 intron in poplars a structure of two hairpins might be involved in attracting the splicing enzyme. Without one 16bp repeat those hairpins fail to be formed, whereas a 2-5-fold repetition does not influence the hairpin structure.

Key words: poplars, group II intron, secondary structure, phylogeny, phylogeography.

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ID-056

DETERMINATION OF POLYMORPHISMS OF MICROSATELLITE PRIMERS IN SERBIAN GERMPLASM

Vladislava Galović, Saša Orlović, Branislav Kovačević
and Andrej Pilipović[1]

The objective of this paper is to examine the functionality and informational value of four microsatellite DNA markers in representative Serbian germplasm. The polymorphism levels of these markers were determined within four Serbian clones (B81, B229, 182/81 and PE19/66) of *Populus deltoides*. Clones were chosen for their high genetic value for breeding purposes. Four sets of microsatellite primers, PTR1, PTR2, PTR3 and PTR4, were chosen for this study. Genomic DNA was isolated from the leaf tissue using a modification of the Permigeant *et al.* (1998) method. PCR amplification of the desired fragments was carried out in a volume of 25 μl according to Gomez *et al.* (2003). All four SSR markers were successfully amplified and sized. Among all four loci, PTR1 proved to be the most polymorphic for all four genotypes examined.

Revealing polymorphisms within genotypes of interest, this microsatellite DNA marker could be successfully used in poplar breeding programs.

Key words: poplar, microsatellites, polymorphisms.

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ID-200

A REGENERATION SYSTEM FOR A HYBRID POPLAR (*POPULUS NIGRA* X *POPULUS DELTOIDES*)

M. Romina Garay[1,3], Pablo A. Noseda[2], Silvia Cortizo[3], Gerardo Mujica[3] and Raúl D. Ríos[1]

We report an *in vitro* regeneration system for *Populus* ×*canadensis* poplar clones (*Populus* ×*canadensis* 'Conti 12' and 'Ragonese 22 INTA'). High frequency of shoot regeneration via direct organogenesis was obtained on a modified MS medium supplemented with 0.5 mg/l *trans*-zeatin and 0.1 mg/l 6-benzylaminopurine (BAP) using petiole explants. Root regeneration in shoots developed *in vitro* was obtained on WPM medium supplemented with 0.5 mg/l of indolbutiric acid (IBA). Poplar plantlets were able to regenerate within three months. The development of a reproducible and efficient *in vitro* shoot regeneration system is a prerequisite if plant biotechnological techniques, such as genetic transformation, are to be applied to *Populus* ×*canadensis*.

Key words: direct organogenesis, *Populus* ×*canadensis,* shoot regeneration.

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ID-055

RESOURCES AND MARKET BALANCES IN POPLAR PLYWOOD MANUFACTURING: THE OUTSTANDING EUROPEAN EXPERIENCE OF GARNICA PLYWOOD

Pedro Garnica[1]

This paper presents data of the Garnica Company which is currently increasing by 20% a year the production of their specialised poplar plywood lines. The existing factories are located in Spain and are being extended in 2008 into Southwest France. The objective of this synthesis is to provide an overall evaluation of the technical and economical aspects of the poplar plywood industry. The different parts of this presentation show how plywood production gives: (1) technical efficiency to supply the market with high quality and flexible products, (2) flexibility to organise the production lines, (3) effective use of the best characteristics of the raw material, and (4) a global and very favourable energy balance considering the sustainable resources used and the optimisation steps of combining, gluing, drying and pressing layers of poplar veneer.

1. Manufacturers must meet the requests for diversified products within very short time frames and with increasingly strict standards of quality. To those requirements for homogeneous quality, are added the needs for increasing quantities of products for increasingly larger markets. Wood manufacturing is not an exception to this rule, but as a natural material, it is biologically less homogeneous than transformed natural resources. Logs peeled to veneer of different thicknesses make it possible to overcome variations in wood characteristics and to maintain high standards of quality and as well as to meet fluctuating volume requirements using the resources in a sustainable way. In relation to raw sawn wood, the association of selected veneer elements in as many layers as needed guarantees a final board of all required thicknesses and with high and homogeneous resistance

2. Plywood products composed of hybrid poplar veneer can meet the quality and quantity requirements of markets for silvicultural and process reasons that will be summarised. Higher homogeneity of wood structure can be obtained more easily with clonal plantations. Often, the benefits of simple vegetative reproduction, which reduces the effects of genetic variation on wood growth, interacts with site variation (topography, water table level and other soil characteristics) and is mainly expressed in changes in wood colour and by the presence of tension wood. Other growth-related defects can be avoided by adapting the clone to the climatic situation of plantation and by respecting silvicultural, pruning and harvesting rules. The length of logs will be discussed. The thickness of veneer is also monitored during the peeling operation, changing from 0.9 mm to more than 2.5 mm.

3. The production model of Garnica Plywood optimises the use of wood by using specialised equipment designed for poplar transformation. Each group of logs is transformed separately according to its characteristics. The veneers are classified on the base of moisture content and visual criteria such as coloration and size and number of knots. By this means the process schedule and requested quality can be achieved.

4. Plywood gives the highest aggregate value to poplar considering economic, technical and environmental perspectives. Veneer has an economic value 10 times greater than pulpwood and five times greater than sawlogs. To add to this highly efficient wood use, the integrated model of Garnica is also optimised in relation to energy use and environmentally friendly processes.

Key words: poplar plywood industry, wood, transformation.

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MOLECULAR AND PHYSIOLOGICAL CHARACTERIZATION OF RESPONSE TO ENVIRONMENTAL POLLUTION TOLERANCE IN POPLAR

M. Gaudet[1], M. Sabatti[1], I. Beritognolo[1], F. Pietrini[2], V. Iori[2], M. Zacchini[2], A. Massacci[2] and G. Scarascia Mugnozza[1, 2]

The increasing number of contaminated sites causes several management problems and often leads to a waste of natural resources, such as soil and water, which cannot be utilized. Biological techniques for remediation of polluted soils - bioremediation and phytoremediation - have been studied for many years. They can give acceptable results with a low environmental impact, even in the long term. However, the use of higher plants in decontamination has been limited by legislative constraints and also by the lack of plant species which can be really effective in regard to specific contaminants. Poplar is a good candidate for phytoremediation and possesses genetic resources for the identification of genotypes with high tolerance to heavy metals and a good capacity for uptake and accumulation of contaminants. Some recent research showed a high variability in the uptake capacity and tolerance to Cadmium (Cd) in Salicaceae.

The work reported here focused on the genetic basis of Cd tolerance in *Populus nigra*. Two *P. nigra* genotypes, belonging to natural Italian populations from contrasting geographic and environmental origins, were chosen as parents to create full-sib progenies. Ninety-two F_1 individuals were analyzed to construct genetic maps based on the pseudo-testcross strategy. From previous experiments it was observed that the two parental genotypes presented different tolerances to Cd stress. Some candidate genes expected to explain these differences were chosen for molecular characterization: metal sequestration (metallothionein 2a), ion transport (vacuolar H^+-ATPase), and response to oxidative stress (ascorbate peroxidase 2, glutathione reductase, glutathione S-transferase). The expression of these genes was analysed in plants submitted to Cd stress. They were also used to enrich the genetic maps in candidate genes for Cd tolerance. A Cd-stress replicated experiment with controls was carried out on the mapping progeny for QTL analyses. Ecophysiological and chemical parameters measured during the experiment will be used for the genetic dissection of plant response to Cd treatment and correlations among allelic variants as well as the phenotypic expression of traits will be calculated. Such an approach will allow a search for QTLs controlling tolerance and concentration of Cd in plant organs (root, stem, leaf).

Future expectation is for the identification of key genes (major genes) for phytoremediation in *P. nigra* and the establishment of molecular markers for selection of poplar material suitable for environmental restoration and phytoremediation.

Key words: *Populus nigra*, cadmium, candidate genes, oxidative stress, QTL.

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ID-203

EMERGING PESTS AND DISEASES IN POPLAR CULTIVATION IN ITALY

Achille Giorcelli, Gianni Allegro and Massimo Gennaro[1]

In recent years, some pests and diseases have changed pathosystems, due both to changes in agronomic management and to environmental abnormalities. Short rotation forestry (SRF) stands for biomass production have spread throughout Northern Italy, creating conditions suitable for an increased role of some parasites and a reduced incidence of other pathogens, in particular those causing wood-quality damage.

In SRF stands, rust agents such as *Melampsora* spp., which take advantage of the particular microclimate of such stands, are dramatically threatening parasites, so much that their attacks rise to levels that may severely affect quantitative production and impair stump viability. Unfortunately, due to the low margins of return of such plantations, chemical treatments against rusts are uneconomic, so this disease may become a highly limiting factor for poplar SRF. The dangerousness of *Melampsora* in both SRF stands and nurseries is increased by the coexistence and frequent development or introduction of physiological races able to overcome the results obtained by breeding for resistance over several decades. Another issue deserving consideration in SRF stands is the maintenance of the regenerative power of stumps after several close cuts over a short period. This may be affected by root rots induced by *Rosellinia necatrix*, a pathogenic fungus, and by *Cryptorhynchus lapathi*, a wood-boring beetle, both finding favourable conditions in biomass stands because of the high density of stumps and the stress induced by competition.

In traditional poplar cultivation (with a rotation of about 12 years and plywood as the main product in Italy), changes in the pathosystem have been recorded in both nurseries and plantations. In the first case, young plants about to be transplanted are increasingly affected by *Cytospora* spp. (anamorphic *Valsa* spp.) to the detriment of the formerly-prevalent *Discosporium populeum*, probably as a consequence of some climate parameters becoming more Mediterranean. Also in nurseries, a new syndrome has been spreading for a few years, occurring especially on some *P.* ×*generosa* clones. With a likely bacterial aetiology (*Erwinia* group), symptoms always appear on lignifying stems or twigs, and may vary from faint bark swellings or small cankers to extended open cankers with hyperplastic reaction tissues. As a consequence of these symptoms, the organ may break and the whole young plant becomes useless for transplanting. This syndrome may limit the possible and advisable diversification of clones cultivated in Italy.

In plantations, apart from the more and more frequent occurrence of water stress with resulting crown thinning and loss of annual increments, attacks by the wood-borer *Megaplatypus* (=*Platypus*) *mutatus* are becoming of critical importance. Accidentally introduced to Italy from Argentina and confined till now to some sites in Campania, it causes great damage to 4-5-year-old and older plants, in which the tunnels of feeding larvae may wholly compromise the use of the log for plywood production. Investigations to find eradication strategies are in progress in order to reduce damage in the affected areas and prevent spreading.

Key words: short rotation forestry, rust fungi, root rots, 'bacterial' syndrome, weak parasites, *Megaplatypus mutatus*.

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ID-132

FOREST ECO-CERTIFICATION AND ENVIRONMENTAL PERFORMANCE IN THE LOW BUENOS AIRES DELTA OF THE PARANÁ RIVER, ARGENTINA

Adrian Gonzalez[1], Adriana Rosenfeld[2] and Edgardo Casaubon[1]

Forest eco-certification aims to promote the sustainable management of all type of forests and to satisfy demands from the market for forest products produced in a sustainable way, from producers offering such products. The certification is an action carried out by a third party which asserts with an appropriate level of security that a certain product or service is made according to specified standards. Although environmental protection has always been attended from an ethical perspective, the need to consider it as an approach integrated with economic and commercial aims is now increasingly seen. At the present moment, companies and the business world in general support this approach with greater conviction, visualizing potential benefits higher than their costs.

In wetlands of the low Buenos Aires Delta of the Paraná River, almost 95,000 hectares of commercial plantations of Salicaceae (*Populus* and *Salix*), natural forests, lagoons, flats and other areas (around 46% of the total surface) have been environmentally protected in the last decade. In the year 2000, UNESCO declared a Biosphere Reserve on 88,624 hectares of islands in the Municipality of San Fernando, with the purpose of conserving the natural environment, the social sustainability and the economic competitiveness of the diverse islands' production. In 2002, a private timber firm, FAPLAC S.A., had 2,050 hectares of commercial forest plantations certified under the FSC (Forest Stewardship Council), environmental standard and in 2004 another private company, EDERRA S.A., had its commercial and silvo-pastoral plantations, with an area of about 1,800 hectares, certified under the ISO 14,001 environmental management system standard.

Considering possible economic and environmental benefits, during the current year, a group of five small forest producers of the low Buenos Aires Delta indicated their interest and began to organize themselves individually, in order to demonstrate their "environmental performance", in about 700 hectares of their own plantations using the non-certifiable ISO 14,031 Standard. The demonstration of their environmental performance constitutes an alternative to the cost of certification, allowing producers to communicate to interested parties the type of forest management they are doing. This group of small foresters tries to differentiate its production and achieve competitive advantages for its products, inserting itself in the market of quality Salicaceae wood for a variety of uses, and taking into account the criteria and indicators suggested in the manuals of good forest management practice in wetlands.

Key words: eco-certification, environmental performance, Paraná River Delta, Salicaceae.

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ID-173

IMPACT OF POPLAR WATER STATUS ON LEAF-BEETLE (*CHRYSOMELA POPULI*) SURVIVAL AND FEEDING

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and Patrick G. Mertens[3]

Climate change tends to induce more frequent, more intense and longer-lasting climate events, with great impacts on ecosystems. The aim of this study was to assess the impact of drought on insect-tree relationships, using poplar as a model tree. Survival and feeding of leaf-beetles, *Chrysomela populi* (Coleoptera: Chrysomelidae) on host plants subjected to different levels of water stress were compared.

Ninety 1-year-old poplar cuttings were grown in a greenhouse, and divided into three groups subjected to different water treatments. After six weeks of continuous water stress inflicted on the plants, adult *C. populi* were put in cages for four days with the terminal five leaves of a shoot. Survival of beetles and leaf areas consumed were then determined. The exposure was repeated once. Predawn leaf water potential values indicated that the drought treatments induced different levels of plant water stress. Plant height growth and total leaf numbers were reduced by plant water stress. Leaf-beetle survival and leaf areas consumed were also reduced proportionally to plant water deficit. Leaf-beetles showed a preference for young, actively growing leaves, as also observed in other studies.

In conclusion, this experiment suggests that drought has a negative impact on *C. populi* survival and feeding.

Key words: climate change, *Chrysomela populi,* insect-tree relationships.

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ID-024

PHYSIOLOGICAL RESPONSES TO SHADE AND DROUGHT IN YOUNG WILLOW PLANTS

A.B. Guarnaschelli[1], A.M. Garau[1], F.D. Caccia[1] and S.C. Cortizo[2]

The Parana River Delta of Argentina is one of the largest regions in the world with willow crops. These short-rotation species are managed mainly for the pulp and particleboard industries. Willows are planted mostly in the inner and lowest areas of the delta islands, which are characterized by the presence of abundant, tall vegetation. During establishment, weed competition is one of the main impediments to successful performance.

Information about how willows tolerate the presence of weeds is comparatively scarce, as well as information about their capacity to adapt their physiological attributes which would facilitate acclimation of plants, allowing resource acquisition and improving the competitiveness and productivity of the plants under new environmental conditions.

In order to assess the effects of different combinations of water and light availability on physiological responses of young plants of *Salix matsudana* × *Salix alba* 'A 13/44', we established an experiment under controlled conditions, which had a factorial design with three levels of light availability: full sunlight, moderate shade and severe shade (100%, 25% and 10% of full sunlight respectively); and two water regimes: with and without water restriction. After 45 days the interactive effects of shade and drought were evaluated by measuring tissue-water parameters and stomatal conductance.

Drought reduced predawn water potential similarly at all levels of light, but midday evaluations showed higher values under severe shade conditions. Water stress also decreased stomatal conductance, with similar responses under sunlight and moderate shade, but with no significant decrease in severe shade. Most of tissue water parameters were significantly modified by the restriction of resources. Drought conditions reduced osmotic potential at full turgor at all levels of light, but the shift in moderately shaded plants was statistically significant with an osmotic adjustment of 0.42 MPa. Similarly pressure potential increased with drought, especially under moderate shade conditions. Plants growing under shade showed lower values of osmotic potential at the turgor-loss point.

These results show that willow plants under the water and light restrictions imposed in the experiment respond differently depending on the physiological characteristic evaluated. Some of these responses could be associated with mechanisms of acclimation to deficits in resources. Results are discussed, including the significance of these mechanisms of acclimation to vegetation management during establishment of willow clones.

Key words: willow, drought, shade, water relations, stomatal conductance.

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ID-117

UNDERSTANDING THE TRANSCRIPTIONAL REGULATION OF WOOD FORMATION IN POPLAR: A STEP TOWARD OPTIMIZING LIGNO-CELLULOSIC FEEDSTOCK FOR BIOFUEL PRODUCTIVITY AND PROCESSING

Kyung-Hwan Han, Jae-Heung Ko, Won-Chan Kim, Sangmin Kim,
Zhongnan Zhang and Mia Choi[1]

Wood is gaining popularity as a source of fermentable sugars for liquid fuel production. Expanding woody biomass energy to the scale of commercial production will require significant improvements in the growth of feedstock as well as its quality. However, our current knowledge of the genetic control of wood formation is limited. The secondary wall of wood cells consists of a complex mixture of cellulose, hemicellulose and lignin. As structural polymers, the matrix of hemicellulose and lignin surrounds the cellulose component of the plant cell wall to protect against enzymatic attacks and, therefore, maintains the structural integrity of the wood. Proportions of these three major components vary, depending on the species of feedstock used, growing conditions, climate, age and the part of the plant harvested. The essentially uncontrolled variability of biomass properties presents process design and operating challenges for the production of biomaterials from woody feedstocks.

Taking advantage of the recent advances in functional genomics and plant biotechnology, we have identified a number of genes involved in the genetic regulation of key pathways that determine the quantity and quality of wood. The candidate genes, including C3H, LIM, NAC, MYB, and PXY transcription factors, are being tested in transgenic plants. The outcome of this research will provide us with novel tools to genetically optimize tree crops as a feedstock for liquid fuel. In this presentation, we describe our genomics approach to novel gene discovery, the functional characterization of selected candidate genes and potential areas of future research in optimizing ligno-cellulosic feedstock for bioenergy production.

Key words: bioenergy, poplar, secondary wall, wood formation.

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MODELING OF BIOMASS PRICES FROM SRC PLANTATIONS IN THE CZECH REPUBLIC

Kamila Havlíčková[1] and Jaroslav Knápek[2]

The future price of biomass is one of the key factors in making investment decisions on new heat and electricity sources based on biomass utilization and energy biomass plantation projects. The paper deals with both sides of the problem – supply and demand with respect to the biomass market. Factors influencing the demand side of the biomass market are discussed and analyzed in the conditions of the Czech Republic. The supply side of the problem is discussed on the basis of analysis of the economics of energy plantations, specifically the example of short rotation coppice (SRC).

The cost of SRC harvest is the decisive cost component for the project, having a weight of more than 50%. The use of a Claas Jaguar 890 harvesting machine with special adapter is assumed. The lower limit of minimum biomass price is about 5 €/GJ (gigajoule) when the average production is 9.5 dry t/ha/year. The lifetime of SRC plantations is expected to be 21 years.

The above results of economic modeling give basic information about the economic effectiveness of this type of "energy" biomass. The data presented could be interpreted as the basic guidelines for comparison of different biomass types and the results can be used for estimating future prices of a given form of biomass and for setting adequate levels of state support. It must be recognized that conditions in different localities can be substantially different and will influence the business of biomass production.

Key words: short rotation coppice (SRC), yields, minimum biomass price, harvesting, electricity sector.

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ID-090

FACTORS LIMITING USE OF SHORT ROTATION COPPICE FOR WASTEWATER PURIFICATION AND SEWAGE SLUDGE UTILISATION

Katrin Heinsoo[1] and Bert Holm[2]

During recent decades there have been a lot of initiatives at the European Union level to promote dedicated energy crop production. At the same time there have been many efforts to improve levels of wastewater purification and sewage sludge treatment to meet increased environmental standards. In 2005 a collaborative research project 'Biopros – Solutions for safe application of wastewater and sludge for highly-efficient biomass production in Short Rotation Plantations' was started with both these focuses.

One task of this project was to undertake field tests in different European regions (Spain, Poland, Germany, Bulgaria and Estonia) in order to analyse in detail the feasibility of the short rotation coppice (SRC) approach. Now, three years later, we are aware that one example per country is not enough to make basic conclusions. However, typical problems and limiting factors can be systematised and add to the SRC implementation experiences the authors have obtained in the Estonian context over a longer period.

A number of technical issues still need to be considered. For example the harvester weight has to be reduced for warmer regions without cold harvesting periods, more information is needed on how to use SRC chips in small boilers, etc. These topics will be clarified if there is a market and if dissemination channels are available.

On the other hand there is a long list of limiting factors that have resulted in a much smaller SRC area compared with that predicted by resource analyses in different countries. The most serious ones are:

- lack of long-term support strategies for SRC that would counteract the investment risks,
- poor selection system for planting material suitable for climate criteria in several regions,
- limited awareness about the environmental impact of SRC on agricultural lands,
- uncertain legal regulation of approvals of wastewater application on agricultural land, and
- no standardised legislation on sludge recycling in agriculture and restrictions focusing mainly on food/feed crops.

As the potential of SRC as the second generation energy crop is still high in the analysed countries, we hope that these limiting factors can be overcome with the close co-operation of authorities, practical users and scientists.

Key words: cultivation, environment, phytoremediation, short rotation coppice, vegetation filters.

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SELECTION OF *P. DELTOIDES* CLONES FOR BIOMASS PRODUCTION IN EASTERN AUSTRIA

Berthold Heinze[1], Norbert Frank[2] and Wilfried Nebenführ[1]

Seed lots from five open-pollinated *Populus deltoides* trees growing along the Minnesota River in Minnesota and Iowa (USA) was raised in the greenhouse, and around 1 000 seedlings (approx. 200 per family) were transferred to the nursery in Vienna, Austria. Growth, stem form and rust infection level were assessed in 2006. Major individual differences were observed especially in leaf-rust infection (*Melampsora larici-populina*). From each family, the best 20% were selected (200 clones in total), and cuttings were planted. Growth of these plants was assessed and measured in 2007. Height, diameter at 10 cm from ground, branching, growth habit and rust infection level were assessed or measured. There are differences in these traits among the families, with a slight indication of a north-south pattern following the origin of the families. First results show that these selections grow very well at the high densities typically used in short-rotation biomass plantations. Re-sprouting behaviour will be assessed in 2008, as the plants were cut back in the previous winter. The most serious concern in using *P. deltoides* in Europe is its general susceptibility to stem canker caused by *Xanthomonas populi*. However, short-rotation biomass plantations do not normally suffer much from this disease in Austria; therefore, we are further exploring selection among these *P. deltoides* clones.

Key words: *Populus deltoides*, open-pollinated families, Minnesota River, selection, biomass, short-rotation.

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ID-092

PRELIMINARY STUDY OF THE EFFECTS OF TRANSGENIC POPLARS ON SOIL MICRO-ORGANISMS

YingJie Hou, XiaoHua Su, RuZhen Jiao, QinJun Huang and YanGuang Chu[1]

Investigation of the differences in quantity of soil micro-organisms between transgenic and non-transgenic trees is an important part of the evaluation of ecological security in genetically-modified plantations.

In this study, a total of 8 lines of soil samples of transgenic and control poplars were collected in the field, and bacteria, fungi and antinomyces were isolated using the flat dilution method to determine possible differences in their quantities. These three types of soil micro-organism showed different trends in different months and years. Results of ANOVA and multiple comparisons suggested that there was no significant difference in soil micro-organism quantity among *P. ×euramericana* 'Guariento' transgenic lines, while there were significant differences among P*opulus alba* × *P. glandulosa* transgenic lines, but these had no relation to the type or number of foreign genes. A few transgenic and non-transgenic plantations of *Populus alba* × *P.glandulosa* also had significant differences, but the reasons for this need further study. Comparing the soil micro-organism quantity for the same months in different years, the results showed that there were significant differences among most lines that might be caused by environment, but no disciplinarian in their changes. It was shown that planting time had no effect on soil micro-organisms in transgenic poplar plantations.

Key words: transgenic poplar, soil micro-organism, ecological security.

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ESTABLISHMENT AND MANAGEMENT OF WILLOW AND POPLAR SHORT ROTATION COPPICE IN CHINA

Jianjun Hu[1], Zicheng Zhao[2] and Mengzhu Lu[1]

Apart from their limited resources, fossil fuels are most responsible for altering the global climate with CO_2 emissions. The use of willow and poplar short rotation coppice (SRC) as a renewable energy source could help to meet energy needs and also to reduce CO_2 emissions. In order to establish an effective management system for willow and poplar SRC for biomass, our study began with selecting varieties and optimizing the planting density and rotation length for willow and poplar.

In the spring of 2006, a SRC plantation with willow and poplar was established on former agricultural land (35°8′ N, 113°17′ E), located in the urban area of Jiaozuo City, Henan Province. The site is 95 m above sea level, and has a temperate climate with mean annual temperature of 15.2°C and mean annual precipitation of 625.4 mm. Four willow clones and five poplar clones were used in the plantations and the former were planted at three planting densities (10,000, 15,000, 30,000 cuttings·hm-^{2}) with three replications for each. All plantations were grown on three-year rotations at maximum. The test plots for the three different densities were planted with 10×10, 8×8 and 6×6 trees respectively and from which 36, 16, 9 trees, respectively, were chosen for measurement. In February 2007, all trees were cut back to a height of 5 cm. In March 2008, the test blocks were coppiced and measured for biomass, growth rate and calorific value for all clones after one year of growth.

The results showed there was a difference in the sprouting ability among different willow clones. The number of sprout shoots was from 9 to 13. *Salix integra*, a shrub willow clone from Jiangsu Province, grew better than three other willow clones. Its biomass productivity at three planting densities (9.28-13.45 t·hm-^{2}) was the highest among all clones. There was no significant difference in biomass production among five poplar clones, which was from 12.38 to 15.37 t·hm-^{2}, more than that of willow clones at the same density. The calorific values of these willow and poplar clones were from 4 463 to 4 856 kcal·kg-^{1}.

Key words: bioenergy, short rotation coppice, biomass, poplar, willow, heat value.

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ID-159

RESEARCH ON OSB PANEL FROM WASTE POPLAR VENEER

Liang Hua[1], Zhengwan Jiu[1] and Yukun Hua[1]

Waste poplar veneers were crushed into strands and were divided into big, medium and small strands. After drying and mixing with urea-formaldehyde (UF) resin, the strands were oriented into a mat and hot pressed to make "OSB panels". The mechanical properties of the panels were determined.

The results showed that the big strands could be made into panels in appliance with the requirement of OSB/2 class in LY/T1580-2000, the Chinese OSB national standard, and the medium and small strands could be made into panels satisfying the specifications of OSB/1. The waste poplar veneers after crushing are suitable to produce eligible UF resin OSB panels.

Key words: waste poplar veneer, strand geometry, UF, OSB.

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ID-220

PRODUCTS AND MANUFACTURING PROCESSES OF POPLAR PLYWOOD

Yukun Hua and Juwan Jin[1]

With the massive plantation of fast-growing poplar in China, wood-based panel industry in this country, especially in Jiangsu Province, obtained rapid development in recent years.

This paper gives a brief introduction of the development of poplar industry in Jiangsu and focuses at the same time on the research and development of poplar plywood products. Wood characteristics of the poplar tree and its effects on the production techniques of plywood were discussed. A unique model of poplar utilization related to veneer-based poplar products was presented and analyzed.

Key words: plantation poplar, plywood, product research and development, poplar utilization mode.

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ID-231

DEVELOPMENT OF FAST-GROWING POPLAR INDUSTRY: PLANTATION, APPLICATION AND REPLANTATION

Yukun Hua, Changtong Mei and Mingzhu Pan[1]

Tree plantations are important for ecological balance. The presence of plantations and wood-based industry can improve the environment for living and accelerate local economic development. In areas with poplar forest, the temperature is 1.4% lower, relative humidity increases by 16%, wind speed is reduced by 33.4%, and crop yields are 12-15% greater. The tax revenue from fast-growing poplar-based industry accounts for 10 to 30% of total local tax revenue in Jiangsu Province.

It is very important to establish the poplar industry where the entire tree is utilized and industrialization has taken root. The plantation-application-replantation is consistent with sustainable development. The fast-growing poplar-plantation industry is a good example of this.

Key words: fast-growing poplar, application, recycle economic.

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ID-210

LOW-DENSITY MAGNESIA WOOD WOOL PANEL: HYDRATION REACTION OF MATERIALS

Rong Huang[1], Xiaoning Lu[1] and Bin Na[1]

In this research on low-density magnesia wood wool panels, the hydration reaction of magnesia and brine was tested using heat as a parameter. The effect on the hydration reaction heat was analyzed in function of different wood species and additives. As such, a theoretical basis for manufacturing of functional magnesia wood particleboards in the future can be provided.

Key words: magnesia, wood wool panel, hydration reaction, additives.

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ID-215

FACTORS INFLUENCING *IN VITRO* STORAGE OF *POPULUS ALBA* VAR. *PYRAMIDALIS*

Jian Huang[1], Hai-Long Shen[1] and Chang-Li Liu[2]

Adventitious shoots of *Populus alba* var. *pyramidalis* cultured on the 1/2MS media containing different concentrations of sucrose and mannitol were reserved at a temperature of 4℃, and the main factors affecting the *in vitro* storage of this cultivar were studied. After 225 days of cultivation, the results showed that the fewest yellow levies were found in the medium supplemented with 0g.l-1 mannitol or 20g.l-1 sucrose, and the fewest red stems were found in the medium supplemented with 0g.l-1 or 20g.l-1 mannitol or 0g.l-1 sucrose. After 225 days of storage, when the buds were resumed to proliferate condition, the highest differentiation rate was seen on the medium containing 20g.l-1 mannitol and 0g.l-1 sucrose, which propagated 5.9 new buds. The next differentiation rate was on the medium containing 20g.l-1 mannitol and 20g.l-1 sucrose, with 4.3 new buds propagated. In cultures preserved at the temperature of 4℃ or 25℃ without adding any retardants additive, the survival rates after 225 days preservation were 100% and 59%, respectively. In three times of resumed culture, buds preserved at 4℃ could resume the original differentiation rate for the first time subculture, while buds preserved at 25℃ could not resume differentiation until the third generation.

Key words: *Populus alba* var. *pyramidalis* BGE, adventitious shoots, in vitro storage, differentiation rate.

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ID-020

INDIAN WILLOWS-BASED CRICKET BATS OF INTERNATIONAL SIGNIFICANCE OF TRADE AND INCOME

S. Showkat Hussain[1] and Sas Biswas[1]

Salix popularly known as willow is a diffuse porous hardwood species which occurs in natural stands and grows in the Indian subcontinent from 900 up to 3500 meters above sea level. On account of its excellent wood properties like shock resistance, strength and light weight is it aptly considered fit for the manufacture of sporting cricket bats. It deserves a mention here that the game of cricket is played with great fervor among the commonwealth countries, particularly in India, Pakistan, Bangladesh and Sri Lanka. To develop the choice based on the quality, willows have great reputation in the market for its wood. During 1930s, willows of exotic species were introduced in Indian Himalayas, particularly in Kashmir Himalayas, where its production touches in million per annum (1.2 million in 2003-04). Kashmir manufactured bats on account of its least accessibility to the outside market have not touched popularity and export potential as otherwise it should have been. With this in view a survey was conducted by the author to explore the willow-based industrial and market potentials. The mechanical properties taken into consideration by the local manufacturers and also the production status and market trends were studied in Kashmir valley. The present annual turnover of the products from *Salix* in Kashmir is 600 million in Indian rupees. The production is targeted to the demand of the Indian market presently.

The present paper deals comprehensively on need and priorities for the incentives and promotion of the sector and the communities involved in the production and marketing, besides the gaps in the integrated approach to fill the demand and supply.

Key words: mechanical properties, export potential, demand and supply.

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ID-243

ENVIRONMENTAL USES OF POPLARS AND WILLOWS: A WORLDWIDE OVERVIEW

J.G. Isebrands[1]

Environmental uses of poplars and willows are increasing worldwide. As part of the revised FAO/IPC book "Poplars and willows in the world", scientists from 12 IPC member countries have synthesized the latest knowledge in the world on environmental uses of poplars and willows with respect to sustainable livelihoods, land use and development.

The topic areas covered include: windbreaks, shelterbelts, soil erosion control, riparian buffers, phytoremediation, mine-spoil reclamation, urban amenities, and carbon sequestration. More emphasis is given to work in China, South America and Australasia than in previous publications. There is also more emphasis on willows than in the past. This presentation will review the latest progress on the environmental use chapter of the book.

Key words: shelterbelt, riparian buffer, phytoremediation, carbon sequestration, environmental services.

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FAO/IPC PUBLICATION '*POPLARS AND WILLOWS IN THE WORLD*': A PROGRESS REPORT

J.G. Isebrands[1] and J. Richardson[2]

Poplars and willows are important worldwide for sustainable development and rural livelihoods. Two previous FAO publications on poplars and willows – '*Poplars in forestry and land use*', published in 1958, and '*Poplars and willows in wood production and land use*', published in 1980 – are now out of date and out of print. A proposal to the Executive Committee of the International Poplar Commission (IPC) to prepare a completely new edition for publication by FAO was accepted and is in the process of completion.

The objective of the project is to produce a major update of previous FAO publications on poplars and willows in an accessible format, providing a practical worldwide overview and guide to their basic characteristics, cultivation and uses as well as issues, problems and trends relating to poplars and willows. The intended audience for the publication is broad, covering both public and private sectors. The focus is on decision-makers and policy-makers in forestry, agriculture and environment ministries, as well as foresters, ecologists, botanists, agronomists and environmental engineers. It is not intended primarily for an academic audience although the text is carefully researched and copiously referenced. The scope is world-wide, including China, Russia and South America, as well as Europe and North America. More emphasis is given to willows than in previous editions, and there is a strong new focus on environmental uses and sustainable rural development, reflecting applications and concerns that have greatly expanded in recent years. The intent is that '*Poplars and willows in the world*' will be a comprehensive sourcebook and information guide on the Salicaceae.

The publication is planned to have 13 independently-prepared chapters, developed by volunteer teams of contributors working with lead chapter authors from multiple countries. Contributions have been received from almost all IPC member countries. Chapters cover taxonomy and characteristics; natural ecosystems; genetic resources; industrial plantations; environmental uses; abiotic risks; diseases; insect pests; properties and utilization; markets, trends and outlook; and sustainable rural development. As they are completed following peer review, individual chapters will be published, first electronically on the FAO/IPC website, and subsequently in hard copy as FAO Forestry Working Papers. The ultimate goal is to publish the whole work in CD-ROM or printed book format.

The presentation will report on the latest progress towards publication of individual chapters. It is expected that several chapters will be released in electronic format by October 2008, and that the majority will be available in hard copy in 2009.

Key words: poplars, willows, taxonomy, species characteristics, genetic resources, plantations, environmental uses, abiotic risks, diseases, insects, wood properties, utilization, markets, sustainable rural development, information source.

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STUDY ON INFLUENCE OF DIFFERENT TREATING SCHEMES ON PERFORMANCE OF BAMBOO-WOOD ORIENTED STRAND BOARD

Chong Jia[1], Siqun Wang[2] and Yukun Hua[1]

Oriented strand board (OSB) was made and tested according to three lay-up schemes, by poplar, bamboo, and the blend of bamboo and poplar. The three lay-up schemes were combined with also three pre-treatments of the material, being treated with acid, alkali or untreated.

The surface wettability and the density of free radicals were analysed after treatment with acid and alkali. The physical and mechanical performance of the OSB was tested.

The results showed that acid and alkali could improve the surface wettability of bamboo and wood materials. The physical and mechanical performance of OSB could be enhanced. The reasons for this improved performance are theoretically discussed.

Key words: OSB, surface wettability, physical and mechanical performance.

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ID-217

PRODUCTIVITY AND BENEFITS OF FAST-GROWING AND HIGH-YIELD PLANTATIONS OF POPLAR UNDER SUBSURFACE DRIP IRRIGATION

Li-ming Jia[1], Yan-kui Wei[2], Chang-shan Xing[3]
and Guangde Li[1]

The growth, productivity, photosynthesis and benefits of poplar plantations of clone I-214 (*Populus ×euramericana* 'I-214') under subsurface drip irrigation (SDI) and normal irrigation (NI) on a sandy soil in the Beijing area were studied. The results showed that the growth and yield of the plantations were increased more under SDI than under NI. In 2000 - 4 years after planting - the average DBH, height and volume per tree were 21.18 cm, 14.23 m and 0.1815 m^3 under SDI, 54.5%, 36.9% and 247.6% more, respectively, than under NI. The productivity of the plantations under SDI reached 22.78-25.81 m^3/ha/year, which was 3.9-4.6 times more than under NI. The physiological mechanism of growth improved and yields increased of plantations on SDI were photosynthesis and water use efficiency of trees were improved. The net photosynthesis rate of poplar leaves under SDI was significantly higher than under NI at different times of day, ranging from 10.0% to 21.4%. During an irrigation cycle, the net photosynthesis rate of tree leaves under SDI was also significantly higher than under NI, ranging from 9.0% to 9.9%. Water use efficiency of trees under SDI was also higher than under NI. Correlation analysis showed that the net photosynthesis rate of poplar leaves could remain high for a long time when the water content of the lower soil layers (15-25cm) was 5%-8%, but it decreased when the water content was lower than 4%. The economic benefits of the plantation under SDI were also much greater than under NI. The plantation benefits under SDI were 5 355 yuan (RMB)/ha/year. which were 3.43 times as much as under NI. Meanwhile, the ecological and social benefits of the plantation under SDI were much greater and the economic benefit increased significantly if these benefits could be converted into money. In addition, the efficiency of use of water, fertilizer and energy of the plantations were quite different between SDI and NI. In 1999, the water, fertilizer and electricity used to produce 1 m^3 of timber were 32.4 t/m^3, 13.5 kg/m^3 and 2.8 kWh/m^3 respectively under SDI, and the corresponding data under NI were 6.1, 5.8 and 6.2 times as much as under SDI.

Therefore, extending the use of subsurface drip irrigation in developing fast-growing, high-yield plantations in arid, sub-arid and seasonal arid areas is recommended, depending on local economic conditions. It would not only improve the sustainable use of water resources, but also greatly increase the plantation yield and improve forestry development in China.

Key words: poplar, fast-growing and high-yield plantations, subsurface drip irrigation, plantation productivity, economic benefit.

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ID-177

STUDIES OF GROWTH TRAITS AND PHOTOSYNTHETIC PHYSIOLOGY OF HYBRID CLONES OF *POPULUS DELTOIDES* AND *P. USSURIENSIS*

Xibing Jiang, Bo Li, Kaifeng Ma, Wenhao Bo
and Zhiyi Zhang[1]

Populus deltoides Bartr., which originated on the coast of Mississippi in North America and has the choice characteristics of long growth period and rapid growth, is one of the most important forest tree species in America. *P. ussuriensis* Kom., distributed in the Changbaishan Mountain and Lesser Khingan Range areas of Northeast China, and characterized by good wood quality and excellent hardiness, is one of the most widely-used trees in forest regeneration in the three northeast provinces of China.

In the present study, growth traits and physiological characteristics of hybrid clones of *P. deltoides* and *P. ussuriensis* have been measured in a completely random block design. For growth traits, the results suggested large variations in these traits among the 66 hybrid clones. In addition, significant differences in DBH (diameter breast-height), DBA (diameter in basal area) and H (height) were found. For photosynthetic index, the diurnal curves of net photosynthetic rate (P_n) and transpiration rate (T_r) were symmetric double-peak curves, while stomatal conductance (G_s) was shown to have a double-peak pattern and the intercellular CO_2 concentration (C_i) was characterized as having a concave pattern. Further analysis indicated clearly that P_n was positively correlated with T_r and G_s. Moreover, it was found that net P_n increased with increase in photosynthetically active radiation and then ascended slowly with a light saturation point (LSP) of 800 $\mu mol.m^{-2}.s^{-1}$, light compensation point (LCP) of 33.63 $\mu mol.m^{-2}.s^{-1}$, and apparent quantum yield (AQY) of 0.043. Net P_n reached a maximum and then decreased with concentration of CO_2 increase, CO_2 saturation point (CSP) and CO_2 compensation point (CCP) were 800 $\mu mol.m^{-2}.s^{-1}$ and 68.79 $\mu mol.\ m^{-2}.s^{-1}$ respectively, and carboxylation efficiency (CE) of 0.04. Photosynthetic characteristics of 27 clones were compared and analyzed and a total of 10 clones were proposed as candidate plants with relatively high P_n.

Key words: *Populus deltoides*, *P. ussuriensis*, growth traits, photosynthetic physiology, hybrid clones.

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PROPERTIES OF ENHANCED LAMINATED VENEER LUMBER FROM POPLAR

Juwan Jin[1], Yonglan Xu[1] and Yukun Hua[1]

This paper investigated the effects of compression ratio, assembly type and a reinforcement method on mechanical properties of enhanced poplar laminated veneer lumber (LVL). Among all factors, the compression ratio was the most effective. Higher compression ratio resulted in higher modulus of rupture (MOR), modulus of elasticity (MOE), and shear strength and, moreover, lower deflection related to creep. LVL assembled using thinner veneers on the face and thicker veneer in the core layers as well as LVL made by resin impregnated veneer showed better mechanical properties in contradiction to Fiberglass reinforced LVL.

Some assembly types mentioned in this paper could be beneficial for LVL by increasing MOR and MOE as well as modifying the creep behaviour.

Key words: laminated veneer lumber; mechanical properties, compression ratio, fibreglass reinforcement, impregnated veneer.

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ID-218

ADVANCES IN TRIPLOID BREEDING OF *POPULUS*

Xiangyang Kang, Jun Wang, Yanhua Li, Pingdong Zhang
and Zhenghai Zhang[1]

Techniques for increasing the efficiency of triploid induction in *Populus* genus were reviewed, based on cytological research. The optimal stage for colchicine doubling of pollen chromosomes is at pachytene. Compatibility of 2n pollen in fertilization was improved by radiation with ^{60}Co γ-rays, which increased the triploid yield more than 30 times. A temporal association between megasporogenesis and microspore development under the same condition was found to identify instantly the effective stage for megaspore chromosome doubling. When a microspore of *P. alba* × *P. glandulosa* reached the late uni-nucleate stage, the megaspore mother cell of the same species was at pachytene. The ratio of triploids was up to 16.7% through treating female catkins with 0.5% colchicine solution at this time. Additionally, a novel approach to induce triploids was found by treating female catkins with colchicines after pollination. The cytological mechanism of this approach was identified as chromosome doubling during embryo sac development. There was a positive correlation between the ratio of triploids in progeny and the frequency of four-nucleate embryo sacs. The ratio of triploids produced by this approach was up to 57.1% in *P. alba* × *P. glandulosa* and 66.7% in *P. pseudo-simonii* × *P. nigra* var. *lica*. This new high-efficient way of inducing triploids in *Populus* may have valuable application in other plant species.

Key words: *Populus*, triploid breeding, cytology, unreduced gamete.

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ID-143

A STUDY OF THE ROOT SYSTEMS OF ONE YEAR OLD POPLAR CLONES I-214 AND 77/51 (SAMSUN)

Ahmet Karakaş[1]

This study was carried out in the fields of Izmit nursery, Turkey in 2007 and 2008. Poplar stem cuttings of clones I-214 and 77/51 (Samsun) were planted in the experimental plots. The experimental plots were fertilized with nitrogen and phosphorus fertilizers. A control plot was also planted in order to observe rooting and plant growth under unfertilized conditions. In May 2007, July 2007 and May 2008, some of the experimental plants grown from stem cuttings were uprooted with great care to avoid damage to the root system and the developmental trends of the roots and plants were investigated. Numbers of roots in diameter classes of less than 2 mm, 2-5 mm and more than 5 mm were determined for each sample plants. The lengths of the cuttings and the shoots were also measured. The roots, cuttings and shoots including twigs and leaves were left to dry in a drying oven at a temperature of 65^{o}C for a period of 24 hours and then their oven-dry weights were determined. The following results were obtained after a year long investigation from May 2007 to May 2008

The numbers of roots on plants of clones of I-214 and 77/51 (Samsun) grown in the fertilized plots were greater for all diameter classes than on those in the control plot. Plants in plots fertilized with nitrogen and phosphorus fertilizers were not observed to have superior root development to those in unfertilized plots. In general, rooting occurred in the lower part of cuttings so as to leave a 10 cm long root free section in the upper part of cuttings. Roots from cuttings of clones I-214 and 77/51 (Samsun) grow horizontally, but roots growing from the bottom of the cuttings grow downward into the soil at an angle. The lower roots from cuttings of clone 77/51 (Samsun) grow somewhat more vertically compared to the lower roots from cuttings of I-214 clone.

Key words: clone, fertilizer, root system.

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ID-028

GROWTH PERFORMANCE AT AGE FIVE OF PROGENY OF ASPEN (*POPULUS DAVIDIANA* DODE) CLONES FROM ARTIFICIAL MATING AMONG SELECTED TREES

Yeong-Bon Koo, Jin-Kie Yeo and Kwan-Soo Woo[1]

In order to develop superior cultivars of *Populus davidiana*, 44 artificially pollinated combinations among primary selected clones produced a second generation of 8,914 individuals, from which 45 individuals from 15 combinations were selected, based on growth performance and other characteristics. Twenty of these 45 individuals were re-selected in a nursery test in 2002 based on each clone's survival rate, growth performance, disease and insect damage rate and vitality. These 20 selected clones and three control clones - a maternal clone of *P. davidiana* used for crossing (clone Sukam 2) and two commercial hybrid clones (clones Bongwha 1 and 7-30: *Populus alba* × *P. glandulosa*) - were propagated vegetatively in a nursery bed in 2003. The growth performance of the 23 clones examined in 2007 was the following:

The average survival rate of the 23 clones was 90%, and clones 99-3, 99-47, 99-72, and the control clone Bongwha 1 had 100% survival. Clones 99-13 and 99-40 showed poor survival rates, 67% and 73%, respectively. The survival rate of tested clones was relatively higher than that of the control clone Sukam 2 (83%), and lower than that of the two commercial hybrids.

Average height and diameter at breast height (DBH) of the 20 test clones were 6.2 m and 6.1 cm, respectively, which are similar to those of clone Sukam 2 (6.2 m and 6.3 cm, respectively). However, height and DBH of clone 99-13 were 7.9 m and 8.3 cm, respectively, which are greater than for control clone 7-30 (7.4 m and 7.3 cm, respectively). Clones 99-21, 99-17 and 99-50 were superior in growth performance, whereas clones 99-40, 99-41 and 99-28 showed poor growth performance. The average volume of clone 99-13 was 0.0545 m^3 per tree, which is 2.2 times greater than that of all other tested clones (0.0243 m^3 per tree) and control clone Sukam 2 (0.0245 m^3 per tree). Clones 99-50, 99-17 and 99-21 were superior in volume (more than 0.03 m^3), but clones 99-20 and 99-56 were poor in volume (less than 0.0138 m^3). Clone 99-13 could be selected as a superior clone based on the latest height, DBH and volume results, but since the trees are too young, further monitoring will be necessary in the future to select the best clones.

Key words: *Populus davidiana*, growth performance, hybrid, survival rate.

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ID-048

UTILIZATION OF EARLY SHOOT AND ROOT GROWTH IN BLACK POPLAR ROOTED CUTTINGS FOR SELECTION TEST IMPROVEMENT

Branislav Kovacevic, Sasa Orlovic, Vladislava Galovic, Andrej Pilipovic and Marina Katanic[1]

The relationship between shoot and root formation at the beginning of the growing period and cutting survival on sandy and loamy fluvisols was examined for 15 genotypes of black poplars (section *Aigeiros* Duby). Results were obtained from field trials established in mid-April. Results of analysis of variance, correlation coefficients and path coefficient analysis of stagnation of root and shoot growth during May indicated that growth and development of shoot and root systems are not balanced immediately after planting of cuttings. The total number and length of roots at the beginning of May, and the increment of shoot height and number of leaves during May were highly positively correlated with cutting survival. This suggests that the ability of root systems to support intensive shoot growth at the beginning of growing period has a strong direct influence on cutting survival.

This research can help in solving the problem of cutting survival through breeding and design of cultivar-adjusted nursery or plantation establishment technology. Shoot characters could be of special interest in selection tests. Those genotypes that are able to support fast shoot growth during May could be considered to have good rooting potential. Measuring shoot characters is not resource-demanding and could be easily performed without damaging plants. This could be particularly important for fast comparison of large groups of genotypes.

Key words: cutting rooting, imbalanced growth, breeding.

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ID-054

GENETIC IMPROVEMENT OF EXOTIC AND INDIGENOUS POPLARS IN INDIA

Dinesh Kumar[1]

The genus *Populus* contributes immensely to the ecological well-being and economic development of northern India. The term "poplar" in this country is used synonymously with *Populus deltoides*, an exotic species of this genus. This underscores the huge popularity of this fast-growing species in plantation forestry in India. Standing trees of this species cover an area of about 60,000 ha outside the forest, especially in agroforestry fields, and supply the primary raw material for a vibrant plywood industry. Systematic work on genetic improvement of *P. deltoides* is underway at the Forest Research Institute, Dehradun. This paper describes the results of a field trial of 95 new clones of *P. deltoides* at Hoshiarpur, Punjab. Twenty-six clones proved superior to the check clone G48 on the basis of stem-wood volume at age 6. The best-performing clone FRI-AM-58 yielded 0.519 m^3 $tree^{-1}$ stem-wood under-bark in comparison to 0.345 m^3 $tree^{-1}$ reported for clone G48. Significant age-age correlations were also observed. The feasibility of early selection and concurrent multiplication has been examined in the light of the available data.

Indigenous poplars, on the other hand, are important from ecological and socio-economic points of view. Their populations are small and are threatened in many places due to over-exploitation. All five sections of the genus *Populus* are represented in the indigenous germplasm. Population survey and genetic improvement activities for these species have been started. The outcomes of research efforts on indigenous poplars are also discussed.

Key words: exotic, indigenous, *P. deltoides*, clones, correlation, early selection, population survey.

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ID-118

POPLARS OUTSIDE FORESTS (POFs) IN INDIA: A POTENTIAL RESOURCE FOR SOCIO-ECONOMIC DEVELOPMENT AND ECOLOGICAL RESTORATION

Gulshan Kumar[1]

With increasing global population and economic development, the area under natural forests is shrinking worldwide. The forestry situation is very peculiar in India, with 97% of the natural forests under Government control and an almost similar percentage of wood-based industries in the private sector. Thanks to India's Forest Policy of 1988, natural forests are to be preserved and protected as national heritage and the raw material needs of the wood-based industries are to be met by growing trees outside forests on farm lands, village common lands and other waste lands. The policy also underlines that the wood-based industries shall establish direct linkages with the tree growers for their raw material needs and the supplies of timber to these industries given earlier at concessional rates shall cease to exist. Added to this, the Apex Court of Law on Land's order to close down wood-based industries located in forest areas, and to allow the establishment of new wood-based industries only on the surety of raw material availability from trees outside forests has opened up hosts of opportunities for private tree growers, particularly farmers growing poplars on their farm lands. The farmers of North Indian States have very conveniently adopted agro-forestry on farm lands with poplars as major species for application in plywood and other wood-based industries. The poplar-based agro-forestry land use option has not only contributed significantly to increase in the tree cover outside natural forests but has also proved to be a potential resource for socio-economic development, ecological restoration and diversification of agriculture. It has generated a multiplier effect in the economy of the rural areas through establishment of poplar woodlots, development of wood-based industries, generation of employment and revenue collection to Government in the form of taxation. The improvement of soil fertility, enhancement of bio-diversity and carbon sequestration have been the ecological attributes of the poplars being grown on farm lands outside the forests.

In the North Indian States suitable for growing poplars, farmers are making a substantial contribution in the production of wood and increase in tree cover through adoption of genetically improved planting stock of poplars. Average productivity of the poplar clones is 25 cubic meters per hectare per year, while some farmers have even achieved trend-setting productivity levels of 50 cubic meters per hectare per year.

This paper examines the role of poplar grown on farm lands in integrated rural and industrial development, employment generation, environmental protection and preservation of gene pools and bio-diversity.

Key words: forest policy, potential resource, raw material, wood-based industry, bio-diversity.

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ID-001

THE REGISTRATION OF *SALIX* CULTIVARS

Julia Kuzovkina[1]

The broad physiological and ecological amplitude of willows (*Salix*) along with their adaptation to a wide range of climates make them suitable for cultivation around the world. The scope and importance of global willow cultivation are currently rising as *Salix* taxa are becoming increasingly more important in biomass plantation research, hybridization, and commercial culture enterprises. Low levels of domestication, short generation time and a relatively small amount of DNA yet wide genetic variation, have made *Salix* attractive for genetic studies. Over the past decades, improvements in yields and tolerances to biotic and abiotic stresses have been achieved through genetic improvement. A considerable number of hybrids have been induced that offer higher yields and exhibit improved pest resistance.

Intensive breeding programmes need to be maintained in order to meet the new challenges of future willow cultivation initiatives. Consequently, the exploitation of the wide biological variations within the genus *Salix* through clonal selection and hybridization is expanding. Today, many research centers worldwide are involved in *Salix* research in which rigorous *Salix* breeding programmes are continuously producing new and improved clones. International collaboration and clonal exchange both stem from a general willingness to share the germplasm. As new clones enter into commercial production, their clear and standard record is an important multinational goal. However, *Salix* is among the woody plant genera for which the International Cultivar Registration Authority (ICRA) has not been appointed. Before the cultivars' records become more complicated and difficult to interpret, the establishment of a formal registrar for willows is essential. The establishment of the ICRA for *Salix* cultivars will facilitate an effective and complete compilation of the '*Salix* Cultivars Checklist' along with proper documentation of new records. This will contribute to the nomenclatural stability of cultivated *Salix*.

Key words: cultivar, hybrid, ICRA.

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LEAD UPTAKE AND TRANSLOCATION IN TWELVE *SALIX* TAXA

Julia Kuzovkina, Tom Morris, Dawn Pettinelli, Cristian Schulthess and Olena Zhivotovsky[1]

Different species of willow, as well as some clones, vary considerably in their metal translocation patterns and their ultimate resistance to heavy metals. Resistance to Cd, Cu and Zn metals have been documented for a few *Salix* species, but little is known about *Salix* resistance to lead. Previous investigations indicated low rates of lead translocation into aerial tissues in the European species *Salix viminalis*, while it has been reported that a few Asian species were able to translocate significant amounts of lead. The research reported in this paper tested a range of genetically-distant *Salix* taxa for their resistance to lead and lead translocation patterns. Twelve North American and Eurasian species, as well as clones important for biomass production, were included in the study.

Greenhouse screening for lead resistance and accumulation using containers and field soil collected from a contaminated site had been implemented as an initial step, and was followed by the field study to demonstrate the full expression of the potential growth of the plants and their ability to accumulate lead under field conditions. The field experiment was performed on a cleared site at the Mukluk, in Connecticut, USA, where there were very high concentrations of lead as a result of its former designation as a skeet range. In parallel, five species were hydroponically screened for their resistance to lead and to determine their critical toxicity thresholds. Specific knowledge was generated on lead movement in willows addressing ecological aspects of phytoremediation strategies and the suitability of lead-contaminated land for willow plantings.

Key words: lead, phytoremediation, willow.

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ID-125

PHYTOEXTRACTION OF CADMIUM, ZINC AND NICKEL FROM CONTAMINATED BIOSOLIDS BY WILLOWS GROWN UNDER FIELD CONDITIONS

W.S. Laidlaw[1], D. Gregory[2], T.T. Huynh[1], M. Godino[1] and A.J.M. Baker[1]

De-sludging of sewage treatment lagoons at Werribee, Australia, generates more than 20,000 tonnes of biosolids annually. Domestic and industrial loading of metals into the sewage stream in past decades has produced a stockpile of contaminated biosolids. The majority of the existing stockpiles exceed regulatory metal contaminant limits for biosolid re-use by land application. Our research has been investigating the use of plants to extract the heavy metal contaminants from the biosolids. Extraction will reduce the level of contamination and allow re-use of these biosolids in agriculture or land rehabilitation programs.

A randomized block field trial was established at a disused soil filtration field and in a biosolids stockpile at Melbourne Water's Western Treatment Plant. Seven species of willows, *Salix* ×*calodendron* 'Balana', *S. caprea*, *S. chilensis*, *S.* ×*calodendron* 'Hybrida', *S. matsudana*, *S. reichardtii* and *S. viminalis* were planted in replicated blocks. Each block was planted with 16 cuttings spaced 0.5 m apart and irrigated with potable water by drippers throughout the growing season (October-April). For three years, the above-ground stems and leaves were harvested every autumn before leaf fall occurred. Harvested biomass was weighed in the field and samples from each block were retained for chemical analysis. Oven-dried and ground samples were digested in nitric acid for elemental analysis by ICP-OES.

In the soil trial, harvested biomass increased each year for all species. The variation among replicate blocks was high due to post-harvest mortality of some plants within each block. The harvested biomass was not significantly different among willow species and the overall mean was 18 ± 10 t ha^{-1}. In the biosolids trial, biomass increased for all species except *S. chilensis* and *S.* ×*calodendron* 'Hybrida'. Harvested biomass (t ha^{-1}) was significantly different among species. *Salix matsudana* (36 ± 33) and *S. reichardtii* (22 ± 8) produced the greatest biomass while all other species produced less than the soil trial in the third season. Leaves made up 13% and 27% of the total harvested biomass from the soil trial and biosolids trial respectively.

The concentrations of cadmium, zinc and nickel were higher in the leaf dry matter compared to the stems for nearly all species. Leaf metal concentrations (mg/kg dry weight) were greater in the biosolids trial (Cd: 8-42, Zn: 1050-3480, Ni: 50-98) than in the soil trial (Cd: 2-6, Zn: 320-1480, Ni: 2-4). The highest metal concentrations were found in *S.* ×*calodendron* 'Hybrida' and the lowest in *S. matsudana* and *S. reichardtii*.

Phyto-extracted metals - the product of tissue concentration × biomass (g ha^{-1}) - varied between species in both the soil and biosolids trials. Harvested leaves contributed a significant proportion of the total metals extracted from the soil trial (Cd: 32%, Zn: 56%, Ni: 38%) and in the biosolids trial (Cd: 48%, Zn: 75%, Ni: 78%). *Salix reichardtii* and *S. matsudana* extracted the most Cd: (180, 150), Zn: (11600, 18900) and Ni: (395, 402 g ha^{-1}) in the third growth season.

Key words: biosolids, heavy metals, phytoextraction, *Salix*, willow.

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CONSTRUCTING A TRANSCRIPTOME MAP OF *POPULUS TOMENTOSA* CARR. WITH A BACKCROSS USING cDNA-AFLP

Bo Li, Xibing Jiang, Deqiang Zhang, Zeliang Wang
and Zhiyi Zhang[1]

Many "functional marker" systems have been used to develop genetic linkage maps, which can be called "functional maps". The "transcriptome map" is one such functional map which can be established based on polymorphic markers originating from RNA transcripts.

In the present study, transcriptome maps of developing xylem of *Populus tomentosa* were generated from an F_1 backcross population of *P. tomentosa* with a two-way pseudo-testcross strategy using the cDNA-AFLP approach. cDNA-AFLP is a robust and efficient approach to display differential expression and genetic analysis from which a "transcriptome map" can be established based on polymorphic markers originating from RNA transcripts. After construction of transcriptome maps for potato, *Arabidopsis* and other herbaceous species, the transcriptome maps for the first woody plant species were generated from an F_1 backcross population of *P. tomentosa* under two-way pseudo-testcross strategy. The transcriptome map of *P. tomentosa* comprised 18 linkage groups with a total of 185 markers (including 4 SSR), which spanned 1,553 cM and had a 70.4% coverage of the estimated genome length (2,205 cM). Thirteen linkage groups with 108 markers (including 2 SSR) were also constructed for the other parent (*P. tomentosa* × *P. bolleana*) presenting 1,030 cM in length with 67.1% coverage of the estimated genome (1,534 cM). The polymorphic markers were distributed across all the linkage maps except several LGs, consistent with the nature of whole genome scanning in this approach. This work provides an efficient platform for QTL mapping of wood traits in *P. tomentosa* and offers new insights into wood formation.

Key words: *Populus tomentosa* Carr., transcriptome map, cDNA-AFLP, wood formation.

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ID-189

DEVELOPMENT OF THE *POPULUS ×CANADENSIS* TAXON FOR POPLAR PLANTATION CULTIVATION IN CHINA'S YELLOW RIVER BASIN

David Li[1] and Brian Liu[1]

Poplar plantations throughout much of China have relied heavily on cultivars of the *P. ×canadensis* taxon (*P. deltoides* × *P. nigra*). Plantations have been managed for a wide variety of uses including timber production, agro-forestry, and ecological protection. Over the last 35 years, plantation development has incorporated Italian cultivars including 'I-214', 'I-45', 'Sacrau-79', 'Robusta', 'I-107' (synonym 'Neva'), 'I-108' (synonym 'Guariento'), and the locally-developed cultivar 'Zhonglin 46'. Although the propagation of many of these cultivars continues, a priority has been placed on the development of new cultivars to support major plantation programs along the Yellow River with an increasing emphasis on broadening genetic diversity to reduce the risk of unforeseen biotic and abiotic challenges. In 2006, three-hundred and sixty-four *P. ×canadensis* cultivars were introduced from North America and established in nurseries at Zhengzhou in Henan Province, Shijiazhuang in Hebei Province, and at Leling in Shandong Province. Two-hundred and sixty-five nursery selections were subsequently made on the basis of growth in height, basal diameter, form, and *Marssonina brunnea* resistance. These were used in establishing three regional clone trials at Zhengzhou in Henan Province, Shijiazhuang in Hebei Province, and at Beijing in 2007 including two check clones. First-year growth variation was evaluated primarily as a function of the clone and clone×site interaction effects. Results showed wide variation among clones at each site. For example, at the Zhengzhou clone trial, height, breast-height diameter and volume varied from 3.1 m to 5.8 m, 2.3 cm to 5.9 cm, and 0.00087 m^3 to 0.00745 m^3 respectively, and their variation coefficients were 10.0%, 15.6% and 34.8%.

Variance analysis and estimates of genetic parameters demonstrated that clone differences were highly significant for height, diameter and volume at each site; clone repeatability ranged from 0.741 to 0.888, indicating the strong genetic effect on growth. Combined variance analysis of the three sites demonstrated significant differences among sites, clones and clone×site interaction effects. Superior clones characterized by both rapid growth rates and high phenotypic stability were identified for each poplar cultivation region using: (1) an analysis of multiple contrast (LSD method), (2) effective clone value (Ci), (3) coefficient of variation for interaction effect variance (iCV), and (4) regression coefficient (bi). Trials are being measured annually to substantiate first-year results.

Key words: *Populus ×canadensis* genetic improvement, genetic variation, clone-by-site interaction.

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ID-088

COMPREHENSIVE ASSESSMENT OF SECTION AIGEIROS CLONES FOR PULPWOOD IN WESTERN LIAONING PROVINCE, CHINA

Jin-hua Li and Qi-wen Zhang[1]

Seven clones of the Section Aigeiros - *P.* × *canadensis* cv. 'DN59', 'DN182', 'DN74', 'N3014', 'N3016', 'Agethe F', and *P. deltoides* cv. 'Imperial' - introduced from foreign countries, were selected and studied in stands in western Liaoning Province, a cold and semi-arid region of China. For each clone, height and breast-height diameter at 13 years, wood basic density, fiber length, ratio of fiber wall to lumen and 1% NaOH extractant of wood were measured and the data analysed for variance and genetic parameters. The results showed that among the seven clones, average values of wood basic density, fibre length and ratio of fibre wall to lumen were 320.7-382.5 kg.m^{-3}, 0.791-0.968 mm and 0.266-0.342. There was significant variability of the six traits among the cultivars. Heritability of diameter and height was 0.8199 and 0.8393, respectively, generally high and significant.

Using gray correlation analysis and the DTOPSIS method, six traits of growth and wood quality were used to comprehensively assess seven clones. With these two methods, there were small differences between the ranking of the seven clones. *P.* ×*canadensis* cv. 'Agethe F' ranked the best, 'N3016' next best, and *P. deltoides* cv. 'Imperial' the poorest. The two methods of analysis used the same gray theory and resulted in basically the same ranking of clones. But the C_i values of DTOPSIS were significantly different among cultivars. Comparing gray correlation analysis with the DTOPSIS method, C_i values for *P.* ×*canadensis* cv. 'Agethe F' were respectively 0.7665 and 0.8387. The difference in gray correlation degrees was not great between cultivars. The ensurement of each trait power for analysis was discussed.

Key words: *Populus*, section Aigeiros, gray correlation analysis, DTOPSIS, multi-trait comprehensive evaluation.

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ID-083

CLONING AND FUNCTIONAL ANALYSIS OF A SPECIFIC PROMOTER IN PHOTOSYNTHETIC TISSUES OF POPLAR

Lisa Li, Lina Xu, Yunan Lin, Weidong Wang, Jinlai Jiang
and Qiang Zhuge[1]

Poplar is one of the important forest tree species with fast growth all over the world. Promoters are an important element in expression vectors used in gene engineering, and have a critical role in transcription and control of foreign genes. In genetic engineering research, highly efficient promoter should be used in order to obtain high expression of target genes in receptor organisms. With the development of molecular biology, cloning and analysis of promoters have become important projects in current studies.

In the research reported in this paper, leaf discs of *Populus* ×*euramericana* cv. 'Nanlin 895' were used as experimental material for promoter cloning, and a 1547bp DNA segment upstream of the rbcS gene was cloned which we called rbcSca4, a specific promoter in photosynthetic tissues by means of homologous cloning and chromosome walking based on information of poplar genomic sequence. The sequence and function of the promoter were analyzed. The rbcSca4 was joined with the GUS gene, and the pattern of rbcSca4 expression in tissues was analyzed by use of GUS instantaneous dyeing. The initial results indicated that rbcSca4 was a specific promoter in photosynthetic tissues and was controlled by light. The sequence of rbcSca4 contained several cis elements related to light induction, such as G-box, GATA-motif, I-box, AT-rich element and ATCT-motif. Deletion analysis of the rbcSca4 promoter was also carried out in this study. PCR was used to amplify four 5'-deletion segments, which were 365bp, 635bp, 1014bp and 1310bp long respectively. All four segments were respectively joined with the GFP gene to analyze the function of the segments by means of electroporation. The results of this research provide the basis for molecular breeding of new species of poplars with elite characters using genetic transformation. This is an efficient way to create new poplar species by genetic engineering technology for the improvement of productivity, wood quality and resistance characteristics.

Key words: poplar, rbcSca4, specific promoter, PEPC, transgenic.

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ID-145

CORRELATION BETWEEN MOLECULAR GENETIC DISTANCES AMONG PARENTS AND GROWTH TRAITS OF PROGENIES IN *POPULUS*

Shanwen Li[1], Zhishui Yu[1], Chengzhong He[1], Xinmin An[1], Bailian Li[1,2] and Zhiyi Zhang[1]

Variation in growth traits of progenies of twenty-three cross-combinations in *Populus* was analysed, and genetic variation among parents was studied by Amplified Fragment Length Polymorphism (AFLP).

The results showed that growth traits of progenies and molecular genetic distance (GD) among parents had considerable variation. Correlation and regression analysis between molecular genetic distances among parents and growth traits of progenies indicated that the relationship between GD and growth was linear within a certain range (0.024 9~0.368 1), and that the relationship was a quadratic parabola with a wide range (0.024 9-0.531 4). If the genetic distance among parents in *Populus* ranged from 0.19 to 0.36, the ideal effect of hybridization could be achieved.

Key words: *Populus*, parents, hybrid progeny, genetic distance, growth trait, correlation analysis.

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ID-191

AFLP ANALYSIS OF SOME *POPULUS* SPECIES AND HYBRIDS

Shanwen Li[1], Youhui Zhang[2], Xinmin An[1], Chengzhong He[1], Bailian Li[3] and Zhiyi Zhang[1]

Thirteen pairs of AFLP primers were screened out and used for the analysis of forty-seven clones, which came from nineteen species and hybrids of four sections in *Populus*. Thirteen pairs of AFLP primers generated 858 fragments, 771 polymorphism fragments among them. The percentage of polymorphism fragments produced by each pair of AFLP primers was 89.9% on average, and varied from 80.7% to 98.1%. The data indicated that considerable genetic variation existed among species and clones at DNA level. Molecular genetic distances among sections, species within sections and clones within species were calculated, and the relationships among them were described quantitatively. The result of cluster analysis among sections was completely consistent with classical taxonomy, and the results of cluster analysis among species within sections and clones within species were basically similar.

Finally, the feasibility of selecting and mating parents and early selection of progenies is discussed based on the results of molecular markers.

Key words: *Populus*, AFLP, genetic variation, genetic relationship.

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ID-190

SALT TOLERANCE OF POPLAR TREES TRANSFORMED WITH THE JEFRS GENE

Yiliang Li[1,2], Xiaohua Su[2], Binyu Zhang[2], Qinjun Huang[2], Xianghua Zhang[2], Zhiyi Zhang[1] and Rongfeng Huang[3]

We can improve the stress resistance of plants by regulating expressions of multiple downstream genes relating to stress resistance. *Agrobacterium* was used to transfer the ERF-like transcription factor, the JERFs-gene, from tomato into the genome of a hybrid poplar (*Populus alba* × *P. berolinensis* Dipple). Eighteen resistant plants were obtained, of which 13 were identified as JERFs-gene transformed plants by PCR tests. Southern blot and RT-PCR tests have proven that the JERFs-gene has been integrated into the genome of the hybrid poplar and has expressed at the transcription level. Stress tests were conducted in a greenhouse with four different concentrations of NaCl: 0, 0.3, 0.5 and 0.8%. With normal watering, the height of transgenic plants was significantly larger than that of the control plants, but statistically, no significant differences in content of proline and chlorophyll were observed. With increasing salt concentration, the extent of damage was significantly less in the transgenic plants than in the control plants and, as well, the reductions in height, basal diameter and biomass were less in the transgenic plants than in the control plants. The transgenic plants in 0.5% and 0.8% NaCl concentrations were 128.9% and 98.8%, respectively, taller than the control plants and dry biomass of transgenic plants was 199.8% and 113.0%, respectively, larger than that of the control plants. Reduction of leaf water content and increase in root/crown ratio were less in the transgenic plants than in the controls. The increase in proline content in leaves of the transgenic plants was greater than in the control plants. Plant leaves can retain high levels of chlorophyll. The content of Na+ was higher in leaves of transgenic plants than in control plants.

In the coastal area in Panjin of Liaoning where the total soil salt content was 0.3%, a salt tolerance trial of transgenic plants indicated that 3-year old transgenic plants were 14.5% and 33.6% taller than the control plants at two different sites. The transgenic plants were vigorous, green in leaf colour and had no symptoms of salt damage.

These results indicate that the JERFs gene had effectively improved the salt tolerance of transgenic poplar trees.

Key words: JERFs gene, *Populus alba* × *P. berolinensis* Dipple, genetic transformation, salt tolerance.

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ID-150

MOR AND MOE OF PLASTIC OSB WITH POPLAR STRAND

Hailan Lian[1], Qin Fang[1], Hui Meng[1] and Yukun Hua[1]

The effects of strand density, resin content, hot pressing time and orientation angle on MOR and MOE of plastic OSB with thin and long strand from fast-growing poplar were investigated.

The strand length was fixed at 200mm. The results showed that a higher orientation angle could lead to lower MOE and MOR of plastic OSB. The board density has significant influence on the MOR (but the MOE was different), influenced by the hot press time. A plastic OSB with a density of 0.75g/cm^3 was produced using a hot press time of 1.4min/mm and a resin content of 350g/m^2, resulting in higher values of MOR (56.4-103 MPa) and MOE (7808-13455 MPa).

Key words: fast-growing poplar, plastic OSB, MOR, MOE, oriented angle.

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ID-219

EFFECTS OF BIOLOGICAL MULCHING ON MICROBIAL POPULATIONS, ENZYMATIC ACTIVITY IN RHIZOSPHERIC SOIL AND GROWTH OF POPLAR PLANTATIONS IN THE SOUTHERN UPLAND AREA, CHINA

Jiujun Liu, Shengzuo Fang, Baodong Xie and Juanjuan Hao[1]

In order to develop a suitable and scientific scheme for establishing poplar plantations in the southern upland area of China, the effects of biological mulching on the dynamics of microbial populations and enzymatic activity in rhizospheric soil of poplar plantations were investigated. The results were as follows:

As weights of mulch applied increased, bacterial and fungal populations also increased; the numbers of bacteria and fungi in the treatment with 7.5 $kg.m^{-2}$ of mulch added were 49.58% higher than in the control and 6.14 times that of the control, respectively. Different mulching materials affected differently bacterial and fungal populations in the rhizospheric soil. The numbers of bacteria were highest in the rhizospheric soil mulched with *Imperata cylindrica* var. *major*, while the largest numbers of fungi were observed in the treatment mulched with *Quercus fabri*. The annual dynamics of bacterial and fungal populations in the soil were synchronized with soil temperature, being greatest in July and least in December. With increasing weights of added mulch, urease and phosphatase activity was enhanced. With different mulching materials, urease and phosphatase activity in the soil was in the order *Coriaria nepalensis*>*Pteridium aquilinum* var. *latiusculum* >*Imperata cylindrica* var. *major*>*Quercus fabri* >control. The annual dynamics of urease and phosphatase activity in rhizospheric soil in the mulching materials trial were similar to those in the mulching weight trial, i.e. gradually increasing, then decreasing, being greatest in July and least in December. Biological mulching clearly promoted tree height, diameter and biomass growth of poplar plantations in the upland area.

Key words: poplar, mulch weights, mulching materials, rhizospheric soil, micro-organisms, urease activity, phosphatase activity, annual growth.

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ID-041

PRIMARY STUDY ON TRANSGENIC *POPULUS TOMENTOSA* WITH THE *MdSPDS1* GENE

Tingting Liu[1], Cui Long[1], Xiaoming Pang[1], Moriguchi Takaya[2] and Zhiyi Zhang[1]

The problem of soil salinity is one of the most significant constraints to agricultural and forestry productivity. How to make use of the large areas of saline soil has become a very important topic for research in the future development of agriculture and forestry. Polyamines play an important role in plants to enhance environmental stress tolerance.

In this study, the spermidine synthesis gene *MdSPDS1* obtained from apple was transferred into *Populus tomentosa* by the *Agrobacterium*-mediated approach. Totally, 15 putative transgenic clones were obtained through kanamycin resistance screening and the integration of the *MdSPDS1* gene into the genome of four clones was confirmed by PCR and Southern blot analysis. No phenotypic differences were observed between transgenic clones and wild types. The expression of the *MdSPDS1* gene and polyamine levels were also investigated.

Results showed that the SPD levels in transgenic plants were 1.65 times greater than in wild-type plants. The primary experiment showed that the transgenic clone with highest expression levels of *MdSPDS1* could live under 200 mM NaCl stress under which wild-type plants wilted. Further transformation attempts and field investigation of obtained clones are in progress.

Key words: *MdSPDS1*, polyamines, *Populus tomentosa* Carr., salt tolerance, transgene.

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STUDY OF WATER CONSUMPTION MECHANISMS IN POPLAR PLANTATIONS

Wen-guo Liu[1], Ling Liu[2], Xu-dong Zhang[1] and Yu-xin Yuan[3]

The water consumption patterns of two American black poplar clones - ′Zhonglin–46′ and ‘Langfang’, which are the main tree clones used for plywood in Langfang region - were studied using quick weighting and a thermal dissipation sap flow probe (TDP). The leaf transpiration rate and sap flow variation characteristics of the poplars were measured.

The aim of this paper is to help explain the water consumption mechanism of poplars, which would help to provide basic information for forest management, especially in relation to ecological irrigation in the region. It was found that on both clear and cloudy days, the diurnal variation of leaf transpiration rates (LTR) took the form of a unimodal curve, with a wide peak on clear days and a narrow peak on cloudy days. The sap flow (SF) of 3-5-year-old ‘Zhonglin-46’ poplars and 5-year-old ‘Langfang’ poplars from day to night followed similar patterns, with a smooth increase at 7:00 or 8:00 hours in the morning and reaching a peak between 11:00 and 15:00 hours, related to increasing solar radiation, rising ambient temperature and decreasing atmospheric relative humidity. After that time, the SF would decrease steadily till 19:00 hours, when it reached a relatively stable plateau, but it would reach the minimum before sunrise. The SF values probed in the stem varied between different aspects. In the daytime, the SF of poplars of 3-5-year-old ′Zhonglin–46′ poplars and 5-year-old ‘Langfang’ poplars was consistently greater on the south side of the stem than on the north side. But at night both north and south stem SF rate differed less and remained steady about 0-2 cm/h.

Key words: poplar plantations, stem sap flow, transpiration rate, sap flow rate.

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ID-161

USE OF GREEN-WASTE COMPOST TO ESTABLISH SRC WILLOW ON BROWNFIELD SITES FOR GREEN REMEDIATION: INTERIM RESULTS OF THE BIOREGEN LIFE AND TRAIL-BLAZER PROJECTS

R.A. Lord[1] and J. Atkinson[1]

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Between 2004 and 2006 pilot-scale trials of willow (*Salix* spp.) short rotation coppice (SRC), miscanthus (*Miscanthus* spp.), reed canarygrass (*Phalaris arundinacea*) and switchgrass (*Panicum virgatum*) were planted on brownfield and control sites in NE England. The brownfield sites were defined according to the current UK definition as those where previous development for non-agricultural use had occurred. This included a former clay pit and coal-ash landfill, an oil-foam land farm near to a Pb-Zn smelter, a former licensed waste management site, and a former shipyard built on a reclaimed tidal estuary. Following successful establishment, growth and hand harvesting, biomass fuel composition was compared to host-soil contamination for willow, miscanthus and reed canarygrass grown on each site. The initial results indicated the potential for long-term remediation of contaminated land during energy crop growth. Concentrations of Zn and Cd were consistently higher in SRC willow for a given site, whereas the grasses had higher contents of ash, which was richer in SiO_2 but lower in K_2O. Thus the choice of species allows either clean fuel production or long-term phytoremediation, depending on the contaminant association and fuel specification required. A number of wider economic, environmental and social benefits of this sustainable type of reuse of derelict brownfield land and carbon-neutral approach to "green" remediation can be identified.

In 2007 preparatory work and planting of five 1-ha brownfield demonstration sites was carried out at full scale under the BioReGen (Biomass, Remediation, re-Generation) EU Life Project (www.bioregen.eu) with the UK Waste and Resources Action Programme supporting integrated trials of the benefits of green-waste compost amendment in this context. A desk study confirmed the potentially contaminative previous industrial uses (shipyard, railway land, iron and steel, coal and coke production, sewage treatment, landfill). Generally low levels of the characteristic contaminant associations of heavy metals and hydrocarbons were confirmed by surface-soil analysis. Current status and ground conditions varied from cleared sites with made ground, to semi- or fully-restored clay-, subsoil- or topsoil-capped grassed open space. PAS100 compost was applied at rates of 250 t/ha, 500 t/ha and 750 t/ha at each site before step-planting of SRC willow (varieties Tora and Torhild) in order to determine the optimum initial amendment rate for successful establishment. Growth was monitored for the 2007 season, as was the impact on total and available levels of N and other key nutrients. Compost application corrected the original soil deficiencies in K, P and N without exceeding limits for leachable N, while enhancing soil organic matter content and providing a slow-release N source. At the two sites without rabbit fencing, the willow failed to establish. At three fenced sites maximum shoot height was measured for each plant and an estimate of the establishment rate made in comparison to the rate at which cuttings were planted. Establishment rates ranged from 15 to 57% for different combinations of site and amendment rate. The willows were pruned by hand in January 2008 to mimic the maiden cut of conventional agricultural establishment and oven-dried biomass yields determined for each site and compost application rate. The results presented indicate that the combined effects of establishment and growth rate are site-specific but in general lead to greater productivity at amendment rates exceeding 250 t/ha.

Key words: Brownfield, phyto-extraction, green remediation, compost.

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PROFILING OF GENES INVOLVED IN THE REGENERATION OF THE SECONDARY VASCULAR SYSTEM IN POPLAR

Meng-Zhu Lu, Min-Jie Wang, Shu-Tang Zhao and Jian-Jun Hu[1]

Wood is the end-product of secondary vascular system (SVS) development, which includes key processes such as cell expansion, secondary wall biosynthesis, lignification and programmed cell death of cambial cells. To study genes involved in wood formation, we have established a regeneration system for SVS in poplar, which could mimic the process of development of the SVS, i.e. redifferentiation to cambial cells, cambium formation, differentiation of cambial cells, and xylem development. Tissues representing different developmental stages of SVS could then be sampled to follow the progress of regeneration over time.

A total of 949 proteins in total were obtained using two-dimensional electrophoresis and 2-D liquid chromatography followed by MALDI-TOF MS (matrix assisted laser desorption ionization time-of-flight mass spectrometer) analysis, of which 324 belonged to the category "function unknown", suggesting their unique involvement in wood formation. The poplar cDNA microarray prepared from poplar and the *Arabidopsis* full-genome arrays were also used to analyze the gene expression in the different regeneration stages, and 428 genes were found differentially expressed. Functional analysis suggested that the change in gene expression profiles was in close accordance with the progress of SVS regeneration. The genes involved in the formation, development and differentiation of cambium and the development of xylem include factors involved in signal transduction and transcription regulators, such as hormone-induced proteins, MYB, AP2, KNOX, G protein, and cellulose, pectin and other cell-wall polysaccharide-biosynthesis-related genes, such as expansin, extensin and hydroxyl proline-rich glycoprotein.

Based on proteomic and microarray analysis, several candidate genes potentially important in wood formation were selected. Priority was given to the transcription factors, signal transduction factors and "function unknown" genes. Over 40 such genes were further analyzed for functional validation. We have preliminarily demonstrated that: the *PtIAA* gene, encoding an auxin-responsive factor, mainly expressing in cambium and developing xylem, plays a role in the regulation of cambium cell division and differentiation; the auxin putative receptor, *PtABP1*, causes the diameter of fiber cells in xylem to increase but the thickness of the cell walls to decrease probably by mediating the effects of IAA on cell division and expansion; mutation of several homologous genes in Arabidopsis could affect the development of stems and flowers. These studies have laid the foundation for elucidating their roles in regulating the development of SVS.

Key words: poplar, regeneration, secondary vascular system, gene profiling, function analysis.

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ID-250

LOW-DENSITY MAGNESIA WOOD WOOL PANEL: COMPARISON OF MANUFACTURING TECHNIQUES

Xiaoning Lu[1], Rong Huang[1] and Bin Na[1]

In this paper, airproof hot-pressing is used to limit decomposition of inorganic material while manufacturing low-density wood wool panels with magnesia. The production of low-density magnesia wood wool panels using steam-pressing technique revealed high process productivity. Moreover, the boards have more stable properties compared with boards made with cold-pressing and hot-pressing techniques.

As such, the panel properties can fully comply with the requirements for cement wood wool panels both for the local Chinese market and for abroad.

Key words: steam-pressing, magnesia, wood wool panel, manufacturing technique.

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LOW-DENSITY MAGNESIA WOOD WOOL PANEL: IMPROVEMENT OF HYGROSCOPICITY

Xiaoning Lu[1], Rong Huang[1], Zhiqiang Wang[1] and Bin Na[1]

This paper discusses the reduction of panel hygroscopicity by using a steam-pressing technique and different additives. The key element to improve the hygroscopicity of magnesia wood wool panel is to increase the hydration reaction degree of MgO and $MgCl_2$ using a steam-pressing technique, as well as prolonged pressing time. The moisture-preventing property of the panel could be improved by implying additives which can react with $MgCl_2$ and block the capillary channels.

In this paper, the compound additives talcum powder, oleic acid and phosphate could improve the brine phenomenon and hygroscopicity of panels effectively and also improve the panel strength compared with the other two additives. But the additives had an effect on the panel strength which could be analyzed from their respective hydration heat.

Key words: magnesia, wood wool panel, hygroscopicity, steam-pressing, additives.

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ID-222

SUSCEPTIBILITY OF LEAVES OF DIFFERENT *POPULUS* CLONES TO *SEPTORIA MUSIVA* IN MENDOZA, ARGENTINA

G. Lucero, N. Riu, P. Pizzuolo, R. Pérez Hurtado and S. Robledo[1]

There are approximately 16,000 hectares of cultivated poplars in the province of Mendoza in Argentina. The cultivation of *Populus* is limited to a very limited number of clones including *P. deltoides* 'Harvard', *P.* ×*canadensis* `Conti- 12´ and `Guardi´. The last of these has shown high sensitivity to attack by *Septoria musiva.* This canker causes severe damage to poplars in the USA, Canada and Argentina. The pathogen responsible of the disease has not been detected in Europe, where its introduction is feared. It causes foliar spots and it can be responsible for early defoliation of trees, as well as cankers on tree trunks, branches and leafstalks. In Argentina, most damage occurs in the province of Mendoza, where large economic losses of wood used for industrial purposes have happened. These serious problems have motivated an on-going search for new clones with good productivity, but above all, clones with a high resistance to the disease.

The aim of the present study was to evaluate the susceptibility of different poplar clones to attack by *S. musiva.* In order to do that, 10 clones were tested in an orchard of parent trees at the end of the 2007-2008 planting season, a period with high incidence of the disease. As controls, the clone *P.* ×*canadensis* `I- 214´, which is not used any more in the region due to its high susceptibility to the disease, and the clone *P. deltoides* 'Harvard` which is less susceptible, were employed. The susceptibility was determined by evaluating the severity of attack, on the basis of the percentage of the foliar area affected by *S. musiva* in 12 leaves of each plant, and five specimens of each clone. The following categories were established: 0 = without damage, 1 = 1-19% of leaf affected, 2 = 20-39%, 3 = 40-59%, 4 = 60-79% and 5 = 80-100%. From statistical analysis of the data, the clones *P.* ×*canadensis* `Negrito of Granada´, `I-214´, `Guardi´ and `I-488´ were the most susceptible, while *P.* ×*canadensis* `Conti 12´, `B.L. Constanzo´ and `Veronese´ were somewhat susceptible, and *P.* ×*canadensis* `NNDV´, `Neva´ and `Luisa Avanzo´ were least susceptible of all.

Key words: *Populus*, *Septoria musiva*, susceptibility, canker diseases.

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ID-059

THE EFFECTS OF PRE-EMERGENCE VARIATION IN WILLOW CUTTINGS ON THE DEVELOPMENT OF SIZE AND WEIGHT HIERARCHIES IN WILLOW SHORT ROTATION COPPICE

Anneli Lundkvist, Nils-Erik Nordh and Theo Verwijst[1]

One of the major problems in the establishment of a willow crop is the variation in plant size which increases over time and leads to mortality, thereby leading to production losses during consecutive harvests. Early variation in willow plant size gives rise to a size hierarchy, which is preserved below-ground over harvest. While the development of size hierarchy variation in willow has been studied and its negative effects have been shown in commercial production, no studies have been undertaken hitherto to quantify the contribution of pre-emergence variation in the cuttings used to establish willow stands.

Commercial planting systems today are based on long rods which are partitioned by a planting machine during actual planting. This implies that planted row sections consist of a series of cuttings arranged in an order from basal to apical origin, and that a cutting from an apical part is always next to a cutting from a basal part. If willow cutting performance differs along a gradient from basal to apical origin, the spatial scale of maximum pre-emergence variation is decreased by the current commercial system, thereby increasing the risk of mortality due to competition from neighbours.

To assess and quantify the effects of pre-emergence variation in willow cuttings on early performance, we have designed a set of experiments which will test for differences between willow cuttings with regard to clone, original position on shoots from which cuttings were derived, and cutting length. Our preliminary results indicate the presence of a substantial pre-emergence variation in willow cuttings and we will illustrate this by quantification and testing of the following hypotheses:

- Cuttings from basal origin will emerge later than cuttings closer to the apex.
- Cuttings from basal origin, for a fixed growth period after emergence, will give rise to shoots with a higher growth rate than cuttings closer to the apex.
- Longer cuttings will produce more and larger shoots than shorter cuttings.
- Thicker cuttings (given the same length and relative position along the original shoot) will produce more and larger shoots than thin cuttings.
- The performance postulated in the above hypotheses is valid for each of the clones from a set of 5 clones to be tested.
- The relative performance (in terms of actual timing, growth and number of sprouts grown) will be clone-dependent.

Key words: cuttings, pre-emergence variation, *Salix*, size hierarchy development.

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ID-167

PRESENT STATUS OF DEVELOPMENT OF PLYWOOD INDUSTRY CLUSTER IN CHINA

Liu Lv[1], Zhiqiang Wang[1] and Xiaoning Lu[1]

With the rapid development of the plywood industry in China, there have appeared four plywood clusters, which are located respectively in Zhejiang, Jiangsu, Shandong, and Hebei provinces, producing nearly 70% of the total amount of plywood in China.

This paper analyzes the product sales, company distributions, economical power and advantage in each cluster area, as well as positive and negative effects of plywood industry cluster on economics and plywood manufacturing based on investigation in Jiashan, Pizhou, Linyi and Zuogezhuang districts. The results indicated that there are two unstable product ends, the key problems of plywood industry in China, in plywood industry line in the clusters. The authors suggest that governments, technical departments and associations pay more attention to these problems, and take effective measurements for keeping the plywood industry cluster developing towards further stability.

Key words: industry cluster, plywood, development, present status suggestion.

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ID-223

SPATIAL GENETIC STRUCTURE OF NATURAL WHITE POPLAR (*POPULUS ALBA* L.) POPULATIONS AT REGIONAL AND LOCAL SCALES

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Poplar is a dioecious riparian tree in which spatial genetic structure is conditioned by a dependence on phreatic soils and a reproduction system that combines sexual and clonal reproduction. Genetic differentiation among main river-basins and clonality levels within populations were studied for Iberian populations of white poplar (*Populus alba* L.) based on cpDNA (2 polymorphic cpSSRs out of 10 tested and 2 gene fragments) and nuSSRs (5 loci screened in five populations out of the 40 used in the cpDNA analysis). We found a total of 27 haplotypes, most of them confined to a single river-basin, and notable differences in haplotype frequency for shared haplotypes, resulting in high among-basin genetic differentiation. Comparison with reference sympatric populations of black (*P. nigra*) and grey (*P. ×canescens*) poplars showed that no haplotype was shared among species. Gene sequences discriminated individuals sharing cpSSR haplotypes, indicating that cpSSRs presented high rates of homoplasy. Finally, within-population analyses based on nuSSRs showed a high level of clonality in all populations, with exceptional clonal assemblies extending tens of kilometres in regions with high human impact. High variability among basins reinforces the idea that these areas must be used as basic units for conservation management.

Key words: genetic diversity, population structure, clonality, *Populus*, Iberian Peninsula.

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ID-130

GERMPLASM COLLECTIONS OF NATIVE POPLARS (*POPULUS NIGRA* AND *POPULUS ALBA*) IN SPAIN: MANAGEMENT AND USE

C. Maestro[1] and N. Alba[2]

Populus nigra L. and *Populus alba* L. are the most common native species in riparian forests in Spain. Despite their wide distribution, both species have been in recent decades strongly threatened by the significant degradation and loss of their natural ecosystems that has created severe fragmentation of populations and natural stands. The importance of these species is due to their value in the development of breeding programs, in selection of hybrid clones better adapted to local environments, and to their ecological value in riparian ecosystems. They are considered priority species in the Spanish Strategy for Forest Genetic Resources Conservation.

Several hundred *P. nigra* and *P. alba* clones are presently maintained in *ex situ* germplasm collections (stool-beds and arboreta) managed by two institutions: CIFOR-INIA and CITA-Aragón. The main recent applications and uses of these collections have been:

- as a source of reproductive material for river restoration activities (as promoted by the National Strategy of Rivers and Rivers-banks derived from the European Water Regulation), and
- as material for research purposes; some research institutions are analysing clones from these collections with a variety of objectives.

The origin, management and uses of these collections are detailed. New activities are presented related to genetic conservation of *Populus nigra* and transfer of information on methodologies.

Key words: *Populus nigra*, *Populus alba*, *ex situ* conservation, gene bank.

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CONTROLLED BREEDING TECHNIQUES TO ACCELERATE ROOTING OF POPLAR FLORAL CUTTINGS BY WARMING THE SOIL

Shengjun Man[1,2], Shengdong Wang[1], Zhiyan Yang[1], Wei Liu[1] and Zhiying Wang[2]

Controlled breeding is a very important way to improve poplars. Typical procedures for controlled crossing involve forced pollination of floral cuttings in water culture in a greenhouse. These techniques for controlled crossing are very useful for female parent of *Tacamahaca* poplars and their hybrids. Species such as *Populus deltoides* which are difficult to root and have a long period of seed maturation are not amenable to controlled crossing using floral cuttings in water culture. Studies were conducted of a controlled breeding technique involving accelerating rooting of floral cuttings by warming the soil using a constant water temperature and at the same time keeping flower buds in dormancy to ensure nutrients are available for seed maturation. The floral cuttings were planted in pots and grown in a cool (3°C) room, the pots being soaked in water at different temperatures. After 25 days, the floral cuttings were moved to the greenhouse for controlled crossing. The treatment at 22°C was much superior to the others. Not only did it result in more and better seed, but it also eased the burden of maintaining the vigour of floral cuttings in water culture.

Results showed: (i) Rooting of floral cuttings can be accelerated by warming the soil. Floral cuttings of *Populus deltoides* planted in pots with internal soil temperature of 22°C had on average 25.5 root hairs, root length of 31.8 cm and root weight of 16.9 g. They had on average 12 root hairs,10.4 cm root length and 2.7g root weight in soils at 18℃ and on average 2.2 root hairs, 4.2 cm root length and 0.4 g root weight in soils at 14℃. (ii) Efforts to improve rooting of *Populus deltoides* by warming the soil have also proved successful in controlled crossing with species of sections *Aigeiros* and *Tacamahaca*. Floral cuttings in soils at 22°C all produced seeds (100%), with an average of 1,800 seeds per floral cutting. There were 60% floral cuttings in soils at 18°C to produce seeds (the remaining cuttings (40%) survived, but flowers fall because the cuttings had so weak root hairs that they were not enough to support blooming, with an average of 1,000 seeds per fruited cutting. Of those in soils at 14°C, 20% of cuttings produced seeds, with an average of 500 seeds per fruited cutting, and 80% of the floral cuttings were infected by canker.

Other female parents such as *P. ×canadensis* showed similar results to *P. deltoides*, but floral cuttings of section *Tacamahaca* have good rooting in water culture, and showed similar results to the rooting treatment of floral cuttings in controlled crossing. Thin floral cuttings are easy to root and can maintain more catkins than floral cuttings in water culture. This is also helpful for female trees.

Key words: controlled breeding, floral cuttings, warming the soil, rooting, poplar.

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ID-075

NON-DESTRUCTIVE DIGITAL IMAGING FOR GENETIC SCREENING OF INTACT POPLAR ROOT SYSTEMS

Daniel W. McDonald[1], Ronald B. Michaels[1], Alexander L. Friend[2], Ronald S. Zalesny[3], Christopher P. Mawata[4] and Robert J. Kodrzycki[1]

The dynamics of root formation are difficult to observe directly over time without disturbing the rooting environment. A novel system for non-destructive, non-invasive root analysis (RootViz FS, Phenotype Screening Corp.) was evaluated for its ability to analyze root formation from cuttings over a 32-day period in three poplar genotypes (DN70, *P. deltoides* × *P. nigra*; NC14104, *P. deltoides* × *P. maximowiczii*; NM6, *P. nigra* × *P. maximowiczii*). The RootViz FS system uses low energy X-rays to produce digital images of root systems growing in a polymeric soilless rooting medium. Poplar cuttings were rooted in this medium as well as in two soil environments (sand and a peat/vermiculite mixture) as controls. Digital X-ray images of the developing root systems were obtained at four-day intervals over a 32-day period to allow direct observation of root-system growth dynamics and morphology. Additional images were taken to investigate the rate of root growth between day and night. ImageJ software was used to analyze individual root systems including the number and length of each primary and lateral root. Individual primary and secondary roots could be observed and counted, and the rate of growth of each root was calculated by examination of the developmental series. Cuttings were generally quiescent for the first two weeks followed by a burst of root growth. Root growth during daylight and nighttime hours was quantifiable and showed little difference between these two environments. Total root number, root length, and other metrics could be quantified by clone and rooting environment. Imaging at 100 micron resolution allowed detailed analysis revealing distinct morphology classes for both primary and secondary roots that are not observable using rhizotron- or excavation-based analysis systems.

This project gave additional insight into the complexity of root systems and root system architectures. Simple traits such as number, length and diameter, while useful, fall far short of capturing the complexity and variety of woody root systems. The high dimensionality data acquired by this system was analyzed using a network graph approach that allows the display of individual plants based on a statistical representation of the overall phenotypic variation. This novel graphic representation allows rapid evaluation of experimental results based on genotype, environment and the overall degree of phenotypic variation of both groups and individual plants in the experiment. This research demonstrates the utility of a novel imaging system for analysis of developing root systems in woody plants. The system is high resolution and non-destructive, allowing repeated analysis of the same root system over time.

Key words: non-destructive analysis, non-invasive analysis, root imaging, rooting dynamics, high dimensionality data.

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ID-115

ROOTVIZ FS: A NEW TOOL FOR NON-INVASIVE IMAGING OF ROOT DEVELOPMENT

Daniel W. McDonald[1], Ronald B. Michaels[1], Christopher P. Mawata[2] and Robert J. Kodrzycki[1]

RootViz FS is a system that enables non-destructive and non-invasive imaging of root-system morphology. Based on digital X-ray imaging, RootViz FS allows analysis of developing root systems of greenhouse-stage plants and is suitable for a variety of genomics and breeding applications involving root-system growth and morphology. Plants or cuttings are grown in a low-density soil-less rooting medium in a controlled environment. Whole plants in the growth containers are placed into the RootViz FS system and digital images are automatically acquired by assembling composite images of the entire root system. Both two-dimensional and stereo representations of the root systems can be acquired. Analysis of the composite images is carried out using standard image-analysis software such as ImageJ. From these images several metric descriptors of root systems can be extracted such as: total root biomass, root length, number of roots, root thickness, and ratio of primary to secondary roots. RootViz FS is capable of producing high-resolution images (100 microns) which allows for fine-root analysis. The throughput of the system is dependent on the size of the plants being analyzed and can be adapted for high-throughput analysis applications. Software for analysis of root system metrics allows characterization that may not be obvious to casual visual analysis.

RootViz FS has been used to measure the growth rate of root systems and to characterize their morphology based on primary-to-lateral root ratio. Root systems of different genetic varieties of the same species can be separated into distinct classes based on image analysis results. More in-depth analysis has been carried out using Cytoscape software to make associations between the phenotypic data acquired and the genetic background of the root systems being analyzed. Because the entire root system can be imaged, RootViz FS has a distinct advantage over existing systems such as rhizotrons for root-system analysis. The dynamic nature of the system also allows direct visualization of root responses to environment as well as differences in root architecture and morphology due to genetic variation. RootViz FS has been successfully applied to root-system analysis of a variety of species including poplars, willows, pine, rice, corn, tomato, and soybean.

Key words: non-destructive analysis, non-invasive analysis, root imaging, rooting development, root morphology.

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ID-116

ENERGY FARMING FOR LAKE TAUPO DISTRICT, NEW ZEALAND: A NEW MITIGATION LAND USE?

Ian McIvor[1], Ian Nicholas[2] and Kevin Snowdon[3]

Global energy-use projections predict that biomass will be an important source of renewable energy in the coming decades. Short rotation woody crops will be the prime source of this biomass. Are woody crops sustainable? An assessment of willow biomass crops indicates that they are sustainable compared to agricultural land-use and the fossil-fuel-based energy systems they will replace. Biomass from willow crops can be used to produce energy with no net addition of CO_2 to the atmosphere. Productivity over multiple rotations will depend on the implementation of good management practices. Rural development and environmental benefits associated with deployment and use will accrue to the local community because of the willow's short supply chain. The economic valuation of these benefits is necessary for the deployment of woody crops, which in turn can help society become more sustainable.

Water quality is the paramount issue for Lake Taupo, and new regional and national initiatives are required to protect the water quality and enable economic land-use activities. One new initiative is farming biomass for energy and high-value extractives. Lower fertiliser inputs and deeper rooted plants reduce N leaching. Less fuel-dependent activities required over a rotation reduce gaseous emissions to the air and improve the economics of biofuel production.

A biomass trial was established at Rotokawa in the Taupo district in the winter of 2005. The trial was designed to determine best current practice in establishing and growing the crop, giving attention to species choice, cutting length, ground preparation, fertilisation and weed control.

As an indication of biomass production after one year, for each stool the maximum leader height and the number of shoots >0.5 m were measured. The number of stool deaths was also recorded. After one year *Salix* species performing well were *S. matsudana* × *alba* 'Tangoio', *S. viminalis* 'Gigantea, *S schwerinii* 'Kinuyanagi', and *S. purpurea* 'Irette'. Mean leader height range was 1.00-1.43 m. mean number of shoots per stool range was 2.60-3.28 and mean stocking rate (i.e. survival) was 8,995-10,068 per ha. On this site there was no apparent benefit of soil ripping, although this should be tested on future significant planting areas. The cutting length of 25 cm appeared to provide adequate height growth, number of shoots and acceptable stocking on this site. Stool deaths were accounted for primarily by inadequate cutting size, poor cutting-soil contact, hare damage and in some cases accidental contact with weed spray. Weed control in the establishment year was the major management issue.

Data on yields of biomass after three years will be presented together with key lessons learned during the project on the suitability of particular *Salix* species and the geographical location for biomass production, as well as the response of local landowners to the prospects of a new land-use opportunity.

Key words: SRC willow, land-use change, trial, water quality.

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STUDY ON LAMINATED STRAND LUMBER FROM POPLAR

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This paper mainly focuses on the influence of strand geometry and stacking on the properties of laminated strand lumber from poplar. Furthermore, the influence of steam-injection on the temperature and gas pressure in the core layer of the LSL mat is discussed.

The impact of strand length, width and thickness on the mechanical properties of LSL were investigated. Strand geometry has major impact on the properties of LSL from poplar. Effect of strand alignment in different layers of LSL mat was also evaluated.

Steam-injection is an effective way to rise core temperature of the LSL mat. Meanwhile, the compaction ratio of the mat can highly influence temperature and gas pressure. The results showed an optimal compaction ratio of approximately 0.43. A longer injection time contributes to fast heat transfer to the core, but elevates the gas pressure significantly. By extending the vacuum time the gas pressure in the core of the LSL mat can be reduced.

Key words: laminated strand lumber, strand geometry, stacking consequence, steam-injection.

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ID-214

COMPARISON OF GAS EXCHANGE AND CHLOROPHYLL FLUORESCENCE CHARACTERISTICS OF INTRODUCED AND NATIVE POPLAR

F.J. Meng and Q.Y. Wang[1]

The gas exchange and chlorophyll fluorescence parameters of leaves of introduced and native poplars were determined under natural conditions. The introduced poplars included Finland polar A21 (*Populus tremula* × *Populus tremuloides*), Finland polar 16 (*Populus tremula* × *Populus tremuloides*), Jiayang (*Populus deltoides* Marsh×*Populus nigra* L). The native poplars included Xiaoyeyang (*Populus simonii* Carr.), Xiaoqingyang (*Populus pseudo-simonii*) and Xinganyang (*Populus hsinganica*).

The results showed that the net photosynthetic rate (*Pn*) of introduced poplars was significantly higher than that of native poplars. The mean values of transpiration rate (*Tr*) and water use efficiency (*WUE*) of introduced poplars were higher than those of native poplars, which indicated that introduced poplars had higher photosynthetic capacity and were better able to use water and light energy. The mean values for initial fluorescence (*Fo*), maximal fluorescence (*Fm*) and actual efficiency of primary conversion of light energy of PS II (*F'v/F'm*) of introduced poplars were higher than those of native poplars, but the mean values for variable fluorescence (*Fv*), potential efficiency of primary conversion of light energy of PS II (*Fv/Fm*), non-photochemical quenching coefficient (*NPQ*) and quantum yield of PS II electron transport（$\Phi_{PS\,II}$）were lower than those of native poplars. Correlation analysis among photosynthetic parameters showed that there were significant positive correlations between *Pn* and Tr、*Ci* and *Tr*、*Fm* and *Fo*、*Fv/Fo* and *Fv/Fm*、$\Phi_{PS\,II}$ and *Fo* ($p<0.01$）and between $\Phi_{PS\,II}$ and *Fm, F'v /F'm* and *Fv / Fo* ($p<0.05$). However, there were significant negative correlations ($p<0.01$) between *Fv/Fo* and *Fo, Fv/Fm* and *Fo, NPQ* and *Fv/Fm, NPQ* and *Fv/Fo* ($P<0.01$), and between *qP*与*F'v /F'm* ($P<0.05$).

Key words: introduced poplars, native poplars, photosynthesis parameters, fluorescence parameters.

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ID-052

POSSIBILITIES FOR IDENTIFYING VENEER PEELING QUALITY IN STILL-STANDING TREES

Patrick G. Mertens[1]

This research deals with the trunk-penetrating strength analysis of standing trees of hybrid poplar clones. This is one of the scientific criteria for determining veneer quality and value. A system for fast evaluation of veneer quality is required by the industry to associate veneer sheets of various clones and thicknesses in spite of the fact that the obtained products have high strength, flexibility and smooth (grain) surface finishing. These products must be homogeneous despite their different forest sources.

The "résistographe" is an instrument which records the power required to drill wood at constant speed. The resistance data are obtained with a 3 mm width rotating needle which can measure to 0.1 millimetre precision the variations in wood resistance. This study identified the variation model along the curve of increasing resistance.

A total of 72 clones of intraspecific hybrids of *P. deltoides* (D), *P. nigra* (N) and *P. trichocharpa* (T) as well as interspecific hybrids D×N and D×T were selected in four stands. They represent the main diversity of the available clones in Western Europe. Three drillings were applied around the trunk of each tree at the same height (1.5 m). All the data were analysed, classified and grouped according to their location in a three dimension principal component system combining the eleven variables calculated for each curve of resistance.

One tree of each great group was felled to evaluate the physical properties of the wood. On each of these six trees, two one-meter long sections were cut from the trunk between 1.5-2.5 and 3.0-4.0 m height. The plates of the veneer sheet constituting a radial section of each the 12 portions (6 trees by two sections) were then bound to determine drilling resistance and other physical properties of the wood. The profiles obtained from this systematic series of clones can be clustered into groups and great groups independent of the types of hybrids tested. On the other hand, the clusters obtained can be explained by the genetic control of the crosses whose parent trees and descendants were still available in stands.

The “résistographe” offers a portable, field-usable and non-destructive technique for the determination of homogeneity of standing trees. These first results of analyses of the resistance profile indicate the adequate sensitivity of these measurements for the identification of trees of good peeling quality. They will be presented by selecting the most significant results and by giving the useful developments of this research.

Key words: wood properties, drilling resistance, “résistographe”.

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ID-025

NATURE CONSERVATION AND POPLAR GROWING: ANALYSIS OF AN EXAMPLE FROM THE SOUTH OF BELGIUM

Patrick G. Mertens[1]

Associations representing owners and managers agree on the need to give more importance to the conservation tasks on *Natura 2000* sites. Poplar can be maintained within these sites, while ensuring the maintenance of the species and habitats, as required by the European Commission. These actions depend on dialogue with and positive involvement of the actors who will be in charge of managing the sites. However, changes of management which generate a loss or a significant cost for the owner were analysed. Methods of compensation were proposed.

The review of habitats and species which must be protected in the Walloon Region led to the proposal of compatible management decisions oriented towards conserving nature using acceptable poplar growing practices. The maintenance of drainage ditches constitutes a source of friction between the biologists of *Natura 2000* and managers of rural areas and particularly poplar growers. Not maintaining ditches will modify the soil moisture conditions and could lead to changes in the vegetation. When this is regarded as a restoration objective, the reduction in productivity and long-term cessation of poplar growing must be compensated for. Buffering of sensitive soils is planned to reduce the impacts of exploitation (every 20 years) of poplar stands. Where protected bird species are present, biologists recommend that there be no exploitation within 100 meters of nests during the nesting period. The dates of vegetation crushing, swathing and soil preparation must be set according to the dates of nesting. The only difficult case is the crushing operation which precedes treatment in June to prevent rust infection. Within the *Natura 2000* framework, the environmental harmlessness of the rust prevention activities should guide the decision whether to authorise the treatments. Unfortunately, the required technical information on the incidence of rust prevention on the *Natura 2000* habitats and species is not yet available.

Key words: poplar groves and *Natura 2000* rules, nature conservation.

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NEEDS AND OPPORTUNITIES FOR VERTICAL ORGANISATION OF THE EUROPEAN POPLAR PRODUCTION AND TRANSFORMATION CHAIN

Patrick G. Mertens[1]*

To improve the future production of poplar in Europe, the need for vertical integration of raw wood production and transformation into high-quality products has recently been recognised. Co-operation between the principal countries producing poplar wood in making use of the broad transformation capacities of this material is seen now as a new development tool in poplar culture.

International meetings organised in France and Spain since January 2008 put forward the requirements for a more optimal use of existing European stands in order to address the increasing and multiple demand for large quantities of basic (semi-finished) but high quality industrial poplar products. The advantage of this increasing value of transformed wood is already evident for owners of roundwood who are obtaining higher selling prices. The choice of poplar wood enhances this sustainable and profitable production even more for the owner of the stands because of the short-term production process.

This presentation focuses on potentially useful procedures for setting up without delay an organised, integrated European market. The presentation has three parts: an analysis of the current situation and its evolution, a description of the need for such an organisation, and benefits of such an integrated development.

The market situation and its evolution are difficult to establish because of the lack, the inaccuracy and the non-homogeneity of national and European statistics. Despite this significant difficulty, trends can be seen. Explanations given by stakeholders, sales persons and transformation companies are therefore important as checks of the assumptions formed. Using this method, the European market trends of poplar wood could be analysed. The most notable finding is a concrete lack of information exchange between the owners (producers) and transformers (companies) of wood (poplar not being an exception in this regard).

Production by private owners and the development of industrial products based on hybrid poplars are the two important characteristics of the West and Central European market in relation to the situation in the United States of America. These characteristics are decisive in the analysis of the needs and appropriateness of this innovative European integration.

The solutions put forward are only just starting to be established. Active co-operation will be required among partners in this European market organisation. Industries which transform poplar will play a determining role in improving the quality of wood produced. This engine of development will give vertical coherence to the use of poplar material which can and must provide for multiple needs in all types of society.

* This presentation is given in the name of the associations which aim to defend this process of European organisations of poplar production with the support of the IPC. I thank them for their confidence that we need now in this moment of globalisation of market trends for wood.

Key words: European poplar markets, vertical integration, wood chain.

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ID-163

THE MULTIFUNCTIONAL COMPOSITE MATERIAL MADE OF POPLAR VENEER AND EXPANDED POLYSTYRENE

Ping Miao[1], Dianxian Zhu[1], Lifang Zhang[1] and Qian Zhang[1]

The rapid increase of energy consumption has been a bottleneck that restricts the steady raise of the economy. The energy conservation has attracted more and more attention worldwide. Meanwhile, as the natural wood resources are decreasing, it is necessary to explore and utilize planted forest resources.

In this paper the poplar veneers used as surface layer were combined with expanded polystyrene to produce a new multifunctional composite wall board. The adhesives were selected for testing and an optimum production process was obtained based on several experiments. The heat transmission coefficients and sound absorbing coefficients were measured.

The results show that the multifunctional composite board is very suitable for indoor construction, based on thermal and sound insulation and for decoration.

Key words: poplar veneer, expanded polystyrene, composite board.

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ID-242

COVER OF FALLEN TREE LEAVES REDUCES HERBACEOUS PRODUCTIVITY UNDER POPLARS IN SILVOPASTORAL SYSTEMS

S.J. Monlezun, P.S. Cornaglia, J.M. Pincemin, H. Zunino, M.P. Clavijo and E.J. Borodowski[1]

A silvopastoral system is a combination of trees, domestic cattle and forage that can provide increased economic income per unit area. However, herbaceous productivity is reduced beneath deciduous trees as a result of shade, temperature regime and the accumulation of fallen leaves in late autumn.

This study aimed to evaluate the effect of the cover of dead tree leaves on the herbaceous productivity of two seeded perennial grasses during the year of establishment. The experiment was conducted in a 13-year-old commercial plantation of *Populus deltoides,* clone `Stoneville 71' (323 plants per hectare), in the low delta of the Paraná River, Argentina (34º 06' S; 58º 47' W). The evaluated forage species were *Festuca arundinacea* (FA) and *Dactylis glomerata* (DG). A randomized complete block experimental design was used, with three replications and two factors: position inside the plantation (north, centre and south) and cover of fallen poplar leaves (with and without). Forage species were sown in lines 15 cm apart, at a density of 500 seeds per m^2, at the end of March (autumn in the Southern Hemisphere). Biomass was clipped to 2 cm above the ground at four dates: July, September, October and December. Data were analyzed by ANOVA with repeated measures, and Tukey's Test ($\alpha = 0.05$) was used to analyse differences in treatment means and interactions. The cover of fallen poplar leaves negatively affected the herbaceous productivity during the establishment year of grasses studied ($P< 0.001$), but was not affected by position inside the plantation ($P=0.71$). The average total productivity was 1178.3 g/m^2/yr and 1176.7 g/m^2/yr for FA and DG respectively in plots without fallen leaves, and 66.4 g/m^2/yr and 151.7 g/m^2/yr respectively in plots with fallen leaves. In relative terms, the reduction on productivity was 94% for FA and 87% for DG. C_3 forage grasses are the best adapted to grow beneath trees because of their ability to sustain positive carbon gains at low irradiance rates. However, our results suggest that the excessive shading of understory forage by dead tree leaves would drastically affect the performance of C_3 grasses. The productivity of a silvopastoral system is a consequence of the balance between the positive and negative interactions among their components. The design of this type of system should focus on minimizing negative interactions: grazing fallen poplar leaves seems to be a tool to minimize their negative effect on herbaceous productivity.

Key words: forage productivity, low irradiance, *Populus deltoides*.

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ID-106

LOW-DENSITY MAGNESIA WOOD WOOL PANEL: MANUFACTURING TECHNOLOGICAL PARAMETERS OF STEAM-PRESSING TECHNIQUE

Bin Na[1], Rong Huang, Xiaoning Lu and Juwan Jin

In this paper, experiments with a technological steam-pressing process were carried out to manufacture low-density magnesia wood wool panels. Special emphasis was on the reaction heat and airproof process to assure the process productivity and the panel quality. Using a team-pressing technique to manufacture low-density magnesia wood wool panel improved the productivity significantly and the panel properties reached the product requirements.

Key words: steam-pressing, magnesia, wood wool panel, technological parameters.

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ID-216

POPLARS IN THE DESIGN OF GREEN FIELDS IN CITIES

Mohammad Reza Naghavizadeh and Mahmmod Azami Rad[1]

Iran is characterized by widely varying climatic and topographic conditions which result in a broad diversity of range and forest ecosystems, species and within-species variation.

Different species of poplar have a wide distribution in Iran and have been cultivated by farmers on private land for centuries. This makes a considerable contribution to both the rural and national economy. However, with urban expansion and mismanagement of natural resources in rural areas, poplars are among the most threatened tree species in native stands in Iran.

Poplars are also of ecological importance as centres for biodiversity. A large number of threatened as well as common species are associated with or dependent on poplars, particularly in floodplain forests, which are among the most diverse ecosystems in Europe. Thus the monitoring and conservation of the genetic resources of poplars in riparian ecosystems is of major significance, not only for the natural control of flooding, but also because the riparian zones harbour great biodiversity. In urban landscapes different poplar species have a special place. However, due to lack of urban management, disease and pests, poplars in Mashhad city have been declining, and in fact disappeared there 8 years ago.

Planting of poplars continues now only in gardens outside the city.

Key words: poplar, green fields, wood industries, riparian control, rural development.

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PERFORMANCE AND ECONOMICS OF DIFFERENT AGRICULTURAL CROPS UNDER DIFFERENT SPACINGS OF *POPULUS DELTOIDES* IN NORTH-WEST INDIA

Dharampal Singh Nandal[1]

An experiment to identify suitable crop rotation and optimum spacing for planted poplar was conducted at the forestry research area of CCS HAU, Hisar (India) during 1995-2002. Agricultural crops of sorghum (*Sorghum bicolor*), cowpea (*Vigna unguiculata*), dhaincha (*Sesbania aculeata*), moongbean (*Phaseolus radiatus*), groundnut (*Arachis hypogaea*) and turmeric (*Curcuma longa*) during the rainy season and wheat (*Triticum aestivum*), oats (*Avena sativa*), berseem (*Trifolium alexandrinum*), lentil (*Lens esculenta*) and potato (*Solanum tuberosum*) during the winter season were interplanted with poplar. In the present study, three poplar spacings (5×4 m, 10×2.5 m and 15×2.5 m) were tested to find the best spacing for obtaining maximum returns from the system. Net returns were worked out for sorghum-berseem and cowpea-wheat crop rotations at the end of the poplar rotation.

Results showed that yield of all crops decreased with advancing age of the poplar. The yield of all crops increased with increasing poplar spacing. The yield reduction of crops under poplar was greater during the rainy season than the winter season. Agricultural crops showed variable performance during both the rainy and the winter seasons. Sorghum and cowpea both grown for fodder during the rainy season and wheat (grain) and berseem (fodder) during the winter season were found to be the most compatible crops with poplar. Poplar attained maximum girth and height at wider spacings of 10×2.5 m and 15×2.5 m with no significant difference between the two. The growth of poplar was better under agroforestry than in apure poplar plantation at all the spacings. Cash-flow analysis of the poplar-based agri-silviculture system revealed that in the event of a drastic fall in poplar prices, mono-cropping of poplar is not economical. The sorghum-berseem crop rotation gave the maximum net present value, benefit:cost ratio and internal rate of return compared to the cowpea-wheat crop rotation at all the spacings of poplar.

Key words: *Populus deltoides*, rainy and winter season crops, poplar spacings, economics.

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ID-077

THE EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY TO THE COLOUR AND MOISTURE CONTENT OF POPLAR CLONES' WOOD

R. Nemeth[1], Á. Ott[1], L. Oltean[2], P. Takáts[1] and S. Molnár[1]

Plantations deliver the raw material in relatively short time for the wood working industry, including timber for construction, panel products, furniture, and pulpwood for paper. Furthermore, plantations can supply fuelwood and fodder, provide soil and water conservation, wind protection, and biological diversity conservation, combat desertification, rehabilitate degraded land, etc.

In Hungary the role of plantations is gaining more and more on importance, because there are free areas for the plantations, as agricultural land was exempted from cultivation. Up-to-date managed plantations deliver proper raw material for the wood working industry, as important properties of wood show lower variability compared to trees grown in natural forests. Through improvement specific wood properties can be enhanced (strength, growth rate, etc). Because of their importance in Hungary the presented research work is focussing on two different hybrids *P.x euramericana* 'I-214' and *P. x euramericana* 'Pannonia'.

Simulated drying experiments at different temperatures were carried out in climate chambers to assess the effect of drying temperature on the colour of the investigated wood species, as this property is influencing the value of the end product considerably. Other important aim was to develop mathematical models to predict the colour change as a function of moisture content and temperature.

Key words: wood industry, Hungary, colour change.

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ID-241

APPLICATION OF SSR MARKERS FOR DNA FINGERPRINTING OF COMMERCIAL POPLAR CLONES

Giuseppe Nervo[1], Paolo Calligari[1], Alberto Acquadro[2], Ezio Portis[2] and Sergio Lanteri[2]

At the CRA Research Unit for Wood Production Outside Forest (CRA-PLF), the former Istituto di Sperimentazione per la Pioppicoltura (ISP), poplar breeding activities have been carried on for selecting elite genotypes, which are maintained through vegetative propagation. They are at present grown worldwide for both intensive culture and plantations outside forests. Traditionally identification of poplar clones is performed by using a combination of morphological and phenological characteristics. However, this method is difficult, time-consuming and may be ambiguous for a number of reasons: (i) observable traits are often affected by environmental factors; (ii) distinctive characteristics may be detected only for a limited period of the year; (iii) individual descriptions are of limited use if two or more similar clones cannot be observed simultaneously. Molecular markers may be valuable tools for unequivocal identification of a genotype and, among them, SSRs (simple sequence repeats = microsatellites) have been widely used for molecular fingerprinting in both plants and animals.

We applied *Populus* SSRs previously developed for assessing their polymorphism in 52 *Populus* commercial genotypes. Seven SSRs, out of the 24 tested, were chosen as being the most polymorphic. They originated 84 alleles which made it possible to obtain a multi-locus fingerprint of each clone, and to clarify synonymies. The present results are of practical application: (i) to ensure effective correspondence between the real and declared identities of a clone, so as to avoid commercial frauds; (ii) to protect plant breeder's rights; (ii) to verify clone identity in nurseries; and (iii) to help establish breeding programmes. Our results demonstrate that molecular tools might be used for standardizing the criteria adopted for international identification of poplar genotypes.

Key words: poplar clones, molecular markers, microsatellites, molecular fingerprinting.

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POPLAR ACTIVITIES IN THE ITALIAN PROJECT ON BIOMASS FOR ENERGY USE

Giuseppe Nervo[1], Gianni Facciotto[1] and Stefano Bisoffi[2]

In 2006 the Italian Ministry of Agriculture (MIPAAF) financed a research program to study the biomass supply chain, from crops to power plants, in order to give effective information to Italian farmers and energy-sector technicians and to help achieve the national objectives for renewable energy. The program activities, coordinated by the Agricultural Research Council-Research (CRA), include different species and crops for biofuels and bioenergy and training courses for technicians and farmers. Several research teams of the CRA, universities, other public and private research centers, and several agro-forestry regional agencies are involved in the program. Trials of 'short rotation forestry' are carried out by the Research Unit for Wood Production Outside Forest (CRA-PLF) in co-operation with some farmer corporations and industrial groups.

The research will be dedicated to the study of potentials and adaptability of different poplar clones selected for energy production. Other aspects such as the incidence of the most important insect and disease problems affecting SRF cultivation under different growth conditions are also considered in the project in order to prevent severe risk of epidemics. The poplar biomass obtained will be used for feeding a demonstration micro-district heating plant with low GHG and PM10 emissions. Preliminary results confirm the high productivity of some poplar clones (20-25 odt ha^{-1} y^{-1}) obtained from the former Poplar Research Institute, cultivated with different plant densities and rotation lengths in association with willow, black locust, paulownia or eucalyptus.

Key words: poplar clones, short rotation forestry (SRF), biomass production.

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ID-111

A DICHOTOMOUS KEY FOR NURSERY IDENTIFICATION OF THE MAIN POPLAR CLONES CULTIVATED IN EUROPE

Giuseppe Nervo, Franco Picco and Achille Giorcelli[1]

In EU countries, propagation material (e.g. poplar plants) to be commercialized must be provided with a clonal identification card (Council Directive 1999/105/EC on the marketing of forest reproductive material). The proper identification of poplar clones on a morphological basis has always been a serious problem for lack of suitable tools. This is mainly due to the difficulty of providing a morphological description of the plants, because of the high polymorphism of genotypes within *Populus* species, and of the easy hybridization among species. These phenomena induce the presence of innumerable transition forms from one individual to another. Besides, in commercial nurseries the difficulties of clonal identification based on morphology are increased by the variation in each character according to agro-environmental and physiological factors, to the topophysis and to the subjective evaluation of the operator. There is no reference clone. Moreover, for observations to be effective, the characters to be observed should be present at the same time, which is often not the case. At present the certifiers do not have proper tools to identify poplar clones. The description cards, comparison tables and dichotomous keys available till now are not useful, since they are generic or applicable only to a few clones.

With the aim of providing certifiers with a suitable tool for the identification of one-year-old poplar clones in commercial nurseries, a dichotomous key was drawn up based on morphological traits This key includes 121 clones cultivable in Italy and registered in EU countries. The validity of characters was evaluated taking into account their polymorphism and intraclonal variability in relation to genetic, cultural/environmental and seasonal features. The characters selected were analyzed with a multivariate statistical approach and used in the elaboration of mathematical classification models. The problem of heterophylly was given due consideration with reference both to the structures on which leaves are produced (main stem or sylleptic twigs) and to the time of their formation in the vegetative season. Many leaf types were detected, and three were found to be useful for morphological clone characterization.

The present dichotomous key splits the 121 clones considered into nine main phenotypic groups, and is supplied with pictures of the discriminating characters. Those that were used are illustrated thoroughly and supplied with pictures. For each clone a supporting description card was elaborated. This dichotomous key is supplied with the CD "DicoPioppo", including a PDF copy of the key, software to use with the key (assisted system) and software for unassisted clonal recognition (free selection of the characters).

Key words: *Populus*, clones, identification, certification, dichotomous keys.

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ID-097

EFFECTS OF NITROGEN FORMS ON THE ABSORPTION AND DISTRIBUTION OF NITROGEN IN *POPULUS TOMENTOSA* SEEDLINGS USING THE ^{15}N TRACE TECHNIQUE

Li-shui Nie, Wen-yi Dong, An-tai Wei, Ji-yue Li, Zhi-yi Zhang and Ying-bai Shen[1]

The stable isotope ^{15}N trace technique was used to study the absorption, distribution and utilization of different nitrogen forms at the same N application level by using seedlings of *Populus tomentosa* clone 87 as materials. The results showed that the plant content of total nitrogen and the labeled nitrogen fertilizer had the same pattern, although the treatments were different. One week after application, the content of total nitrogen and of the labeled nitrogen fertilizer was increasing at a remarkable rate, both of them reaching a peak 28 days after fertilization. The maximum total nitrogen under the NO_3-^{15}N labeled treatment was 0.67 g-plant^{-1} and 0.59 g-plant^{-1} under the NH_4-^{15}N labeled treatment. The maximum absorption of NO_3-^{15}N fertilizer was 0.26 g-plant^{-1} and that of NH_4-^{15}N fertilizer was 0.12 g-plant^{-1}, which accounted for 38.70% and 20.22% of total nitrogen respectively. After that, the content of labeled nitrogen stayed at the same level but slightly lower than before. The nitrogen use efficiency (NUE) of the two nitrogen forms varied significantly. The maximum NUE of NO_3-^{15}N fertilizer reached 25.83%, nearly twice that of NH_4-^{15}N fertilizer (12.03%). Nitrogen distribution rate was obviously different in different organs and the trend was that leaf higher than root and root higher than stem. In the leaf, the distribution of NO_3-^{15}N was higher than that of NH_4-^{15}N. The nitrogen which accumulated in the roots was mainly supplied for the growth of above-ground organs and declined generally. Through the stem which is like a temporary storehouse, *P. tomentosa* seedlings mainly transported nitrogen to leaves and other organs which grew vigorously.

Key words: *Populus tomentosa*, nitrate nitrogen, ammonia nitrogen, absorption, nitrogen use efficiency, distribution.

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ID-160

AN INTERNATIONAL INVESTOR'S PERSPECTIVE ON TIMBERLAND OPPORTUNITIES IN CHINA

Jeff Nuss[1] and Brian Liu[2]

GreenWood Resources (GWR) is a global company focused on the development and management of fast-growth high-yield tree farm assets and has operations in North America, South America, and Asia. GWR's core competencies are capital and investment management, superior plant material and tree improvement methodologies, tree farm operations, and sales and marketing. The company uniquely addresses the broad skills required to produce superior, risk-adjusted returns for investments in intensively-managed tree farms.

GWR currently manages US$175 million of professional timber-investment capital with 14,000 hectares of poplar farms in the Pacific Northwest region of the United States and is developing nurseries and short-rotation high-yield poplar plantations in China and South America. GWR has organized timber investment capital with a large single client and will continue to organize additional opportunities for pooled investors to participate in investing into tree farms in China.

Forest industry in China is at an early stage of market reform and the current forestry resources of the country are unable to meet the explosive domestic demand for raw wood material. This imbalance has created investment opportunities for world-class 'timber investment management organizations' (TIMOs). In addition, the Chinese government, state-owned and private enterprises are eager to partner with these investors to enhance China's national wood resources and build a sustainable business in short-rotation tree farming.

This presentation will provide an international investor's perspectives on China's timberland opportunities, and will focus on four key topics: (i) key changes in the timber investing world, (ii) fundamentals of the Chinese plantation industry which include policies and incentives that attract direct foreign investment into this sector, (iii) opportunities and challenges for timber investing in China, and (iv) keys to success and concluding thoughts for international investors entering China's timberland industry.

Key words: poplar, plantation, fast-growth high-yield tree farm, forestry, timberland investment, capital management, timber investment management organizations, TIMO, risk-adjusted returns.

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ID-199

COMPARING *POPULUS* CLONES FOR SHORT ROTATION FORESTRY IN ITALY AFTER TWO TWO-YEAR ROTATIONS: SURVIVAL, GROWTH AND YIELD

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Short rotation forestry (SRF) plantations of hybrid poplar clones are currently attractive for Italian farmers due to generous public grants and the possibility of producing wood chips for production of heat and electricity. Growth and above-ground biomass yield of newly-selected clones of hybrid poplar, intended for SRF, were evaluated after two two-year rotations at locations across northern Italy within a network of experimental fields established in spring 2003 on three sites of low (Bigarello), medium (Vinovo) and high fertility (Mira). Soil preparation, planting density (6 000 trees ha^{-1}), weed control and tree water status were the same across the sites. Nitrogen fertilization was applied only at Mira (300 Kg N ha^{-1} in the second cycle). Each experimental plantation was mechanically harvested after every two years.

At all sites, survival of all clones was high and stem density increased dramatically, with a parallel decrease in stem dimensions after the first coppicing. At Bigarello, with limiting soil conditions, there were no significant differences among clone yields which varied from 5 (first rotation) to 7.5 (second rotation) Mg dry matter (dm) ha^{-1} $year^{-1}$. At the medium and high fertility sites of Vinovo and Mira, there were significant differences in clone yields, with the newly-selected clones performing better than control clones (I-214 and Lux). At Mira, mean yield increased from first to second rotation cycle - from 14 to 20 Mg dm ha^{-1} $year^{-1}$.

The network of experimental plantations showed yield variability related to soil fertility and fertilization management, with a range of SRF newly-selected clones of hybrid poplar performing better than traditional ones in medium- and high-fertility site conditions.

Key words: agroforestry, bioenergy, hybrid poplar, wood chips, coppicing.

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ID-247

LINKING WOOD BIOMASS PRODUCTION AND PHYTOREMEDIATION WITH POPLARS IN ITALY

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and G. Scarascia-Mugnozza

Increasing interest in bioenergy (biogas, biofuel, and solid biomass) as an alternative to fossil fuel places much emphasis on the energy uses of wood (fuelwood, chips and pellets, lignocellulosic ethanol) which have productivity and environmental benefits with only minor impacts on food markets, and low environmental impact in terms of CO_2 emissions and energy balance.

In Italy, wood is the second most important source of renewable energy, and it is mostly produced in natural forests under sustainable management. Using wood either for domestic heating or for industrial production of heat and/or electricity is often more economic than using fossil fuels. Part of the wood supply required could be provided by coppice plantations of fast-growing trees (poplars, willows, *Robinia* and eucalypts) planted by farmers on agricultural land with public grants and intensively managed with short harvesting cycles (1-5 years).

Phytoremediation is an opportunity to further improve the benefits from woody biomass. SRF plantations, combining high levels of biomass yield (up to 25 t dry matter $ha^{-1}y^{-1}$) and high capacity to remove contaminants, due to elevated densities of stems with very small diameters (2-4 cm), have interesting applications in phytoremediation with many possibilities that need to be further investigated through applied and basic research. Multi-year research activity currently carried out at CNR-IBAF, Italy, shows that SRF plantations can be used for many phytoremediation purposes. Case studies will be presented of research activities using poplars for disposal of animal sludge (agricultural research), and for removing heavy metals from contaminated soils.

Key words: agroforestry, bioenergy, hybrid poplar, nitrogen, heavy metals.

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ID-248

EFFECTS OF SLURRY COMPOSTING AND BIOFILTERATION LIQUID FERTILIZER ON GROWTH PERFORMANCE OF POPLAR CLONES IN A RECLAIMED COASTAL AREA

Jung-Hyun Park[1], Jin-Kie Yeo[1], Yeong-Bon Koo[1], Won-Woo Lee[1], Hyun-Chul Kim[1] and Chi-Ho Park[2]

We studied the effects of slurry composting and biofiltration liquid fertilizer (SCBLF) on the growth of two-year old poplar clones planted in a reclaimed coastal area. The soil on the experimental site had lower concentrations of both exchangeable cations and salt than before reclamation. However, the organic matter content was low compared to most soils.

We applied SCBLF to the poplars six times at the rate of 5 l every 80 days. Ten clones of six poplar species or hybrids were tested in this study: *Populus alba* × *P. glandulosa* (Clivus, 72-30, 72-31, Bonghwa1), *P. deltoides* × *P. nigra* (Dorskamp), *P. deltoides* (Lux) × *P. deltoides* (Harvard) (97-19), *P.* ×*euramericana* (Eco28, I-476), *P. nigra* × *P. maximowiczii* (62-2) and *P. koreana* × *P. nigra* var. italica (Suwon). Growth performance varied more among clones than among species. Average height growth of treated plots was 18% greater than untreated controls, and clones Clivus, 97-19, Eco28 and Dorskamp were more vigorous than other clones. Diameter at breast height in treated plots was 41% greater than controls, and 97-19, Dorskamp, Eco28 and Clivus were the four best clones in this respect. Mean leaf area of treated trees was 26% greater than for control trees. Chlorophyll content was similar between treated and controlled trees. Available phosphate and total nitrogen were analyzed in leaves and stems. There was no difference in phosphate concentration, but total nitrogen values in leaves and stems were much higher in treated trees - 18% and 15% respectively. SCBLF treatment applied to poplars planted in the reclaimed soil helped tree growth. The selection index of adaptation was higher in clones Dorskamp and Eco28 than in other clones.

Key words: clone, growth performance, SCBLF, poplar, reclaimed area.

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ID-050

BIOLOGICAL CONTROL OF *PLUTELLA XYLOSTELLA* (L.) (LEPIDOPTERA: PLUTELLIDAE) USING GAMMA RADIATION AND *BACILLUS THURINGIENSIS*: POTENTIAL FOR POPULATION SUPPRESSION IN THE FIELD

Wai Htun Phyoe, Wine New New Oo and Moe Kyaw Thu[1]

In Myanmar, infestations of the diamondback moth (DBM), *Plutella xylostella*, are considered one of the major constraints to cruciferous vegetable production. Control of the diamondback moth (DBM) was investigated in field cages under laboratory conditions (25±5°C, 75±5 RH).

Four-day old pupae of a field strain of the moth were treated with 175 Gy, 200 Gy and 225 Gy of gamma radiation and radiation-induced reductions in fecundity, viability and sterility from each dose were studied during the P1, F1 and F2 generations. The sex ratio was investigated among F1 and F2 progeny. When treated males were released into field cages at a 5:1 over-flooding ratio with unirradiated moths, a reduction in the number of F1 and F2 adults emerging in the field cages was found. Moreover, a remarkable reduction (65-75%) in the F1 generation compared to the control was found in the control of DBM when combined applications of radiation-induced sterility and *Bacillus thuringiensis* were used.

Key words: cruciferous, diamondback moth, gamma radiation.

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ID-165

BIOMASS ESTIMATING FUNCTIONS FOR POPLAR SHORT ROTATION COPPICE

Gianni Picchi[1]

Poplar short rotation coppice (SRC) has emerged as a new crop, promptly accepted by farmers of Northern Italy. Representing an intermediate crop between forestry and agriculture, these plantations pose a new challenge for estimating the standing biomass, which is the sole commercial parameter. An easy-to-use and reliable system is required by farmers and technicians for assessing the biomass present in the field at any given moment. Many allometric functions have been proposed, but most of these are based on single-stem stands, as they appear after establishment. Following the first harvest, poplar stools resprout with multiple stems, which quickly experience mutual competition for light because of the very dense plantation design (6,000-14,000 stools/ha). In these conditions, functions based on single stem trees are no longer applicable because the biomass is made up of many stems with different sizes (and shares of total biomass) even in the same plant. Furthermore, increasing the rotation length enhances the competition, resulting in few dominant stools of larger size which cause further complexity in estimating stand yield.

In order to assess the effect of rotation length on coppice stand structure and to determine the best estimation methodology, a 6-year-old experimental plantation was studied. Poplars (*P. deltoides*, clone Lux) had been planted with a density of 10,000 plants/ha and divided into three plots with different harvest treatments: yearly (T1), every other year (T2) and on a three-year rotation (T3). In each plot, five 6-meter-long transects were selected. The diameter of the four dominant stems of every stool was measured at three heights (22, 70 and 130 cm) with the aim of assessing the relevance of this variable in the biomass estimation. The stems were subsequently harvested and weighed individually and as a sum for each stool. The available data were used to build simple regressions in which the dependent variable was the dry matter (weight) and the independent variable was the basal area (BA) of a progressively growing number of stems: (a) the first in diameter, (b) the first plus the second, (c) the sum of the bigger three and (d) the sum of the four stems. Allometric functions were calculated for the three treatments (1, 2 and 3 years) and for the sum of the three as a control, resulting in a total of 48 biomass functions.

Functions were compared by checking the homogeneity of the correlation coefficient resulting in T1 functions being non-homogenous. Thus it was possible to create a general function for T2 and T3 with a slight loss of accuracy, but T1 could not be included. Diameter height sampling gave no difference even in the shorter T1 stems, thus the quicker DBH (130 cm) sampling should be preferred. Regarding the number of stems to be considered when calculating the BA, in T1 the R^2 of the function increased constantly requiring the consideration of four stems (adding the fourth increased the R^2 by 2.52 points), because of the lower inter-stool competition. In T2, competition started selecting the shoots and BA of the two bigger stems already provided an R^2 equal to 95.84%. Adding the third only increased R^2 to 97.96%. T3 had the strongest selection and the bigger (dominant) stem alone gave an R^2 of 92.26% increasing to 94.80% with the second stem.

Key words: SRC, allometric functions, biomass estimation, harvest interval, sampling method.

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ID-196

CRUDE OIL PHYTOREMEDIATION INVESTIGATION WITH DIFFERENT POPLAR AND WILLOW CLONES

Andrej Pilipovic[1], Sasa Orlovic[2], Natasa Nikolic[3], Borivoj Krstic[4] and Karolina Nemes[5]

Amongst the limited number of tree species suitable for phytoremediation, poplars and willows are the most important woody plants used for this purpose in the northern hemisphere. Their deep root systems and vigorous growth make them perfect candidates for phytoremediation of various contaminants.

This paper presents the results of an investigation of the potential of various poplar (*Populus* spp.) and willow (S*alix* spp.) clones for phytoremediation of soils contaminated with crude oil. Three poplar clones: (i) *Populus deltoides* clone PD2, (ii) *Populus* ×*euramericana* clone EA8, and (iii) *Populus nigra* × *maximowiczii* × *Populus nigra* var. *italica* clone NM3, and three willow clones: (i) S*alix alba* clone SA/H/1, (ii) *Salix alba* clone SA/I/1, and (iii) *Salix alba* clone SA/K/1 were grown in pots with soils containing six different levels of crude oil contamination. At the end of the experiment period growth parameters, including diameter, height and biomass, production of affected plants were measured. In the rhizosphere of the plants, groups of microorganisms were determined and their development and enzymatic activity were assessed. Degradation of TPH and mineral oils was monitored through determination of their amount at the beginning and the end of the experiment. Results showed different effects of crude oil contamination on plant growth and different reactions of investigated genotypes. Presence of TPH in soils increased share of oil-degrading bacteria, while degradation of TPHs and mineral oils was stimulated by the presence of the plants.

Key words: poplars, willows, phytoremediation, crude oil, degradation.

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ID-053

DIFFERENTIAL RESPONSE OF TEN POPLAR CLONES TO FERTILIZATION AND CLIMATE EFFECTS UNDER CONDITIONS OF LOW GROUNDWATER TABLE

Nenad Potočić[1], Tomislav Ćosić[2], Davorin Kajba[3], Marija Pecina[2],
Boris Vrbek[1] and Ivan Seletković[1]

The building of new river dams for electricity production has resulted in severe changes to water regimes in the basin of the Drava River (a tributary of the Danube), through Italy, Austria, Slovenia, Hungary and northwest to northeast Croatia. Large areas of ecologically very valuable forests have been exposed to the significant lowering of the groundwater table along the diversion channels, resulting in severe dieback, growth depression and poor natural regeneration of riparian tree species. The urgent need for selected genetic material adapted to specific conditions of alluvial soils with low groundwater levels is accompanied by the lack of a clear view on the future forest and environmental management of riparian ecosystems damaged by urban development.

A trial of 10 poplar clones (six *P. deltoides* clones, two *P. ×euramericana* clones and one clone each of *P. nigra* and *P. alba*) was established in the year 2001 next to one of the diversion channels. In 2004 and 2005, a fertilization experiment was incorporated into the existing trial to test the response of clones to four nitrogen (N) fertilizer doses added annually: 0, 100, 200 and 300 kgN/ha. P and K were given uniformly over the whole experimental area at 100 and 150 kg/ha, respectively. The response of height and diameter increment percentages differed significantly among clones and N treatments, indicating insufficient, adequate or excessive N fertilization. The mass of leaves (mL) and foliar concentrations of N, S, P, K, Ca and Mg, content of N (mN), and ratios of mineral elements (particularly N/Ca) were used to explain these differences. Climate differences between 2004 and 2005 were an additional source of variability, influencing both nutrition and growth of clones.

Key words: *Populus* spp. clones, N fertilization, nutrition, increment, water, climate properties.

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ID-136

A STUDY OF THE ANTIBIOSIS RESISTANCE OF 21 POPLAR CLONES TO *PHLOEOMYZUS PASSERINII* SIGN.

Zahra Rafiei-karahroodi[1], Hossein Allahyari[2] and Ibrahim Sadeghi[3]

The woolly poplar aphid (*Phloeomyzus passerinii* Sign.) is one of the most important sucking pests of poplars in a number of provinces of Iran, in particular in Markazi province.

In this study, carried out in 2003-2005 in Markazi, antibiosis resistance was investigated in 21 clones of *Populus alba* L. and *P. nigra* L.. The test was carried out under controlled conditions of 60-70% relative humidity and 16/8 hours light/dark photoperiods. The length and diameter of the poplar cuttings were 20 and 1-1.5 centimeters, respectively. Following the establishment of ephemeral nymphs on the cuttings, the aphids were able to reach the mature stage. After that, the number of first instar nymphs deposited and the nymphal mortality rate on each tested cutting were recorded daily and throughout the lifecycle period. Any aphid natality was observed on *P. alba, P. nigra* betuli and *P. nigra* 63.135, which showed these clones, are completely resistant to this aphid. The most r_m was observed on *P. nigra* 56.52, *P. nigra* 72.14, *P. nigra* 72.18, *P. nigra* 47.40 and *P. nigra* 49.5 with 0.59398, 0.58016, 0.50335, 0.47381 and 0.44057 and the least r_m was observed on *P. nigra* 56.75, *P. nigra* 72.5, *P. nigra* 72.4, *P. nigra* 56.21, *P. nigra* 56.53 and *P. nigra* 56.72 with 0.29748, 0.27934, 0.24868, 0.21575, 0.20719 and 0.13419, respectively. The different r_m observed show there is antibiosis resistance among poplar clones in Markazi province.

Key words: Iran, *Phloeomyzus passerinii,* clones, antibiosis, resistance, *Populus alba*, *Populus nigra.*

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A STUDY OF DAMAGE CAUSED BY THREE XYLOPHAGE PESTS ON POPLAR CLONES IN MARKAZI PROVINCE, IRAN

Zahra Rafiei-karahroodi[1] and Ibrahim Sadeghi[2]

Increasing human population, the need for wood and the limited sources of wood in Iran have led to the planting of poplars. Unfortunately, these trees are attacked by different pests, especially xylophage insect pests.

In this research, three xylophage pests were studied: *Melanophila picta* and *Paranthrene tabaniformis* were studied on 35 clones of *Populus nigra*, *P. deltoides*, *P. alba*, *P. euramericana.* The poplars were 6-year-old. For *Melanophila picta,* we selected four trees in each plot and counted all holes on the trunks up to 2 meters height. To study the damage caused by *Capnodis miliaris,* 52 two-year-old clones were selected in the nursery and the percentage of died trees caused by the pest was calculated. For *Paranthrene tabaniformis,* 10 branches, 1 meter long each, were cut from each clone in each replicate and the number of galls on each branch was counted.

Melanophila picta caused less damage on *P. alba* 44.13, *P. deltoides* missori, *P. alba* 44.9, *P. alba* 49.39, *P. euramericana* vernirubensis, and *P. alba* 72.7 than on *P. nigra* 72.11, *P. deltoides* 77.51, *P. euramericana* 214 and *P. nigra* 72.14. Less damage caused by *Capnodis miliaris* was observed on *P. alba* 44.9, *P. euramericana* 214, and *P. nigra* 56.75 than on *P. nigra* 47.38, *P. alba* 72.17, *P. nigra* 56.72, *P. alba* 72.7, *P. nigra* 63.135 and *P. alba* 45.77 in terms of the percentage of dead trees. Less injury caused by *Paranthrene tabaniformis* was observed on *P. alba* 44.13, *P. alba* 49.39, *P. deltoides* missori and *P. nigra* 72.8 than on *P. nigra* 72.11, *P. nigra* 63.135, *P. nigra* 72.18, *P. nigra* 56.53, *P. deltoides* 77.51 and *P. nigra* 72.13, Differences between clones are related to differences in wood fibre characteristics.

Key words: Iran, *Melanophila picta, Paranthrene tabaniformis, Capnodis miliaris*, *Populus nigra*, *Populus deltoides*, *Populus alba*, *Populus euramericana.*

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ID-007

A STUDY OF ANTIXENOSIS RESISTANCE OF 21 POPLAR CLONES TO *PHLOEOMYZUS PASSERINII* SIGN IN MARKAZI PROVINCE, IRAN

Zahra Rafiei-karahroodi[1] and Ibrahim Sadeghi[2]

The woolly poplar aphid (*Phloeomyzus passerinii* Sign.) is one of the most important sucking insect pests of poplars in a number of provinces of Iran, particularly Markazi province.

In this study, in 2003-2005, antixenosis resistance in 21 clones of *Populus alba* L. and *P. nigra* L., tests were carried out in controlled conditions of 60-70% relative humidity and 16/8 hours light/dark photoperiod, using poplar cuttings 20 centimeters long and 1-1.5 centimeters diameter. Ephemeral nymphs were established on the cuttings and could reach the mature stage. A single cutting of each poplar clone in five replicates was tied together with two aphid-infested cuttings using elastic bands. After two days, the infested cuttings were taken apart and the number of aphids on each cutting was recorded every two days.

The data showed no significant differences between clones. The aphid was not able to establish on *P. alba, P. nigra,* 63.135 and *P. nigra* betuli clones. These poplar clones were completely immune to the aphid and there was significant difference between clones. *P. nigra* 56.53*, P. nigra* 56.75*, P. nigra* 72.14 and *P. nigra* 72.5 clones were most preferred by the aphid, while *P. nigra* 72.11*, P. nigra* 72.19*, P. nigra* 49.5, *P. nigra* 72.18*, P. nigra* 56.72 and *P. nigra* 72.4 clones were least preferred. The different populations of aphids on different clones showed there is antixenosis resistance among poplar clones in Markazi province.

Key words: Iran, *Phloeomyzus passerinii,* clones, antixenosis, resistance, *Populus alba*, *Populus nigra.*

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ID-008

IMPORTANCE OF RESISTANCE SCREENING IN WILLOW AND POPLAR BIOMASS PLANTATIONS

Mauritz Ramstedt[1]

Diseases are dynamic and changing, and therefore a continuous screening for resistance in breeding programs is a necessary routine activity in the selection process to find the best material for further work to develop new suitable clones.

Traditional field assessments over a number of years in clonal trials will certainly exclude the most susceptible clones. Although this is repeated for several years, it only diagnoses the diseases present at the time of assessment, or appearing in large enough quantity. For economically safe investments in new commercial clones, it is therefore of utmost importance to conduct lab-screening studies in addition to field assessments.

Known important pathogens, from fungal and bacterial culture collections, can be inoculated under controlled conditions favourable for infection and for promoting disease growth and propagation. Also, for diseases easily spread over long distances, such as leaf rust, known aggressive strains from distant sites could be included in the test setup. Clones otherwise not known to be susceptible will face a great risk of infection within a few years, even though they now seem to be highly resistant. Whenever these more aggressive pathogen strains are spread, naturally or unintentionally by man, the clones otherwise could be an economical failure.

One must, however, keep in mind that the screening and "health-security" program is not finished when a new crop variety is introduced on the market. The dynamic process of diseases will allow new pathogenic strains to develop and adapt. Varieties formerly low in number will increase in time with the new crop and might have a devastating effect after a few years.

Therefore, it is important to continuously follow the presence of different pathogens in plantations, to plan clonal compositions and to record when to change varieties. This will also be helpful in answering to questions of the importance of different management methods, plant density and humidity as well as monoclonal plot size for development of disease.

Key words: disease screening, leaf rust.

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ID-206

PHYTOREMEDIATION OF PAH-CONTAMINATED SOILS FROM A RAILROAD SITE

Mauritz Ramstedt[1], Ulf Granhall[2] and Harald Cederlund[2]

A willow clone with earlier good performance for creosote and petroleum breakdown in greenhouse trials was selected for planting in an outdoor trial at Hovgården Deposit Plant. The soil was heavily contaminated with creosote and diesel-fuel, originating from Resecentrum, Uppsala (Central Railway Station).

Two treatments - with and without *Salix* - were used to follow the breakdown and disappearance of the contaminants in soil deposited on waterproof tarpaulin and separated by ditches and dikes. Four replications of 4×3 m for each treatment were used with 4 plants/m^2. Sampling took place at the start and after 4, 15 and 27 months. Five subsamples were taken for each master sample on each site (0-20 cm depth).

Simultaneous decrease in the content of diesel and PAH could be seen in the field samples. On the sites planted with *Salix*, a continuous decrease (a total of 74%), especially of the light PAH-components, could be seen in both the establishment year as well as the first growing season. The unplanted controls showed a decrease for the same period of only 17%. The willow clone Tora did not show any physiological defects during growth in initially 1000–1500 ppm diesel hydrocarbons (diesel) and 50 ppm PAH (creosote). The site with the highest *Salix* biomass production also showed the significantly highest breakdown of total PAHs (91%). At this site also the carcinogenic PAHs decreased by 66%.

The trial indicated that a significant increase in breakdown of all kinds of PAH will appear in connection with good growth of *Salix* (clone Tora).

Additional sampling will take place in September-October 2008.

Key words: Phytoremediation, *Salix*, PAH.

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ID-253

'THE ENVIRONMENTAL APPLICATIONS OF POPLAR AND WILLOW' POSTER AND LEAFLET

D. Riddell-Black[1], J. Isebrands[2], K. Perttu[3], M. Labreque[4],
A. Massacci[5] and M-N. Dos Santos[6]

The Working Group on Environmental Applications of Poplar and Willow (WP6) has produced a poster and leaflet to increase awareness of the potential environmental uses of poplar and willow and to promote the activities of the Working Group. The poster and leaflet briefly describe the activities of the Working Group and give examples of a number of environmental applications, including wastewater management, snow fences, sound barriers and land remediation.

Both items will be accessible to view on the WP6 IPC website and available to download. Different resolutions of the poster will be available to enable printing at A4, A3 and A0 sizes without loss of picture quality.

It is hoped that research departments and companies involved in these areas of activity will use the poster and leaflet to generate interest in the topic, both within their host organisations and in the wider research, forestry, agricultural and environmental sectors.

The poster and leaflet are available in four languages: English, French, Spanish and Italian.

This poster for the 23rd Session of the International Poplar Commission will provide examples of the Environmental Applications poster and leaflet.

Key words: IPC Working Party, environmental applications, publicity poster, publicity leaflet.

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ID-201

DRIP IRRIGATION OF SIX-YEAR-OLD POPLAR

N. Riu, M. Agüero and N. Naves[1]

In the province of Mendoza, Argentina, there is a history of drip irrigation and fertigation of vines, fruit and vegetables, but not in forestry. The objective of this trial was to study the impact of drip and surface irrigation on the growth of 6-year-old poplar (*Populus* ×*canadensis* 'Conti 12') fertilized with nitrogen.

The research was conducted at the experimental field of the Faculty of Agricultural Sciences of the National University of Cuyo, Mendoza, Argentina. Two blocks were installed, one with surface irrigation and the other with drip irrigation. The design was a randomized block with four replications. The individual experimental unit consisted of 6 poplars planted at 5 × 5 m.

The soil was clay loam, pH 7.7 and not saline. In regard to fertility, it did not show major differences in nitrogen, phosphorus or potassium content in the different treatments. Soil analyses were performed at the beginning and end of the growing season. Texture, pH, and electrical conductivity were determined at 0-30 cm, 30-60 cm and 60-90 cm depth and fertility at 0-30 cm and 30-60 cm depth.

Urea 200 kg/ha was used as the nitrogen fertilizer. Under the surface irrigation treatment, 60% of the dose was applied in spring and the remaining 40% in late summer. The same doses were applied in the drip irrigation, but through six applications in spring and four applications in summer, at intervals of two days. Tree diameter breast height (DBH) and total height were measured before fertilizing.

Under drip irrigation, average height and DBH were 14.50 m and 0.169 m respectively, while under surface irrigation they were 13.00 m and 0.162 m respectively.

Statistical analysis of wood production showed no significant differences between the treatments.

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Keywords: poplar, drip, fertigation.

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ID-120

NINE-YEAR-OLD POPLAR RESPONSE TO DIFFERENT IRRIGATION REGIMES

N. Riu, M. Agüero and S. Robledo[1]

An irrigation trial was conducted for three years on nine-year-old poplar trees (*Populus ×canadensis´* I-214') in Rivadavia Department (Lat 33° 09' S, Long 68° 28' W), Mendoza, Argentina. The soil had a deep sandy-loam texture. The experimental area was 192 m^2 with a total of 20 trees. The irrigation intervals (IR) were 7, 14 and 21 days. The trial was established with a randomised block design with four replications.

Breast-height diameter (DBH) of all trees and total height of the average trees were measured. Wood production for each treatment was calculated from this data.

Soil moisture was determined by the gravimetric method at four depths: 0-30 cm, 30-60 cm, 60-90 cm and 90-120 cm, and this data was used to obtain the real crop evapotranspiration (ETC).

Results showed that for the 7-day IR Real Evapotranspiration was 2759.7 mm, for the 14-day IR it was 1124.4 mm, and for the 21-day IR it was 941.7 mm. Daily evapotranspiration for IRs of 7, 14 and 21 days was 18.65 mm/day, 7.60 mm/day and 6.68 mm/day, respectively.

Crop Coefficients (Kc) were obtained by relating Etc to potential evapotranspiration using the Blaney-Criddle method and the pan evaporimeter. Results comparing these two methods were: Kc = 3.65 and 4.86, respectively, for IR of 7 days, 1.47 and 1.92 for IR of 14 days, and 1.21 and 1.56 for IR of 21 days.

The irrigation interval of 7 days gave the highest values for wood production with 147.24 m^3/ha/year, whereas with IR of 14 and 21 days the wood production was 103.3 and 84.63 m^3/ha/year, respectively. Statistical analysis showed that wood production with an IR of 7 days was significantly greater than with the other two irrigation regimes.

Key words: poplar, irrigation, evapotranspiration, Kc.

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SUSCEPTIBILITY OF TRUNKS OF DIFFERENT POPLAR CLONES TO *SEPTORIA MUSIVA* IN MENDOZA, ARGENTINA

N. Riu, G. Lucero, P. Pizzuolo, R. Pérez Hurtado and S. Robledo[1]

There are approximately 16,000 hectares of cultivated poplars in the province of Mendoza in Argentina. The cultivation of *Populus* is limited to a very limited number of clones including *P. deltoides* ´Harvard`, *P.* ×*canadensis* `Conti- 12´ and `Guardi´, the last of these having high sensitivity to attack by *Septoria musiva.* This is a pathogen which causes severe damage in the United States of America, Canada and Argentina but is still absent from Europe where its introduction is feared. The fungus causes foliar spots with early defoliation as well as cankers on tree trunks, branches and leafstalks. In Argentina, the worst damage is found in the province of Mendoza, where large economic losses in wood used for industrial purposes occur. Due to such problems, it is critical to try new clones with good productivity but, above all, clones which present a high degree of resistance to *Septoria.*

The aim of the present study was to evaluate the susceptibility of different poplar clones to attack by *S. musiva.* In order to do that, nine clones were evaluated in a 7-year-old populetum. Susceptibility was determined by the presence of stem cankers produced by *S. musiva.* From statistical analysis of the data we found that the clone *P.* ×canadensis `Neva´ was the most susceptible, while *P.* ×*canadensis* `Boccalari´, `NNDV´, `Stoneville 81´ and `Guardi´ and *P. deltoides* `Triplo ´ were somewhat susceptible and *P.* ×*canadensis* `Conti 12´, and *P. deltoides* `Dvina´ and `Lux´ were least susceptible of all.

Key words: poplar clones, susceptibility, *Septoria musiva*, trunks.

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ID-060

IDENTIFICATION OF SIX CLONES OF *POPULUS* SPP. IN A UPOV PLANT NURSERY IN MENDOZA, ARGENTINA

N. Riu, S. Perez, N. Naves and J. Bustamante[1]

In Mendoza, Argentina, forestry activity is mainly based on poplar-growing. However, only a very few clones, recognized by their behavior and productivity, have been used at the commercial level. A larger genetic base is needed. One of the aims of the Instituto forestal (Forestry Institute), Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo, is to permanently incorporate new clones of different provenances, which have been evaluated for their adaptation to local site conditions.

It is also very useful to establish morphological and phenological differences between clones, especially in the nursery. For this reason, six poplar clones were planted over a 5-year period under the standards of the International Union for the Protection of New Varieties of Plants (UPOV) at Chacras de Coria, Luján, Mendoza (Lat. 33°09'S, Long. 68° 52'W): *Populus* × *canadensis* 'I-72', *P.* ×*canadensis* 'I-486', *P.* × *canadensis* 'El Campeador', *P. deltoides* 'Stoneville 91', *P. deltoides* 'Stoneville 92' and *P. deltoides* 'Stoneville 124'.

The date of initiation of the different phenological phases of growth in 1/1 plants was determined. As a reference, the mean date observed for clones *Populus* ×*canadensis* 'I-214' and *Populus deltoides* 'Harvard' was used. The date of initiation of phase 2 is considered a useful parameter for differentiating clones because, generally, it is the easiest to observe, it is stable and has a constant relationship between clones from year to year.

It was observed that clone *P.* ×*canadensis* 'El Campeador' burst bud in the first fifteen days of September at the same time as clone *P.* ×*canadensis* 'I-214'. Clones *P.* ×*canadensis* 'I-72' and 'I-486' and clones *P. deltoides* 'Stoneville 91', 'Stoneville 92', and 'Stoneville 124' burst bud at the same time as clone *P. deltoides* 'Harvard' in the second half of September.

In 2004, in 1/1 plants, the dates of initiation of phase 2 of sprouting were 15 September for *P.* ×*canadensis* 'El campeador', 25 September for *P.* ×*canadensis* 'I-72' and *P.* × *canadensis* 'I-486', 22 September for *P. deltoides* 'Stoneville 91', and 27 September for *P. deltoides* 'Stoneville 92' and *P. deltoides* 'Stoneville 124'. Clone *P.* ×*canadensis* 'I-214' reached phase 2, on average, on 10 September and clone *P. deltoides* 'Harvard' reached that stage on 24 September.

Key words: poplar clones, phenology, identification.

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PATHOGENIC ENDOPHYTIC FUNGI IN POPLAR NURSERY PLANTS

E. Rocco[1], A. Giorcelli[2], M. Gennaro[2], G. Deandrea[2] and N. Anselmi[1]

In new plantations, transplanted poplars often die from attacks of fungal bark necrosis (transplant crisis). In Italy, the most important agents usually causing these necroses are *Discosporium populeum* (Sacc.) Sutton, *Cytospora* spp. and *Phomopsis* spp.; *Fusarium* spp. were also detected. These fungi are all weakness pathogens that parasitize young stressed plants, particularly soon after transplanting. Recent studies showed that some of them are able to live asymptomatically inside healthy tissues (endophytic pathogens).

The aim of this research was to assess the frequency of poplar endophytic fungi on asymptomatic nursery poplar plants, with particular reference to latent pathogens, and to identify those involved in transplant crisis.

Sampling was carried out in 2006 and 2007 in 1- and 2-year-old *Populus ×canadensis* (clone 'I-214') in nurseries in Viterbo (Central Italy) and in Casale Monferrato (Northern Italy). In each nursery, 10 plants were randomly selected and from each one, 20 twigs and buds were collected. After surface sterilisation, fragments of the twigs and buds were transferred onto suitable nutrient media. The fungal isolates were subcultured and identified by their morphological and molecular characters.

Pathogenic and non-pathogenic endophytic fungi were found in asymptomatic poplar tissues. Among latent pathogens, the presence of important agents of bark necrosis such as *Cytospora* sp. and *Phomopsis* sp. was noted; *Discosporium populeum* was found exclusively in samples from Casale Monferrato, *Cytospora* sp. only in samples from Viterbo. This finding is in agreement with the high incidence of *D. populeum* and sometimes *Phomopsis* attacks on 1- and 2-year-old plants during transplanting in Northern Italy, whereas in Central and Southern Italy *Cytospora* are usually present.

Our results showed that the aforesaid fungi often live asymptomatically in healthy tissues of nursery plants. In new plantations they are probably induced to cause necroses by the stress associated with transplanting. The importance of these results from a practical point of view is discussed, as well as the possibility of establishing nurseries on sites where dangerous pathogens are not likely to be found.

Key words: poplar, nursery, weakness pathogens, endophytism, transplant crisis.

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POPLAR WOOD DENSITY ASSESSED BY X-RAY DENSITOMETRY: NEW INSIGHTS FOR INFERRING WOOD QUALITY

Fidel A. Roig[1,2], Alberto Calderón[2], Natalia Naves[2], Arturo Somoza[2], Claudio S. Lisi[3] and Mario Tomazello Fo[4]

Wood density is a variable influencing many of the technological and quality properties of wood. The X-ray techniques, traditionally applied to conifer woods to obtain information useful to detect those environmental factors influencing wood density in natural forests, have also been successfully used to assess the wood quality properties of commercial tree plantations. Large-diameter vessels in broadleaf trees would, however, be a serious limitation to the production of reliable wood density data from the application of radiodensitometric techniques. This problem certainly decreases when pores become narrower and uniformly distributed in the growth ring. Since *Populus* woods show this particular type of anatomy, 12-year-old poplar clones cultivated in Mendoza, Argentina were selected to study wood density characteristics as determined by radiodensitometric techniques.

Transversal laths of poplar wood 2 mm thick were conditioned for 12 hours at 18ºC and 60% atmospheric relative humidity, and then radiographed (Hewlett Packard, Faxitron 43805 N; 5 min, 16 kV, 3 mA). For densitometric calibration, a wedge of cellulose acetate with steps of known density was included in the radiography. After the development of the radiographic films, they were digitized with a scanner (Hewlett Packard ScanJet 6100C/T) to a resolution of 1000 dpi with a gray scale of 256 degrees. In the digitized image, comparisons were made between the gray scale of the wood samples and the calibration wedge. Density readings were obtained by using specific image analysis software, producing the following tree-ring parameters: ring width, early- and late-wood width, total ring density, early- and late-wood density, and minimum and maximum density. The X-ray technique applied to poplar wood gave promising results: (a) the densitometric profile identifies clearly the passage from maximum to minimum density zones between adjacent rings, (b) the intra-ring density profile follows a similar incremental progression to those observed in conifer wood, (c) the X-ray density values successfully reproduce the mean density values usually found in poplar wood (450 kg/m^3) as well as the minimum and maximum density values (300 kg/m^3 and 650 kg/m^3 respectively), (d) the X-ray method allows the analysis of density values throughout the complete life-span of the tree, giving a continuous densitometric profile from pith to bark, and (e) the method allows densitometric comparisons between radii of the same tree, between trees on the same site and mean density values between sites. The only limitation of the X-ray method is its relatively high cost and the time it takes. However, we strongly suggest the use of X-ray techniques in density calculations related to poplar wood quality.

Key words: poplar, wood density, X-ray densitometry, wood quality.

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ID-066

ADAPTIVE TRAITS AND PRODUCTIVITY OF EUROPEAN POPLAR SPECIES

Maurizio Sabatti[1], Muriel Gaudet[1], Isabella Paolucci[1], Isacco Beritognolo[1], Francesco Fabbrini[1], Catherine Bastien[2] and Giuseppe Scarascia Mugnozza[1]

Forest trees dominate many terrestrial ecosystems and are extremely interesting for their ecological value and economic importance. Among forest trees, poplars are important components of riparian ecosystems and are now accepted by the scientific community as an ideal model to study perennial plants. Poplars have several advantages as a model system, including rapid growth, prolific sexual reproduction, ease of cloning, small genomic size, easy transgenesis and tight coupling between physiological traits and biomass productivity.

Taking advantage of germplasm collections from Italian natural populations of *P. alba* and *P. nigra*, genotypes were selected on the basis of their origin and divergence of adaptive traits, to be used as parents to produce F_1 full-sib families. Two intra-specific F_1 families of *P. alba* and *P. nigra* were planted at three sites in Europe and two sites in Italy, respectively. A randomized block design was defined for the establishment of the experimental plantations for both pedigrees. Six complete blocks were used and one replicate of each F_1 genotype and parent was randomly assigned to each block. The results have shown significant variation within a set of selected morphological and phenological traits for genotypes, sites and GxS interactions across the sites in the two intra-specific full-sib families. Broad-sense heritabilities and genetic correlations will be presented for the study traits in relation to the different environments. The results obtained will be discussed, introducing the utility of this work for genetic improvement and mapping of QTLs for different adaptive traits and yields on contrasting sites.

Key words: poplar germplasm, genetic mapping, QTL, productivity, sustainable management.

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ID-202

SALIX PRODUCTION FOR THE FLORAL INDUSTRY IN NORTH AMERICA

Margaret Saska and Julia Kuzovkina[1]

Ornamental willows are produced in North America as a value-added specialty crop for cut stem sales in the floral industry. The current state of ornamental willow production was addressed in a mail survey following the "tailored design method" which polled 52 *Salix* growers throughout North America. The survey reviewed the existing cultural practices and identified a set of research questions to stimulate further development of this crop. The survey instrument was designed to obtain information on grower profile, gross sales from *Salix* crops, taxa in cultivation, cultural practices, sales outlets and grower views on the potential of this crop. The survey received a 69% response rate.

Respondents grew *Salix* as a traditional seasonal specialty cut product, complementing their overall product selection. The majority of respondents described themselves either as small-scale specialty cut-flower producers (58.6%), or as large-scale specialty cut-flower producers (24.1%). Total gross sales of *Salix* for 80.0% of the growers were less than US$25,000, 17.0% grossed US$25,000-50,000 and 3% grossed US$50,000-100,000. The majority of growers (51.7%) viewed the crop as of secondary importance in their overall selection, and 24.1% considered *Salix* a "major" crop. The greatest percentage of respondents produced *Salix* on less than ¼ of an acre (app. 1,000 m^2) (44.4%), or on land 1 to 5 acres (app. 4,000 to 20,000 m^2) in area (22.2%). Taxa cultivated for catkins were referenced 58 times, 38 references were made to curly or corkscrew willow, 11 references were to fasciated stem production and 4 references were made to cultivation for stem color. Taxonomic identifications using botanical names were indicated by five growers; otherwise common or descriptive names were given. Cultural fertilization practices varied widely among growers. Irrigation was never used by 42.9%, 35.7% irrigated during a dry spell and 21.4% irrigated regularly. Deer and Japanese beetle were the most common pest problems, mentioned by 35.7% of respondents respectively, and the most frequent disease problem was tip-dieback (48.3%). The majority of growers (60%) indicated that it took three to five years for a planting to reach full production. Precociously-flowering taxa were harvested primarily in January through March, peaking in February, and harvest for stem color or shape was most common October through March. Stem length (93.1%), catkin density (58.6%) and color (44.8%) were important criteria used to grade stems for sales. The largest sales outlets were to wholesale buyers (70%), farmers' markets (62.1%) and retail (36.7%).

Key words: ornamental willows, value-added crop, specialty crop, cut stem production.

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ID-126

THE IMPORTANCE OF *PARANTHRENE TABANİFORMİS* ROTT. AND *CRYPTORHYNCHUS LAPATHİ* L. IN TURKEY

Fazıl Selek[1]

Paranthrene tabaniformis Rott. exists in all the forest nurseries in Turkey. This insect causes significant damage to young sapling poplar trees and results in important economic losses. Traditional control methods are not sufficient due to the expanding life cycle of the insect.

Cryptorhynchus lapathi L. also causes major damage in poplar nurseries and plantations. The insect spreads through the use of infected saplings.

In this study, we studied both these insects in poplar plantations. In some cases, poplar growers had approached the Poplar and Fast Growing Forest Trees Research Institute in regard to insect problems and we investigated their poplar plantations. In most of these cases, these two insects were determined to be the source of the problems.

We will present some conclusions in regard to these two insects in Turkey.

Key words: *Paranthrene tabaniformis, Cryptorhynchus lapathi,* control methods.

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ID-091

BACKYARD PLANTING - A VITAL PRODUCTION SYSTEM OF SOCIAL FORESTRY IN NORTH-EAST INDIA

S.K. Sharma[1]

Backyard planting is an age-old practice in India. Inhabitants of north-east India have long raised willow (*Salix*) and bamboos in their backyards. This practice is one of the easiest to implement and also the most rewarding component of social forestry to reduce poverty and improve food security in an otherwise backward area where the benefits of development have not fully reached. The temperate zone of the Himalayas ranging in altitude from 1600 to 3500 m is one of the phytogeographic regions of India considered best suited for backyard planting of different varieties of willow (large to small trees) grown from branch cuttings: *Salix alba* (bis), a large tree used for cricket bats, matchwood, tool-handles, fuel and fodder; *Salix babylonica* (majnu), a large tree used for fodder, fuel and ornaments; and *Salix daphnoides* (bhashi, bashroi), a small tree suitable for basket-making, fuel and fodder.

This study examined how willow planting in the north-east region of the country ties into wider national agendas, including those associated with poverty reduction. Best practices, constraints and opportunities for establishing effective linkages were identified through interviews with representatives from civil society organizations The study revealed that backyard planting, as a part of social forestry in north-east, is a labor-intensive activity and large-scale adoption of this program which would help generate income through employment and through the sale of surplus goods and services, thus enhancing their contribution to the reduction of poverty. The activity of raising willow and bamboos in their backyard and their marketing has not only taken employment to the very door-steps of the unemployed but also contributed to the reduction of poverty in the poor areas of north-east India.

Key words: phytogeographic regions, backyard planting, social forestry, poverty, *Salix*.

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EFFECTS AND MECHANISM OF EXOGENOUS SILICON IN ALLEVIATING SALT STRESS IN POPLAR SEEDLINGS

Yanhua Shen, Xizeng Xu and Shengzuo Fang[1]

The possible function of exogenous silicon in salt stress was investigated in the greenhouse by measuring and analyzing photosynthesis, lipid peroxidation, and activity of enzymes, X-ray electron probe microanalysis, and growth. The main conclusions were as follows:

1. Under salt stress, the degree of chloroplast injury in poplar seedlings was strongly correlated with salt concentration in the soil thus decreasing photosynthesis. Application of silicon increased plant photosynthesis, e.g. chlorophyll content, photosynthetic rate, stomatal conductance, and intercellular CO_2 concentration in the leaves of poplar clone seedlings all increased. This indicated that the addition of silicon under salt stress can maintain photosynthetic efficiency at a high level for the poplar seedlings.
2. Under salt stress, the activities of catalase (CAT) and peroxidase (POD) were gradually reduced, while the content of malondaldhyde (MDA) and relative permeability (RP) of the plasma membrane increased. Application of silicon increased the activities of CAT and POD, and reduced the content of MDA and RP under salt stress. This implies that damage to poplar seedlings caused by salt stress could be alleviated by silicon addition.
3. X-ray electron probe microanalysis showed that the relative content of Na+ and Cl- in the cells of epidermis, cortex and stele under NaCl stress was much higher than control, while that of K+ was lower. However, after the addition of silicon, the contents of Na+ and Cl- in those cells decreased markedly and the K+ content increased significantly. The results indicated that the addition of silicon under salt stress ameliorated ion imbibition and ion micro-distribution status.
4. With increasing soil salt content, stem growth and total biomass of poplar clones decreased. However, when exogenous silicon was added to the soil, new branches grew longer, and root activity increased compared to control, which indicated that silicon improved the growth and physiology of poplar seedlings.

Key words: poplar, salt stress, silicon addition, photosynthetic rate, enzyme activity, X-ray microanalysis.

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ID-039

EVALUATION OF THE PERFORMANCE OF CLONES FOR BIOMASS PRODUCTION IN A PLANTATION IN THE MADRID REGION, SPAIN

H. Sixto, M. Sanchez, I. Aranda and J.L. Montoto[1]

The species and hybrids of the genus *Populus* are among the most suitable for the production of lignocellulosic biomass in our latitudes and permit short-term, programmed production of raw material for energy purposes, as part of the priority objectives at both national and European levels, to obtain energy from renewable sources. However, if sustainable production is to be optimized, detailed knowledge is required of the appropriateness of the materials, cultivation techniques and cultural treatments applied.

In order to evaluate different poplar genetic materials for use as sources of biomass, an experimental plantation was established beside the Henares River (Madrid), as part of a network of trials across the main regions of Spain in which poplar is grown. A hierarchical split-plot experimental design was employed with four replications, in which one of the factors to be analyzed was the clones. The density was 33 333 cuttings/ha (spaced 1,00×0,33 m). The trial was irrigated with a sprinkler system. The clones belonged either to the Spanish national base material catalogue or to the Italian catalogue, the latter having been selected specifically for biomass production. The clones used were: I-214, MC, 2000 verde, Guardi, AF2 (*P. ×euramericana*), Unal and USA 49-177 (*P. ×interamericana)*, and Pegaso and Monviso (*P.×interamericana × P. nigra*). The growing material was coppiced after the first year in order to encourage sprouting. Data were recorded at the end of the second growing season.

The following parameters were evaluated: (i) growth (total height (Ht), diameter over bark at breast height ($d_{130)}$ and at a height of 10 cm (d_{10})) and production (volume of biomass); (ii) crown architecture, including number and length of branches (short, intermediate and long), height to the lowest and highest live branches, and diameter of the first branch lower than 1,30 m; (iii) functional variables, including net photosynthesis rate (A), stomatic conductivity (g_s), specific leaf area (SLA), intrinsic water use efficiency (IWUE) and δ^{13} analysis. In this case, the evaluation was conducted on three of the clones included in the experiment: 'Monviso', 'Unal' and 'I-214', each belonging to different hybrids. Growth and production variables differed significantly among clones, and were significantly higher for clones AF2 and 2000 verde under the specific conditions of the trial. The Pegaso, Unal and USA 40-177 clones showed the lowest growth, and the remainder reached intermediate levels.

With regard to the architectural variables, significant differences were found in total number of branches as well as in the distribution of types of branches. Clones with the highest number of branches were USA 40-177, Unal, Monviso and 2000 verde. In these clones, among the three types of branches assed, the intermediate length was the most abundant, showing an equal number of short and long branches. Crown shape may affect not only production but also biomass characteristics, through producing more or less bark content, as well as the logistics of harvesting. Functional variability was also evident in relation to the efficiency of water use by clones with similar growth. The Monviso clone was found to be the most efficient of the three in terms of water use, highlighting the need to take into account criteria additional to those of growth and production when considering the suitability of clonal material for sustainable biomass production.

Key words: poplar, biomass production, short-rotation coppice, water use efficiency.

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ID-101

HARVESTING POPLAR MEDIUM-ROTATION COPPICE WITH LIGHT EQUIPMENT

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Poplar plantations for biomass are constantly increasing in Italy, with a total area of over 5 000 hectares planted in less than 10 years. The first plantations were based on the Swedish model, with double rows, very high densities (14 000 plants per hectare) and harvested every year. This model turned quickly to longer rotations and lower density as poplar in Italy showed higher growth rates than willow in Sweden. Under these conditions, selected hybrids had enhanced productivity and biomass quality was improved due to a better wood/bark ratio, leading plantation designers to try a new scheme, intermediate between short-rotation coppice (SRC) and fast-growing plantations for plywood. These new plantations, called medium-rotation coppice (MRC), with 1 100 plants per hectare and 5-year-long rotations, produce trees with breast-height diameter exceeding 20 cm. While SRC can be harvested with efficient modified foragers, MRC trees require heavier machinery. Forestry equipment with multiple-stem handling seems to provide the best solution, but the size of most forestry-dedicated prime movers is a constraint because such machines cannot travel on public roads, while plantations are scattered over the countryside and rarely connected by private roads. With the aim of providing a solution to this problem, CNR tested a light harvesting system equipped with a multiple-stem head for which transportation by road is much easier and cheaper, but with productivity still to be determined.

The harvesting system is based on a tracked mini-loader with a light Davco feller-buncher head. The head weighs only 700 kg and can handle two trees per cutting cycle while the circular saw ensures minimum blockage even if working with low stump visibility. The working scheme was extremely simple: the harvester cuts two trees (or stumps with multiple stems) from a single row moving forward, then it turns to the side and lays the bunch of trees in windrows spaced every six rows. By accumulating the stems of many cycles it can create large bunches which optimize the subsequent chipping. This last operation was carried out with a self-propelled radio-controlled chipper fed with whole trees by a wheeled loader. Chipping can be postponed for a few months after felling in order to naturally reduce the moisture content of the whole trees. The machine was tested in a 5-year old *P. alba* (biomass clone "Marte") plantation with a density of about 1 100 stems/ha. The average DBH of the stand was 9.8 cm with a green mass of 87.9 t/ha. During the test the machine harvested 2 143 trees in 767 working cycles reaching a productivity of 10.1 t/hour, including down time, with a resulting cost of 5.0 €/t. This performance can be compared with the productivity of a forestry-dedicated harvester (Timberjack 762 C) tested in a similar *P. alba* plantation. Working in a better stand (DBH 10.7 cm and 107.4 green t/ha), the working cost for this system is 4.9 €/t. In both cases biomass chipping and logistics as well as machine transportation must be included in the cost of the operation, but while chipping and logistics costs are expected to be very similar for the two harvesting systems, the transport of the mini-loader is much cheaper compared than the forest harvester, resulting in a clear economic advantage for the new system, particularly when dealing with small scattered plantations.

Key words: SRC, medium rotation, poplar, mechanization, harvest.

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ID-197

POPULUS HYBRIDIZATION FOR THE RENEWABLE TRANSPORTATION FUELS INDUSTRY: INTEGRATION OF GENOMIC TOOLS INTO A VARIETAL DEVELOPMENT PROGRAM

Brian J. Stanton[1] and Richard A. Shuren

Poplar plantation management along the lower Columbia River floodplain in North America involves select clonal varieties of the first-generation of the *Populus* ×*generosa* inter-specific hybrid taxon. Varietal development efforts have mainly emphasized a short-term improvement approach featuring non-recurrent F_1 breeding because of the good opportunity to expedite the improvement in plantation yields owing to an increase in selection intensity that accumulates throughout the period that hybrid populations have been annually bred, tested, and selections made. The goal has been to provide for near-term substitution of the lowest-ranking clones in the deployment pool and to counteract the virulence of evolving *Melampsora* pathotypes. Poplar is now being bred as a priority crop for the cellulosic ethanol industry. Hybridization goals include improvement of the standard agronomic characteristics, as well as biomass compositional traits that will lead to high-yield varieties that can economically undergo conversion to liquid fuels. Initial *Populus* ×*generosa* studies revealed little variation in carbohydrate and lignin chemistry among full-sib families, but significant variation among individual genotypes, suggesting the importance of within-family clonal selection. To assist parental evaluations and increase family segregation rates, molecular tools are being developed to identify DNA sequence variation in genes controlling phenotypic variation in cellulose and lignin biosynthesis in a *P. trichocarpa* parental breeding population. Sequence variation in 40 candidate genes has been surveyed using a panel of 15 unrelated clones to discover single nucleotide polymorphisms to be used in associating phenotypic with genotypic variation in the entire breeding population. At the same time, a 25-family factorial mating design is being developed with parents selected from the mean and extreme values in the ratio of syringyl-to-guaiacyl lignin as a proof-of-concept population with which the approach to a genomic-assisted hybridization program can be validated.

Key words: *Populus* genetic improvement, association genetics, renewable energy, genomics.

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ID-087

EFFECTS OF PARENTAL GENETIC COMPOSITION ON BREEDING COMPATIBILITY OF POPLARS

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Superior poplar varieties selected from China and introduced exotic genetic resources were used in hybridization experiments to study compatibility of different combinations of pure species × hybrid, hybrid × hybrid between different sections, pure species × pure species, pure species × hybrid and hybrid × pure species within section. Leaf shape, growth, and insect resistance of hybrid progenies were analyzed to study the impacts of parental genetic composition on these cross-combinations.

Results indicated that parental genetic composition had a larger effect on compatibility. Intra-specific hybridization or one of the mating parents being a pure species is desirable criteria for hybridization. Parental genetic composition had a certain impact on compatibility. Intra-specific hybrids as mating parents had higher compatibility than pure species and were more suitable for hybridization. Therefore, greater attention needs to be given in future hybridization of poplars. Parental genetic composition closely relates to heterosis. Inter-section F1 hybrids are basically intermediate in growth traits while intra-section hybrids often appear to have heterosis, which increases with aggregation of genetic components from the same parent species. This study is intended to provide theoretical information for poplar breeding practice.

Key words: poplar, parent, genetic composition, breeding effect.

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ID-151

POPULUS SPP. USED FOR PLYWOOD IN ARGENTINA

Raúl O. Suárez[1]

In Argentina, we have about 100,000 ha planted with *Populus* spp. in different ecological conditions:

- areas with excess water, such as the Delta of the Paranà River and Uruguay (minimal summer-winter differences);
- continental and/or arid areas (annual rainfall: 800-1,000 mm). Mainly Buenos Aires Provinces, South of Santa Fe (slight summer-winter temperature range);
- semi-arid/arid areas with irrigation systems (irrigation by flooding, drip irrigation, etc.). Provinces of La Pampa, Neuquén, Río Negro, Chubut, more precisely the area of the country known as Patagonia (major summer-winter temperature range). It is in this region that the Medanito S.A. forest industry company is located (West of La Pampa Province - irrigation by flooding; and North of Neuquén - pressurized drip irrigation). The company plants almost exclusively clones of *P.* ×*euramericana* even if it is not with *deltoides* and/or *deltoides* in the parent line. In principle, it seems that it is not the case for this specific region.)
- no doubt that this geographic situation plus the climatic situation influence in any way the "qualities" of the wood which is harvested, in its colouring and in its density.

The basic characteristics of the plywood industry are the production of laminated boards for Medanito S.A. and shoots for the match industry. There are only two companies at present utilizing wood of *Populus* spp and *Salix* spp. for value-added products. In order to obtain wood of sufficient quality, planting distance is very important (6 m × 6 m = 278 plants per ha), as well as pruning and other silvicultural activities. Accepting these distances has not been easy, even when there are incentives from the State. In the last 10 years, the situation has changed, since previously the pulp-and-paper industry has always dominated the discussions.

The Company produces plywood of superior quality and has the individual elements which compose it. The plywood produced varies in thickness between 3 and 22 mm and is made up of rolled-up sheets, glued criss-cross, with fibres oriented in different directions. It should be noted that plywood is excluded from the phytosanitary control which is applied to other wood products under FAO Norm NIMF 15 and SENASA (National Organization) Resolution 3/2.005.

The peeler logs used by Medanito are 2.20 m, 2.50 m and 2.60 m long, with diameter between 0.22 m and 0.60 m. The annual consumption of this type of wood is around 16-18,000 tonnes, for a plywood production of 5-6,000 m^3 per annum, to be used in pear containers for export (for example bag-in-box system), for concentrated apple, grape and lemon juice, as well as for carpentry and coating.

Key words: ecological characteristics, qualities, harvested, density, colouring, plywood.

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EFFECTS OF DIFFERENT PRUNING INTENSITIES ON PHOTOSYNTHETIC CHARACTERS, GROWTH AND YIELD OF CROPS IN AGROFORESTRY

Shangwei Sun, Xinli Xia, Xiaodong Liu, Weilun Yin[1]
and Senkun Chen

Facing severe ecological damage and a large population, it is imperative for farmers in China to seek alternative land-use practices to optimize their production. Agroforestry, the combination in o0ne system of agriculture, forestry, and/or livestock, is a practice that can improve total capture of light energy and productivity per unit land area. However, the yield of crops generally decreases because of competition with trees for light, soil nutrients and soil water.

An experiment was established in Shandong Province of China to demonstrate whether pruning could act as an optimization measure for agroforestry systems. This study was to determine the effects of pruning on crop productivity when crops (winter wheat, summer maize) were grown between rows of trees (*Populus* ×*euramericana* cv. '74/76'). At the start of the experiment, the trees were 4-years old and the density was 833 trees ha^{-1} with spacing within- and between-rows of 2 m and 6 m respectively. Selected trees were pruned to remove 0%, 16.7%, 33.3%, 50% and 66.7% of the lower green crown length. The agronomic parameters, yield components and photosynthetic parameters, such as net photosynthesis rate (Pn), transpiration (Tr), stomatal conductance (Gs), and intercellular CO_2 concentration (C_i) of winter wheat and summer maize were measured. The results showed that Pn, Tr and Gs of winter wheat and summer maize all increased after pruning. Moreover, greater was the increase the more severe was the defoliation. This response occurred throughout the daytime, especially near the midday. The height, ground-level diameter and aboveground biomass of winter wheat and summer maize all increased very greatly, and the increases for summer maize were greater than for winter wheat. The yield of winter wheat and summer maize increased by up to 171% and 399% respectively following pruning, and the increased yield of wheat came mainly from thousand grain weight and the number of grains per spike, but that of maize came mainly from numbers of spikes. Furthermore, the increased yield of maize was higher than that of wheat, but the total yield was lower than that of wheat. So winter wheat was more suitable for agroforestry systems than summer maize.

Key words: agroforestry, pruning, wheat, maize, photosynthesis.

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ID-071

GROWTH RESPONSE AND HEAVY-METAL ACCUMULATION CHARACTERISTICS OF POPLAR AND WILLOW SEEDLINGS EXPOSED TO LEAD AND CADMIUM STRESS

Luozhong Tang, Yong Yang, Tian Wang and Shengzuo Fang[1]

In recent years, pollution by heavy metals such as lead and cadmium in the atmosphere, water and soil has been increasing in China. Poplars and willows have special characteristics such as rapid growth and wide distribution. In the research reported in this paper, the growth responses and heavy-metal accumulation characteristics of poplar and willow seedlings exposed to lead and cadmium stress were studied using hydroponics in the greenhouse. Branches of *Populus* ×*euramericana* cv. Nanlin 895, *Populus deltoides* '35' and willow (*Salix matsudana*) were cut into 18-cm sections and grown in Hoagland's nutrient solution with lead in 0, 5, 50 and 500 mg/l concentrations and cadmium in 0, 0.5, 5 and 50 mg/l concentrations.

After two months, the experimental results indicated that:

1. Lead treatment at 500 mg/l obviously inhibited the growth of the two poplar species and the willow. However, differences in growth of poplar were not significant among the lead treatments with 0, 5, and 50 mg/l concentrations. The growth of willow was better in lead treatment at 5 mg/l than in the control. Lead content in leaves, stems and roots of the two poplar species and the willow increased with increasing concentration of lead in the culture solution. The lead content was in the order of roots > leaves > stems for the two poplar species and the willow. Lead accumulation activity was higher in the willow than in the two poplar species.
2. Cadmium treatment at 50 mg/l obviously inhibited the growth of the two poplar species and the willow. However, the growth of the two poplar species and the willow was not clearly reduced when the cadmium concentrations were less than 5 mg/l. Cadmium content in leaves, stems and roots of the willow was higher than in the two poplar species. Cadmium accumulation activity was higher in the willow than in the two poplar species.

The study demonstrated that the potential phytoremediation effect of the willow on lead and cadmium was greater than that of the poplar.

Key words: poplar, willow, seedling, lead, cadmium, phytoremediation.

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ID-068

ECOLOGICAL RESTORATION: A NEW MARKET FOR POPLARS

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The habitat directive of the European Union protects a list of threatened species and habitat types. This legislation requires that habitat types or habitats of listed species be managed in a good state of conservation. This obligation has resulted in an economic market for ecological restoration of threatened habitat. Poplars have potentials for this new market which is looking for rapid techniques for restoring and creating habitat. These new afforestations differ clearly in goal and management from classic poplar plantations.

We studied the effect of tree species, site conditions and management on the soil development, shrub and herb vegetation succession and stand structure in plantations on farmland. The soil pH under a poplar stand remained high while under nearly all other tree species soil pH decreased (5.1-5.6 *vs.* 3.8-5.0). This high pH created good opportunities for the development of a herb layer typical for natural forests. Our research showed that most ancient forest plants grew successfully under poplar afforestations. Classic poplar plantations have in general a low biodiversity; this is mainly due to management, site history and isolation from other forests, rather than related to the tree species.

It is well known that poplars grow faster than most other tree species. If the forest is not economically managed, this results in ecologically interesting forest structures (if planted 8x8m or more) with tick trees and large amounts of dead wood in a small time period. This forest structure is important for many animals like cavity-nesting birds. Also for the number of tree specific arthropods, poplars do not score lower than other tree species.

This leads to the conclusion that poplars are ideal tree species for creating or restoring new forest habitat. Old forests are in general hard to replace, and poplar afforestations do not have the same ecological value as old forests. But poplar afforestations can be used for enlarging and connecting small forest areas to bring these habitats into a favourable state of conservation. Combining poplars with other tree species will create the best options for restoring or replacing forest habitat. Most of the poplar cultivars are crosses between American and European species and are therefore considered as non-native which is the most problematic issue for using them in the perspective of nature conservation.

Key words: tree species effect, afforestation, European habitat directive.

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ID-004

MICROFLORA ANALYSIS OF POPLAR PLANTATIONS IN BEIJING

Tian Liu[1], Ren Guifang[2], Li Yong[1] and Piao Chungen[1]

An important component of the urban ecosystem, poplar plantations are the most common type of urban forest in China, determining the health and development of the urban ecosystem and human habitation. Microorganisms are the most sensitive and variable biological marker and significant index in assessing the health of urban forest ecosystems. Poplar plantations of three different ages - juvenile, middle-aged and mature - were selected for an experimental study with a total area of 20m × 30m and a total of 100-200 plants. To assess the relationship between the health of the poplar plantation ecosystem and the microbial community in Beijing, microorganisms from the air, leaves, bark and soil were investigated. Primary results indicated that microorganisms collected were mostly bacteria and fungi depending on the seasons, and the dominant species were *B. laevolacticus* and *B. maroccanus*.

In autumn, numbers of bacteria and fungi in different poplar plantations were: soil bacteria > leaf bacteria > bark bacteria > air bacteria and bark fungi > leaf fungi > soil fungi. Only bacteria were found in the air, and the quantity of these bacteria was not very different in different poplar plantations. Bark microorganisms were mainly bacteria and fungi.and their numbers varied in different parts of the bark. Leaf bacteria were most numberous in middle-aged poplar, while mature poplars were similar to juvenile poplar. Numbers of bacteria and fungi on bark were similar to numbers of leaf fungi. Compared to the surface of the plants, the quantity of soil bacteria were similar in middle age and old age poplar. However, the quantity of soil bacteria in infancy poplar was less. Numbers of soil fungi were greatest in mature poplar.

In winter, numbers of bacteria in different poplar plantations were: soil bacteria > bark bacteria > air bacteria. Because of leaf senescence, microorganisms could not be cultivated on leaves. Bacteria on bark were most numerous in mature poplar and the least in middle-aged poplar, these extremes differing by a factor of 10. Numbers of bark fungi were similar to those of bark bacteria. Soil bacteria, actinomycetes and *Bacillus* spp. were not detected in poplar plantations of different ages. The quantity of soil fungi was more than that in infancy poplar, but it was not remarkably different in three different age of poplar artificial forest.

Key words: poplar artificial forest, urban forest ecosystem, microflora analysis.

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ID-178

NUTRIENT DYNAMICS IN POPLAR AGROFORESTRY PLANTATIONS IN NORTH-WEST INDIA

Om Parkash Toky[1]

Intensive studies on nutrient dynamics have been carried out in tropical forests in India, particularly during the development of fallows through secondary succession. However, only a few comprehensive studies have been made on agroforestry systems. In agroforestry systems, the whole crop, or a part of it, is removed after a period of 4-10 years, upsetting recycling processes and depleting soil fertility, thereby making the system unsustainable. With repeated removal of biomass (from crops and/or trees), problems arise because of depletion of available phosphorus and nitrogen in the system. To maintain an optimum level of productivity and soil fertility, nutrients need to be replaced through external inputs. The strategies of trees, such as pumping of nutrients from deeper layers to the upper root zone and storage of nutrients in perennial woody components, help to restore the nutrient balance to a great extent, and hence are important aspects of nutrient cycling. The rates of transfer of nutrients from vegetation to soil and *vice versa*, as well as the re-translocation of nutrients before litter fall occurs, are other important processes. The regeneration of biomass through coppice, as is the general case for trees which are lopped frequently for fodder, fuelwood and timber, is one of the important functions of nutrient cycling. Nutrient cycling in different aged plantations of *Populus deltoides* on deep alluvial soils in north-western India has been investigated.

The present study revealed that the concentration of potassium is greatest in different parts of poplar trees and also sugarcane, both of which are important components of poplar agroforestry systems. For example, the total input of nutrients through litterfall of poplar (5 t/ha/year) alone contributed 28 kg N, 9 kg P, 76 kg K, 103 kg Ca and 16 kg Mg per ha in a 7-year old plantation in the eastern parts of Haryana; as a result, the input of nutrients from inorganic fertilizers decreases substantially compared to younger plantations (1-3 years old). The loss of nutrients through agricultural crops and timber was greatest for potassium, which would have a long-term effect on soil fertility. This is discussed in the present paper.

Key words: agroforestry systems, *Populus deltoides*, nutrient cycling, loss of nutrients.

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ID-080

EFFECTS OF MYCORRHIZAL INOCULATIONS ON WILLOW FOLIAR CHEMICAL RESISTANCE TO INSECT HERBIVORY: A CARBON ECONOMY PERSPECTIVE

Y. Toljander[1], C. Baum[2], P. Fransson[1] and M. Weih[1]

Willow species (*Salix spp*) are commercially used for biofuel production in Sweden. However, plant growth is often decimated by pests such as leaf beetles. Leaf phenolic compounds constitute important components of willow defense against herbivorous insects, and the production of these secondary metabolites is a carbon cost to the plant. Willows are mycorrhizal, and while mycorrhiza has many potential benefits to the plants, e.g. improved nutrient and water acquisition, the fungal symbiont also requires photosynthates from its host. The overall aim of this project is to investigate whether the impact of mycorrhizal symbiosis on plant carbon allocation affects the production of foliar phenolics.

In a controlled-environment experiment performed in Uppsala, Sweden, two willow varieties of the species *S. dasyclados* ('Loden') and *S. schwerinii* × *S. viminalis* ('Tora') were planted in pots containing γ-irradiated agricultural soil and inoculated with the ectomycorrhizal fungal species *Hebeloma fastibile* (Hf) and *Tricholoma cingulatum* (Tc). A non-mycorrhizal setup was included using autoclaved inoculum of Hf. The plants were grown in a phytotron and harvested after 4 months. Preliminary results show the willow varieties respond differently to inoculations in terms of growth and leaf concentrations of N and total phenolics. Under the prevailing conditions, forming symbiosis with Hf appears costly to the plants and hampers growth for both varieties. For the 'Tora' plants, total leaf phenolic concentrations were significantly lower in Hf-inoculated plants compared to non-mycorrhizal plants. The 'Loden' plants responded to Hf inoculations with lower foliar N concentrations. No such negative effects of mycorrhiza were observed following inoculation with Tc.

The willow varieties and fungal strains used in the Swedish phytotron study were also included in an outdoor pot-experiment in Rostock, Germany. Inoculated willows, grown in cages using non-sterilised soil, were harvested after 4 and 6 months. Also in this experiment, preliminary results show that different combinations of mycobiont-phytobiont give different responses in terms of plant growth and leaf concentrations of N and phenolics. For the willow varieties and fungal strains in common with the phytotron experiment, plant responses were similar, albeit not identical. The 'Tora' plants responded to inoculations with both Hf and Tc with a lower total phenol concentration in the leaves, compared to the same variety without mycorrhiza. As in the phytotron experiment, the 'Loden'-Hf symbiosis led to a lower than expected foliar N concentration. However, no reduction in plant growth was observed in this experiment. Instead, there was a clear positive impact of mycorrhiza on willow growth. This discrepancy in results between the two studies could be the result of greater light-restriction for the phytotron plants, which would lead to less carbon being available for plant growth.

In conclusion, the effects of mycorrhiza on leaf chemistry were dependent on the combination of fungal species and plant genotype, but were also influenced by the growing conditions. Ongoing research focuses on specific phenolic compounds, i.e. salicylic acid and condensed tannins, in the experiments described above.

Key words: *Salix*, mycorrhiza, plant resistance, phenolics, herbivory, carbon allocation.

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ID-098

POPLAR DEVELOPMENT IN TURKEY

Ferit Toplu[1]

Turkey is a country characterized by widely varying geographic, climatic and topographic conditions which result in a broad diversity of forest ecosystems, species and within-species variation. Four native species of poplar - Aspen (*Populus tremula* L.), black poplar (*Populus nigra* L.), white poplar (*Populus alba* L.) and Euphrates poplar (*Populus euphratica* Oliv.) - and various clones of hybrid poplar have a wide distribution in Turkey and have been cultivated for centuries. Turkey has approximately 138 500 ha of poplars in plantations and natural areas, of which 70 000 ha are hybrid poplars, 7 000 ha are aspen, 950 ha are white poplar, 550 ha are Euphrates poplar and 60 000 ha consist of various clones of hybrid poplar. Annual wood removals from poplar plantations in Turkey are 3.8 million m^3. The most widely cultivated varieties of black poplar in Turkey are *P. nigra* var. *italica*, used mostly in the western part of the country, and *P. usbekistanica* var. *afghanica*, which is more widespread. A third one is *P. nigra* var. *caudina* which is distributed in east and west Anatolia. White poplar is distributed along watercourses and in areas with difficult soils (drainage, saltiness, marshiness, heavy soil, etc.) throughout Anatolia. *Populus euphratica* is found along the Euphrate, Goksu and Botan rivers in south and southeast Turkey. Natural aspen stands can be seen in mountaineous areas throughout Anatolia.

Poplar gene resources are under threat in Turkey. The following are some factors threatening the genetic resources of native poplar species in Turkey, as elsewhere in Europe and other parts of the world. Human activities like agriculture and urbanization change the ecosystems. Especially on the Euphrate, the construction of big dams destroys native Euphrates poplar stands. Poplar gene resources have been disappearing because of overexploiting of native poplar stands for fuelwood and other wood products in rural areas. Gene introgression from cultivated clones and other poplar species is a potential threat to the integrity of native poplars. For this reason, considerable progress has been made in the conservation and identification of native poplar clones in Turkey. *Ex situ* and *in situ* conservation programmes for poplar species are in progress in Turkey.

The poplar clones used in plantations in Turkey include: *Populus deltoides* clones: Samsun (ex. I-77/51); hybrid clones: I-214, I-45/51; black poplar clones: Kocabey (ex. Tr. 77/10), Gazi (ex. Tr. 56/52), Anadolu (ex. Tr.56/75).

Research projects on poplar (selection of germplasm, nursery and field clonal trials, artificial hybridization, resistance to biotic and abiotic factors, economy, ecology, silviculture, public awareness, etc.) are under way through the Poplar and Fast Growing Forest Trees Research Institute in Izmit. In agroforestry activities, maize, beans, hazel nuts, sugar beet and tomatoes are used.

Key words: Turkey, poplar, clone*, ex-situ, in-situ*, hybrid, gene.

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ID-015

SELECTING POPLAR CLONES FOR TEMPERATE REGIONS OF TURKEY

Ferit Toplu, Teoman Kahraman and Filiz Kucukosmanoglu[1]

In this study, we evaluated poplar clones (*P. ×euramericana* and *P. deltoides*) at the juvenile stage used in the breeding program for temperate regions of Turkey. Trial sites were established using a randomized block design (4 blocks) with 226 clones at İzmit, and 162 clones at Samsun province. Selection index values of the clones were estimated using data for diameter, height and survival to compare the growth performances. Also stem form and leader shoot dominancy characteristics were determined as morphological traits. Analyses of variance were conducted on individual values for all traits to detect significant differences among the clones. If the clone means were proven to be significantly different, Duncan's multiple range test was applied to rank the clones.

Analyses of variance for selection index value, stem form and leading shoot dominancy showed significant differences at the 0,001 probability level among the clones at both trial sites. According to the Duncan test, the selection index value at the İzmit trial site was best for the *P. deltoides* clone 'Lux'. Control clones 'Izmit' (*P. deltoides*) and 'I-214' (*P. ×euramericana*) were ranked 14 and 87 respectively. At the Samsun trial site, the *P. deltoides* clone '89.M.063' was the best performer. Control clones 'Samsun' (*P. deltoides*) and 'I-214' (*P. ×euramericana*) ranked 53 and 118, respectively.

For the next stage of the poplar breeding program, 20 best performer clones were selected on the basis of selection index value and morphological traits from juvenile stage trials.

Key words: *Populus ×euramericana*, *Populus deltoides*, breeding.

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ID-044

SELECTING WILLOW (*SALIX* L.) CLONES FOR THE KIRŞEHIR REGION OF TURKEY

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In earlier research, four clone trials were established in different regions which had proved suitable for willow growth, but some years after establishment, the trees in three of the clone trials suffered from lack of water. On the other hand, at the Kırşehir-Kocabey site, there was a high water table even in summer, as well as poor drainage conditions, and trees in this trial survived well.

In the present study, growth performance (diameter, height and volume production), bole straightness and survival of the clones of the *Salix* clone trial established at Kırşehir-Kocabey in Central Anatolia were compared. The trial was established in 1988 with 27 willow clones in a randomized block design. One-year-old saplings were planted in 50-cm-deep holes.

Statistical analysis showed significant differences (at the 0.001 probability level) in diameter and height among the clones. For survival, differences were significant at the 0.05 probability level. After 14 years of measurements, clones 84/24, 84/21 and 84/30 were found to have the best. Clones 84/22, 84/24, 84/23, 84/30, 84/21 and 84/14 were the best height performers. Maximum volume production and increment was found with clone 84/24 (280.941 m^3/ha and 20.067 m^3/ha/year). Evaluation of the clones for bole straightness showed that seven clones (84/30, 84/28, 84/8, 84/4, 62/8, and 62/9) were very straight. Broad sense heritability of the clone means were found to be $H^2 = 0.90$ and $H^2 = 0.83$ for diameter and height respectively. This means considerable genetic gain could be realized by applying selective improvement methods. Expected genetic gain were found to be $\Delta G = 10.6\%$, and $\Delta G = 14.99$ for height and diameter respectively. In other words, if we use the best six and five clones on the basis of height and diameter performance of all clones, genetic gain was estimated to be 0.41 m and 2.4 cm for height and diameter respectively.

Key words: willow, breeding.

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ID-043

INCREASING THE PRODUCTIVITY OF *POPULUS* PLANTATIONS IN THE CENTRAL AREA OF CHILE

Jorge Toro[1], Luís Villacura[1,2] and Jaime Ulloa[1,3]

The Compañía Agrícola y Forestal El Alamo Ltda has a *Populus* plantation estate of 3,000 ha, planted with different varieties of *Populus*, located 320 km south of Santiago, Chile. The Company established its first plantation in 1938 and since then, the soils have been used only by *Populus* rotations and agricultural crops growing between the lines of the plantation during the first two growing seasons. The soils are quite fertile and are derived from recent volcanic ash, namely andesitic and basaltic material. The average annual rainfall is 1,000 mm, occurring mainly in the winter season, and the plantations receive a monthly irrigation from October to March.

In 2003 a progressive reduction of the yields of all varieties of *Populus* in the plantations was observed, the most evident when the plantations were entering the fourth year of growth. Once the problem was detected, the Company organized a working group to study means of controlling this phenomenon. The soils were analyzed physically and chemically and exploratory fertilizer trials were installed using the variety I-488 in an 8-year-old plantation. This variety has the lowest growth rate of all the varieties that the Company uses operationally. During the next two growing seasons, the fertilizer treatments applied in July 2004 gave on average a gain of 35% in breast-height diameter (dbh) increment, relative to the control plots. Based on these preliminary results, the Company started in 2006 to develop a programme of research seeking as a main goal to recover the growth lost and increase the volume of the plantations by an additional 30%.

The results of the research applying different site-specific silvicultural techniques have been quite interesting. It was found that mineral fertilization alone is a good option, because the three varieties of *Populus* - I-214, I-488 and I-64/51 - responded in growth diameter with increments ranging from 32% to 67%. When herbicides were applied alone without fertilizer, the average response in diameter and height was 86% and 100% respectively over control plots. When herbicides were applied in conjunction with fertilizers, the responses were higher than when either fertilizers or herbicides were applied alone. Both the diameter and height increments were more than 100%. Even the variety I-488, which generally displays the lowest growth response, increased more than 100% in comparison to the control plots.

As a conclusion, after two years of applying fertilizers and chemical weed control treatments, alone or in combination, the three most important varieties of *Populus* used by The Compañía Agrícola y Forestal El Alamo Ltda improved their growth rate, displaying a range of increment responses between 35% and 100% in both diameter and height, indicating that the problem of reduction of growth may be solved, through the combination of weed control and mineral fertilizers like nitrogen, phosphorus, potassium and boron.

Key words: *Populus*, site productivity, forest nutrition, volcanic soils.

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ID-014

LONG-TERM TESTING OF POPLARS IN RUSSIA

Anatoly Tsarev[1] and Vadim Tsarev[2]

Russia has the first place in the world in terms of area of forests (1/5 of the world's forest area), and of area and growing stock of natural stands of poplars (more than 21.5 million hectares with a growing stock of about 3.2 billion m^3). However, the distribution of forests across the country, their availability, efficiency and quality leave something to be desired. To improve the situation, in particular in densely populated regions of European Russia, plantations from tested fast-growing clones and cultivars of poplars must be created.

In order to select the most suitable clones, hybrids and cultivars of poplars in the central part of European Russia, over a number of decades the authors and their colleagues have created an experimental base consisting of 50 experimental entities. These include: 15 reproductive plantations (8.81 ha), 4 collections of clones (8.36 ha), 5 collections of more than 1000 hybrids created by the authors and their collaborators in the Central Research Institute of Forest Genetics and Breeding (5.48 ha), 4 mini-rotation plantations (1.7 ha), and 22 test plantations (70.91 ha). Most of these are located in the forest and forest-steppe zones (36 sites totalling 63.09 ha), 8 sites are in the steppe zone (12.56 ha) and 6 in the North Caspian semi-desert zone (19.61 ha).

This genetic research foundation, representing more than 300 clones and cultivars of poplars and aspen, was assembled from various regions of the former USSR and of European countries. The investigated forms were distributed among the following six morphologic-systematic groups: (i) white poplar with pyramidal crown form; (ii) white poplar with spreading crown form; (iii) black poplar with pyramidal crown form; (iv) black poplar with spreading crown form; (v) balsam poplars and their within-section hybrids; and (vi) inter-section and complex hybrids of the European poplars.

The study of growth dynamics up to age 33-35 years, phenology, resistance, bole straightness and wood quality has allowed the recognition of regular patterns in these parameters depending on age, geographic origin, ecologic-climatic conditions of growth or area of cultivation, systematic status and genetic peculiarities of poplar clones and cultivars.

The investigations allowed improved selection of clones, hybrids and cultivars of poplars for different climatic zones and types of stands.

In general, poplar clones and the cultivars originating from southern Holarctic regions, in the conditions of the central forest steppe of the European part of Russia have a longer growing season and greater resistance to drought, rust attack and damage by wind. On the other hand, they have less straight trunks, less dense wood, shorter wood fibres, and lower frost resistance. On the other hand, poplar clones and cultivars from northern regions and areas with a sharply continental climate had the opposite characteristics.

Key words: testing, selection, poplar cultivars, growth dynamics, resistance, wood quality.

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ID-003

HYBRID ASPEN (*POPULUS TREMULA* L. × *P. TREMULOIDES* MICHX.) COMPLEX STUDY PROGRAMME IN HEMIBOREAL ESTONIA

Hardi Tullus, Arvo Tullus, Tea Soo and Aivo Vares[1]

Short-rotation plantation forestry has spread from southern Europe to the Baltic Sea region, including areas that belong to the boreal and hemiboreal vegetation zone (Estonia, Finland, Latvia, Norway, Sweden and Russia). Several political and socio-economic reasons have supported such development. The EU member states have to increase the share of energy from renewable resources, including energy from woody biomass. The agricultural land use has decreased during the past decades in several countries of the region resulting in large areas of abandoned agricultural land. Forest plantations are an alternative land use option for such areas. The need for industrial timber is also rising and forest plantations provide an opportunity to reduce the timber harvest from natural forests.

Hybrid aspen (*Populus tremula* L. × *P. tremuloides* Michx.) has proved to be one of the fastest-growing deciduous trees in boreal Europe. It can be managed in 20–30 year rotations for production of pulpwood, energy wood and aspen logs. In Estonia the establishment of hybrid aspen plantations started in 1999, since when approximately 700 ha of former agricultural land has been cultivated with the hybrid. Hybrid aspen and short rotation plantation forestry in general are new subjects for Estonian forestry, also the experience of neighboring countries does not exceed half a century. Therefore a complex study programme was started in Estonian hybrid aspen plantations on abandoned agricultural land by the research group of the Institute of Forestry and Rural Engineering in the Estonian University of Life Sciences. The aim of the current paper is to provide outlines of the study programme and summarize initial results citing articles where these results have been published.

A network of 58 permanent experimental plots (each 0.1 ha in area) has been created in 24 hybrid aspen plantations on former agricultural land and in two plantations on reclaimed oil shale mine-sites. In order to develop a growth model for hybrid aspen in Estonian conditions, approximately 5,000 trees within the experimental areas have been measured twice: at ages 5 and 7 years (next measurement at age 12 yrs). As part of the plant-soil analysis, soil type according to the World Reference Base and physico-chemical soil properties have been determined. Foliar analysis will help to clarify the nutrient requirements of hybrid aspen plantations on different former field soils. Biomass productivity and wood properties (dry matter content, NPK, cellulose/lignin, calorific value) are studied in order to evaluate the removal of biomass and nutrients in harvesting. Hybrid aspen is compared with alternative tree species recommended for afforestation of abandoned agricultural lands in Estonia, e.g silver birch, alders and triploid European aspen. As one part of the programme, the natural biodiversity of forest plantations is studied, and 232 permanent vegetation-cover monitoring plots have been established. Evaluation of environmental impacts of monocultural forest plantations with half-exotic hybrid aspen covers the questions of possible gene flow towards natural aspen forests, pests and diseases, and plantations at the landscape level. Hybrid aspen is also used as a model tree in a climate change manipulation experiment (Free Air Humidity Manipulation, www.lote.ut.ee/FAHM) in cooperation with the current research programme.

Key words: hybrid aspen, plantation forestry, plant-soil relations, ecological monitoring.

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ID-082

DETERMINATION OF RESISTANCE OF SOME POPLAR CLONES TO RUST FUNGI IN TURKEY

Kazim Uluer, Fazil Selek, Faruk S. Ozay and Ayhan Karakaya[1]

Rust fungi lead to defoliation in poplar plantations and predispose plants to attacks by secondary pathogens. Rust was not previously a problem for commercial plantations in Turkey, because trees were infected only towards the end of the growing season. But since 2001 rust attacks have begun earlier causing severe defoliation in stoolbeds and poplar plantations in the Marmara region of Turkey.

The main purpose of this study was to determine the resistance of selected poplar clones at different spacings to *Melampsora alli-populina* Kleb. The trials were located in the nursery area of the Poplar Research Institute at İzmit and in the poplar plantation area at Ipsala in the Marmara region. Planting was done in the first week of March 2003 and 2007. In this study, experimental plantations were established with *P. ×euramericana* and *P. deltoides* clones (I-214, 45/51, 77/51 (Samsun), S.307.26 and 89 M.060) at four different spacings (3m×1.5m; 3m×2m; 3m×3m; and 3m×4m). Rust appeared at the end of July. In 2003, rust disease surveys were carried out twelve times during the growing season. Severity of rust infection was assessed on 24 October 2007. The reaction to natural rust infections was scored on the basis of the actual percentage of leaf area infected. To count the uredosori on the leaves, a template was used. The template had five windows, each measuring 1 cm×1 cm. The clone with the greatest number of uredosori was determined as the most sensitive clone.

Analysis of variance was used to determine the differences in resistance to *Melampsora alli-populina* Kleb. among the five selected poplar clones at the four different spacings. Rust infection was calculated by clone and spacing. According to the results of analysis of variance, significant differences in rust infection were found among clones, but not between different planted spacings. Among the five clones, 89 M.060 clone was found to be highly resistant, 45/51 and S.307.26 clones were found to be resistant and 77/51 (Samsun) and I-214 clones were found to be susceptible.

Key words: poplar, rust fungi, *Melampsora,* resistance.

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IMPACTS OF GENOTYPE OF ASPEN ON SALINE STRESS TOLERANCE

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Plants growing in their natural habitat represent a valuable resource for elucidating mechanisms of acclimation to environmental constraints. A greenhouse study was undertaken to better understand the influences of genotypes of *Populus tremula* on tolerating saline stress. The seedlings were subjected to two salt levels by addition of a solution of salt with the irrigation water for four weeks after four months cultivation. Shoot growth dynamics, root characteristics and photosynthesis capacity of *P. tremula* seedlings, as well as ectomycorrhizal (ECM) fungal colonization intensity and diversity, were investigated during the cultivation period. Significant differences in growth rate of shoots among the 12 tested genotypes of *P. tremula* were found during the early stage of cultivation. However, the differences in growth rate among those genotypes decreased from the third month of cultivation. The salt level had a strong influence on the growth rate of shoots, and the dry weight of above-ground and below-ground parts of the plant. Variation among different genotypes of *P. tremula* in response to saline stress was, however, detected. The photosynthetic capacity of plants measured by chlorophyll florescence of leaves did not decrease during four weeks of saline treatment. There was significant difference on ECM fungal colonization intensity among different genotypes of *P. tremula*. Visual inspection of saline stress symptoms correlated negatively with growth rate of shoots and dry weight of both above-ground and below-ground parts. This study indicates that there was variation in saline tolerance among *P. tremula* genotypes. Shoot growth dynamics and root characteristics of young seedlings are good indicators for screening aspen genotypes suitable for phytotechnologies.

Key words: aspen, ECM, genotype, phytotechnologies, saline, variation.

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ID-089

DEVELOPMENT OF DECAY IN PRESERVATIVE TREATED POPLAR PLYWOOD

Joris Van Acker[1]

Poplar is a fast growing species and may in future become more important for both the conversion of agricultural crops and the self supplying policy of the European Union. In Flanders, the northern region of Belgium, poplar has become a widely spread species. It provides approximately one third of the wood volume produced while covering merely 10% of the forest area. Poplar has also very interesting wood properties. Besides a range of specific end products as a light hardwood, it is most suitable for the production of plywood.

Yet poplar is very vulnerable to the attack of wood destroying organisms, such as wood rotting Basidiomycetes. Therefore poplar plywood should be preserved in all cases where a sufficient service life is at risk. The research described here focuses more in particular on the preservative treatment of assembled poplar plywood.

Despite poplar plywood being easily treatable, standard retentions for different preservatives do not always result in good protection. To achieve full biological protection of poplar plywood a high loading of preservative is required. The glue-line in poplar plywood does not cause significant problems but it certainly needs consideration.

When translating toxic thresholds derived from toxicity testing to practical retention requirements, it should be realised that no unique 'multiplication' factors can be established. For special wood products like preservative treated plywood, it is important to evaluate the biological durability of the commodity and it should be recommended to introduce a commercially viable quality mark, too.

Poplar plywood is considered the most suitable hardwood plywood to be upgraded by means of a preservative treatment. It is easy treatable and its susceptibility to degrade by the white rot fungus *Coriolus versicolor* is lower than for plywood made of low density tropical wood species.

Key words: poplar plywood, service life, preservative treatment, efficacy testing.

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ID-237

FUTURE IMPACT OF POPLAR AND WILLOW ON THE EVOLVING EUROPEAN FORESTRY-WOOD INDUSTRY CHAIN

Joris Van Acker[1] and Lieven De Boever[2]

Due to many .factors, the European forestry-wood industry chain is rapidly evolving. The rapid increase in demand for wood is profoundly changing the balance of the sector. This effect is increased by new emerging markets such as bio-energy and wood-polymer composites using the same source of raw material. Factors such as new plantation timber, the mobilizing of currently underused forest areas, environmental issues, price levels and wood quality discussions are the main driving forces that influence the complex forestry-wood industry chain. In filling the gap between demand and supply of wood resources, planted fast-growing stands will play an increasing role. The planted area is mostly in Asia and there is actually very little in Europe and North America. Questions can be raised as to how Europe will provide the industry with raw material in the future.

The major poplar-producing and -processing countries in Europe are Italy, Spain, France, Hungary and Belgium. In total they represent almost 700 000 ha of poplar plantations, yielding a yearly harvest of around 9 million m³. Two trends will clearly change the position of poplar within the European forestry-wood industry chain. In traditional poplar-processing countries such as Italy, France and Belgium, a large gap is growing between the processing capacity and the local availability of suitable logs in terms of both quantity and quality. The main reason for this is environmental criticism of the sustainability of fast-growing plantations. The exotic origin and monoclonal character of most poplar plantations were considered the most negative aspects of poplar cultivation. Using several poplar clones in polyclonal plantations, including also the more indigenous willow clones, and the renewed discussion on carbon sinks could alter the balance again in the future. Replacing other more energy-consuming materials such as concrete and steel with wood will have positive effects on achieving Kyoto goals. It could be summarized as “save the environment, use wood”. On the other hand, former ‘eastern’ European countries, such as Hungary, the Czech Republic and Romania, have greatly extended their poplar plantation area in recent years, but industry is following much more slowly, resulting in significant export volumes to other European countries, mainly Italy. A final unknown impact remains the increased demand for woody biomass for energy production. Poplar and willow will definitely play an important role in satisfying these future demands.

Europe needs a clear strategy to describe the place that plantation-grown timber should take within the forestry-wood industry chain. However, production of large wood volumes to fill the existing gap between demand and supply should not only focus on quantity. Hereby, options for technological improvement become more important in order to use lower quality material in higher-value-added products as well. This strategy should aim at securing local supplies of adequate raw wood material and maintaining as well as extending the already vast knowledge in poplar processing.

Key words: European forestry-wood industry chain, plantation timber, poplar and willow wood, sustainability.

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ID-184

INTERSPECIFIC CROSSABILITY STUDIES PROVIDE INSIGHT INTO THE RISK OF GENETIC EXTINCTION OF EUROPEAN BLACK POPLAR (*POPULUS NIGRA* L.)

An Vanden Broeck, Boudewijn Michiels, Paul Quataert and Jos Van Slycken[1]

Besides habitat destruction and modification, hybridization and gene flow from domesticated poplars may have substantial impact on the evolution of native poplar populations. This may be particularly the case for rare native poplar species like the European black poplar (*Populus nigra* L.) coming into contact with abundant domesticated poplar plantations.

In a previous study, we found evidence for natural hybridization between cultivated clones of *Populus* × *canadensis* Moench. and native *Populus nigra* L. in Belgium. The objective of this study was to improve insight into how interspecific pollen interactions (i.e. mixtures of pollen of cultivated hybrid *Populus* × *canadensis* and native European black poplar) affect siring success of the European black poplar and the frequency of hybrid formation. Crossing relationships between European black poplar and clones of *P.* × *canadensis* were studied in greenhouse experiments during the period 2005-2008 with 47 hand-pollinated controlled crosses using pollen mixtures. Hybridization events and paternity of the seedlings were defined by using molecular micro-satellite markers. Hybridization events obtained under controlled conditions in the greenhouse were compared with those under field conditions by analysing open-pollinated half-sib progenies of black poplar females located in Belgium.

When pollen of the hybrid poplars were included in the pollen mixtures, the controlled pollinated female black poplars produced significantly lower numbers of seeds compared to the controlled crosses with black poplar pollen alone. The results indicate that hybridization of *P.* × *canadensis* can pose a threat to native black poplar populations even if gene pools do not mix. The presence of hybrid plantations of *P.* × *canadensis* near natural black poplar populations can result in a waste of reproductive effort of the native black poplar populations and therefore hasten extinction of populations, even if gene flow does not occur.

Key words: hybridization, controlled crosses, *Populus nigra*, *Populus* × *canadensis.*

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TRADITIONAL AND ADVANCED MECHANIZATION IN POPLAR PLANTATIONS: ANALYSIS OF NINE LOGGING SYSTEMS

Stefano Verani[1], Giulio Sperandio[2] and Giuseppe Nervo[1]

The main objective of our work was to verify through technical and economic analysis the sustainability of introducing advanced mechanization in poplar plantation logging in Italy. Nine logging systems, with different levels of mechanization, were analysed and compared, taking into account technical and economic parameters. From the economic point of view, the system with advanced mechanization offered interesting profitability with 32.18% return on investment (ROI) for an average capital investment of 370,000 €, while for the traditional logging system the ROI is 17.46% for an average capital investment of 50,000 €.

From the technical point of view, 68 hectares per year were harvested using the advanced system, while 17 hectares per year were harvested using the traditional system. The results hint at the very high potential of advanced mechanization in the management of poplar plantations.

Key words: mechanization, poplar plantation, technical parameters, economical analysis.

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ID-081

REHABILITATION OF THE EUROPEAN BLACK POPLAR (*POPULUS NIGRA* L.): CASE STUDIES FROM ITALY, BELGIUM AND GERMANY

Lorenzo Vietto[1], An Vanden Broeck[2], Kris Van Looy[2], Michael Tautenhahn[3] and Pier Mario Chiarabaglio[1]

Floodplain forests are among the most diverse and important ecosystems in Europe and the European black poplar (*Populus nigra* L.) is very likely the tree species most representative of these riparian habitats. As a typical pioneer species, it is tightly linked to the river dynamics. It dominates, together with other members of the *Salicaceae* family, the early successional stage of the riparian forests. It is a tree of social and economic interest and of ecological importance as a biodiversity indicator; moreover riparian areas contribute to the natural control of flooding (slowing run-off that is accelerated by paving of urban areas) and to water quality (filtering chemicals and excess nutrients coming from agricultural lands).

Nowadays black poplars are considered among the most threatened tree species in Europe. Riparian areas are commonly impacted by human activities and, as a result of many centuries of overuse (agriculture, urbanization, mining, flood control), a large area of freshwater habitats has disappeared. Moreover, native poplar resources have often been replaced by more productive hybrid poplar stands, and gene introgression from exotic hybrids from pure *P. nigra* varieties like Lombardy poplar is also a potential threat to black poplar. Initiatives are underway in many countries to protect its germplasm and to implement conservation strategies (EUFORGEN Programme, Scattered Broadleaves Network).

Conservation of riparian habitats is a high priority in Europe and the restoration projects aiming to re-establish river ecosystems can also effectively contribute, on appropriate sites, to the *P. nigra* conservation. To restore riparian woodlands as natural corridors, black poplar is extremely important and by planting such a pioneer species a permanent forest cover can be re-established over a short period.

Three case studies of black poplar rehabilitation projects along the River Po in Italy, the River Meuse in Belgium and the River Oder in Germany are discussed. The genetic origin of the plant material, site preparation, planting methods, after-planting care, success rate and future management activities are described.

Key words: *Populus nigra*, black poplar, river restoration, riparian forests, introgression, EUFORGEN.

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AN OVERVIEW OF *POPULUS* GENETIC RESOURCE IN SOUTHWEST CHINA

Xueqin Wan[1], Fan Zhang, Yu Zhong, Changliang Wang, Yunhai Ding and Tingxing Hu

There is abundant genetic resource of native poplar in southwest China, which plays an important role in scientific research and practical application. But this resource is unfamiliar to the rest of the world, and its value has not been appreciated by most poplar researchers. The aim of this paper is to present the resource to the world, and to invite more people to pay attention to its conservation and utilization. The value, classification, distribution, adaptability, growth, conservation and utilization of the resource are sequentially discussed in the paper.

There are 28 species, 20 varieties, and about 10 natural hybrids in the region. Of the 28 species, 25 are endemic to China, and 17 of them are indigenous to southwest China. Although there have been many studies on the classification of *Populus*, some contradictions still exist. A new taxonomic system proposed by Neng Chao classified the *Populus* in southwest China into 20 species and 22 varieties. Based on the evidence of fossils, paleogeography, paleoclimate, spore zone and modern distribution, it is preliminarily deduced that *Populus* may have originated in the southwest and middle regions of China in the late Cretaceous, and Kangding county of Sichuan province could be regarded as a distribution and variation centre for section Tacamahaca in China.

The species of *Populus* in southwest China show an obvious zonation on horizontal and vertical distribution, and fall into three types of plant flora: China-Japan, China-Himalayas, and approximate ancient tropical zone. They can adapt to a variety of environments ranging from warm-humid low mountains to dry hot valley, and from warm-humid canyon to high cold plateau, and usually have stronger resistance to biotic and abiotic stresses than introduced poplar. There are distinct variations in growth rate among the species, and some species have an excellent growth in diameter and height of up to 3 cm and 3 m per year, respectively. At present, only a small quantity of the resource receives people's recognition, and is grown and utilized to some extent, while most of it is in a state of wildness and face severe threat. With the rapid expansion of the Chinese Western Development Program, extensive construction of hydropower, traffic, mining, tourism and urbanization has brought a severe damage to the resource. Without sufficient attention to conservation, the valuable resource would gradually reduce and even disappear. Therefore it is urgent to recognize, conserve and utilize the poplar resource in southwest China.

Key words: native poplar, genetic resource, southwest China.

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ID-179

INDUCTION OF UNREDUCED EGGS VIA MITOTIC INHIBITION DURING EMBRYO SAC DEVELOPMENT AND TRIPLOID BREEDING IN *POPULUS* (SECTION TACAMAHACA)

Jun Wang, Xiangyang Kang, Daili Li, Hongwei Chen and Pingdong Zhang[1]

Triploid cultivars of *Populus* have many desirable properties in growth and pulpwood characteristics compared to diploid clones. Fertilization of a 2n egg with n pollen may be the most valuable mode for triploid production, because 2n pollen does not compete well with n pollen. After mega-sporogenesis in angiosperms, the haploid megaspore undergoes one or more rounds of mitosis to form a mature mega-gametophyte. These mitotic rounds contribute the potential to produce 2n eggs during embryo sac development. To prove this possibility and obtain triploid plants, female catkins under embryo sac development of *Populus pseudo-simonii* × *P. nigra* var. *lica* were treated with colchicine solution, and the induction of 2n eggs was estimated by triploid production in progeny.

Through pollen germination tests on stigmas of catkins, we found that the catkins had optimal stigma receptivity at 5.62±0.47 cm long 84 hours after they emerged from their bract scales. The paraffin sectioning technique showed that embryo sac development of *P. pseudo-simonii* × *P. nigra* var. *lica* initiated 12 hours before pollination and finished 132 hours after pollination. It was a successive and asynchronous process. After pollination on catkins with optimal stigma receptivity, the catkins were treated with colchicines every 6 hours. Twenty-three triploids were detected in the progeny and the rate of triploids was up to 66.7% in one treatment. The rate of yield of triploids was positively correlated with the frequency of four-nucleate embryo sacs (r = 0.6660, p = 0.1024). Generative cell division of pollen of *P.* ×*beijingensis* took place 3-16 hours after pollination. It did not coincide with the period of triploid production. This suggests that 2n eggs are induced through treating the developing embryo sacs and that the third mitotic division of the embryo sac may be the effective stage to induce 2n eggs.

In conclusion, a novel approach for 2n egg induction in *Populus* was found, which can produce completely homozygous 2n eggs. It will have promise in improvement and genetic research on trees and crops.

Key words: 2n eggs, embryo sac development, *Populus*, section Tacamahaca, triploid breeding.

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ID-147

VARIATION IN POLLEN AND ITS CYTOLOGICAL MECHANISM IN AN ALLOTRIPLOID OF CHINESE WHITE POPLAR

Jun Wang[1], Xiangyang Kang[1] and Qi Zhu[1]

Allotriploids of Chinese white poplar (*Populus tomentosa* Carr.) are one of the most important types of trees in the north of China. The hypothesis of a triploid bridge implies that triploids can be a transition in the production of a new polyploidy through their fertile gametes. In this investigation, microsporogenesis and pollen variation were studied using the squash technique and indirect immunofluorescence, to contribute to the further improvement of white poplar.

The allotriploid studied here is from a cross between a hiploid egg of *P. alba* × *P. glandulosa* and diploid pollen of *P. tomentosa*. In the allotriploid, most of the pollen grains were viable and only 9.7% were shrivelled and unstainable. The diameters of stained pollen grains ranged between 23.2 μm and 72.9 μm with an average of 36.95 μm (± 0.21). The distribution of pollen sizes was not bimodal, but trimodal at 33.5 μm, 38.5 μm and 52.5 μm.

There were plenty of meiotic abnormalities, which resulted from coaction between the heterozygosity and polyploidy of the allotriploid. Univalents, bivalents, and multivalents were observed at diakinesis. At metaphase Ⅰ, some chromosomes precociously migrated to the poles, and even multiple spindles formed. Lagging chromosomes and bridges were observed at anaphase I. The lagging chromosomes formed micronuclei in telophase I. The fate of these micronuclei was decided by the microtubular system. Some micronuclei were controlled by microtubules. They took part in the second division, and formed microcytes in the meiotic products. The other micronuclei lacked action of microtubules. These might be assimilated by cytoplasm or stay in the microspores together with primary nuclei after meiosis. Abnormal orientations of spindles were determined in the second meiotic division. Besides spindles with a certain angle, parallel spindles, fused spindles, tripolar spindles and multiple spindles were found in metaphase Ⅱ. Consequently, there were monads, dyads, triads, tetrads and polyads in the meiotic products.

Meiotic cytokinesis is involved in the nuclear-based radial microtubule systems (RMSs). Lack of RMSs in some microsporocytes at telophase Ⅱ was found, which resulted in the aberrant cytokinesis. The aberrant cytokinesis caused the production of monads and the increased frequency of dyads and triads.

Key words: allotriploid, cytokinesis, meiosis, microtubule, pollen, Chinese white poplar.

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ID-148

INFLUENCE OF ENDOGENOUS PLANT HORMONES ON ROOTING OF HYBRID ASPEN IN TISSUE CULTURE

Qiuyu Wang and Chuanping Yang[1]

Plant hormones are metabolic products as well as substances which regulate plant growth. They also have a noticeable influence on plant morphology and growth on rooting of propagules when used during breeding.

In this paper, one clone of transgenic hybrid Aspen - *P. tremula* × *P. tremuloides* - from tissue culture was used as the test material and its non-transgenic ramets were used as the control. The endogenous plant hormone content of different rooting types, such as rooting and non-rooting types of transgenic aspen, direct- and callus-rooting types of non-transgenic aspen, were measured by means using the ELISA method. The objective was to study the interaction between the hormones, and to determine the endogenous plant hormone influence on rooting of hybrid aspen in tissue culture.

The results indicate that rooting of transgenic plants was great influenced by phytohormone content in the ramets, especially the level of IAA and ABA. IAA and ABA contents in the rooting ramets were much lower than in the non-rooting ramets. GA content among the rooting ramets is slightly higher than that among non-rooting ramets. On the other hand, for the non-transgenic plants, independently on whether the ramets were direct- or callus-rooting, content of GA was always highest, ABA was next, and IAA was lowest. The contents of all three kinds of phytohormone were generally higher in direct-rooting ramets than in callus-rooting ramets. This shows that gene transformation causes great changes in the phytohormone levels of hybrid aspen.

The endogenous ABA induces transgenic ramets to produce roots when the concentration is 150ng/g fw. Differences in endogenous IAA concentration have a distinct influence on the rooting of transgenic and non-transgenic plants, and rooting is generally improved at the level of approximately 200ng/g fw. The levels of endogenous GA are comparatively stable in hybrid aspen and have less influence on rooting. Plants with lower IAA/ABA ratios, and higher GA/ABA and GA/IAA ratios, have better rooting rates.

Key words: transgenic aspen, ELISA, endogenous plant hormones, rooting.

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ROOT GROWTH AND LEAF BIOCHEMICAL REACTIONS IN RESPONSE TO SOIL DRYING IN *POPULUS EUPHRATICA* OLIV.

Tianxiang Wang and Huafang Wang[1]

Populus euphratica Oliv. is the oldest and a uniquely dominant tree species in desert areas in China. Its strong stress-tolerance mechanisms may, to some extent, give it a special and important role in improving tree adaptability to harsh site conditions, such as drought, salinity and cold stress. Many scientists worldwide have paid focused on exploring plant tolerance mechanisms.

This paper focuses on plant root growth and leaf biochemicals in response to soil drying. Methods used in the study included investigation of plant root growth in the field, growing the plant under simulated field conditions in the laboratory. Root growth, activities of several enzymes and concentrations of soluble compounds in oxidation and anti-oxidation reactions were determined.

It was found that a hard calcareous chemical sediment layer exists at a depth of 60 cm below the soil surface. The roots of the *P. euphratica* could grow directly to groundwater and pass through the calcareous layer to deeper soil layers. In experimental system in the laboratory, with soil moisture (Soil Water Content, SWC) reduced from 4.5% to 0.7% ($g_{water}/g_{(water+soil)}$ %), the activities of enzymes PPO, SOD, POD, and CAT catalyzing anti-oxidation reactions in leaves were reduced. In contrast, the concentrations of soluble compounds, proteins, proline and MDA increased. However, as the soil moisture decreased between SWC 1.6% and 1.45%, the activities of all the enzymes and the concentrations of the soluble compounds dramatically reduced to the minimum and then increased quickly to high levels like V type in curve. Then, enzyme activities and soluble compound concentrations decreased as SWC decreased further. At SWC, with the lowest activities of enzymes and concentrations of soluble compound, many new fine roots appeared in clusters.

Key words: *Populus euphratica* Oliv., drought tolerance, enzymes, protein, praline, MDA.

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ID-249

COMPARATIVE GENOME MAPPING OF *POPULUS ADENOPODA* × *P. ALBA*, *P. DELTOIDES* × *P. EURAMERICANA* AND *P. TRICHOCARPA*

Yuan-Xiu Wang, Ming-Xiu Wang, Min-Ren Huang and Li-An Xu[1]

Poplar has been accepted as a model system for the study of perennial woody plants, mainly due to its rapid growth, rapid seed formation, small genome size (~550Mbp) and superior genomic and molecular foundation: good reference maps, whole genome sequence, co-dominant molecular markers and large EST database. Among *Populus* species, *P. adenopoda* and *P. alba* belong to the Section *Populus* which is the most primal population and is important in evolution and phylogenetics of *Populus.*

We report a molecular genetic linkage map for an inter-specific F1 hybrid population between *Populus adenopoda* × *P. alba* by means of a two-way pseudo-test cross mapping strategy. A total of 122 markers were available for mapping on the maternal *P. adenopoda*. Thirty-one linkage groups were constructed with map length between 2.1 cM and 153.7 cM, 59.90 cM being the average group length. A total of 1857 cM was observed for the *P. adenopoda* map. A total of 153 markers were available for mapping on the paternal *P. alba*. Thirty-five linkage groups were constructed with map length between 14.2 cM and 257.4 cM, 64.95 cM being the average group length. A total of 2273.1 cM was observed for the *P. alba* map.

Comparison of the *P. trichocarpa* reference map and the 2 parental maps revealed 181 homologous markers, 107 of them common to the female map and 127 to the male map. Sixteen and seventeen homological linkage groups were aligned in *P. adenopoda* and *P. alba* maps respectively. The orthologous markers showed higher synteny and co-linearity between the three maps. Seventy-one of 107 homologous markers between the *P. adenopoda* map and *P. trichocarpa* reference map and 90 of 127 homologous markers between the *P. alba* map and *P. trichocarpa* reference map were at higher synteny. Sixty-three of 71 and 78 of 90 respectively in the *P. adenopoda* and *P. alba* maps were at higher co-linearity.

The *P. deltoides* (clone `I-69') and *P. ×euramericana* (clone '1-45') maps of this comparative analysis were kindly provided by Dr. Zhang Bo. They were constructed in our laboratory using the same strategy. Comparison of these 4 maps revealed 42 SSR common markers. Five of them were common to the 4 maps, 16 markers were found on 3 maps and 12 markers were found only on 2 maps. Nine markers were mapped on different linkage groups among the 4 maps and 7 linkage groups had no common markers.

Finally, we aligned the *P. adenopoda* and *P. alba* maps with the *P. deltoides* and *P. euramericana* maps and the *P. trichocarpa* reference map. The co-alignment of these 5 maps revealed 345 common markers. Only three markers were present on all 5 maps, 19 markers were common to 4 maps, 93 markers were common to 3 maps, 178 markers were common to 2 maps and 52 markers were mapped on different linkage groups. The marker order was conserved in most of the cases.

Key words: *Populus*, genetic map, SSRs, comparative map, synteny, collinearity.

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ID-141

CLONING OF TWO HIGHLY SIMILAR DREB-RELATED GENES IN *POPULUS HOPEIENSIS* AND THEIR EXPRESSION PROFILES UNDER ABIOTIC STRESS

Zeliang Wang, Xinmin An, Bo Li, Yuanyuan Ren
and Zhiyi Zhang[1]

Plants are exposed to environmental stresses such as drought, high salt, and low temperature, which cause adverse effects on the growth of plants and the productivity of crops. Being sessile, they have adapted to respond to these stresses at the molecular and cellular levels as well as at the physiological and biochemical levels, thus enabling them to survive. A number of genes are regulated by these stresses, and function not only in stress tolerance but also in the regulation of gene expression and signal transduction in stress responses. Among these, the dehydration-responsive element-binding factor (DREB) is a plant-specific family of transcription factors which plays an important role in plant response and adaptation to abiotic stress.

In the present study, two highly similar CBF/DREB1-like genes sharing 95% overall amino acid sequence identity with each other, were cloned from *P. hopeiensis* and designated as *PhCBF4a* and *PhCBF4b*. These two genes contain all conserved domains known to exist in other CBF/DREB1 genes. In the AP2 domain, there is only one different amino acid residue between *PhCBF4a* and *PhCBF4b*, Alanine or Valine, the non-polar amino acid, suggesting that *PhCBF4a* and *PhCBF4b* may have similar DNA-binding ability. A comprehensive phylogenic analysis revealed that the CBF/DREB1-like genes underwent complex events of duplication and divergence in plants. Real-time quantitative analysis showed that expression of *PhCBF4a* and *PhCBF4b* is strongly induced by cold stress, but only mildly by drought, abscisic acid (ABA) and salinity, although their expression patterns are slightly different. Moreover, gene-specific amplification from genomic DNA demonstrated that the same two products as those in *P. hopeiensis* are present in *P. suaveolens*, but that only one of the two products are present in *P. tomentosa* 'LM50', *P. deltoides* 'T66', *P. davidiana*, implying that *PtCBF4a* and *PtCBF4b* may be a pair of alleles. Their detailed functions are discussed and remain for further study.

Key words: CBF, DREB, abiotic stress, *Populus hopeiensis*.

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COLD TOLERANCE FACTORS, THE CBF GENE AND ITS APPLICATION IN WOODY PLANTS

Zhanbin Wang, Lianrong Feng and Zhe Huang[1]

Temperature is an essential factor in plant growth, low temperature being one of the important environmental stress factors for plants. More and more cold-resistant genes have been discovered, some related cold-resistance genes transferred into plants and cold-tolerant transgenic plants reported. Furthermore, transferring the transcription activator of a COR (cold-regulated) gene has become a new pathway. The CBF (C-repeat binding factor) gene recognizes and specifically binds with the cis-acting element of CRT/DRE (C-repeat/dehydration responsive element) in the COR gene promoter region, to induce the expression of the CBF gene, thereby enhancing cold resistance. CBF genes can improve plant resistance traits synthetically and it is one of the most important current research topics in molecular breeding.

In this study, the CBF3 (CRT/DRE-binding factor) gene of *Vitis amurensis* was cloned and analyzed. The main results of this study were as follows:

1. The complete cDNA was cloned and analysed (EU672969). The gene size is 854bp, its coding area has 720 bases, its protein consists of 239 amino acids. The protein relative molecular weight is 25914.7, its isoelectric point 7.02, aliphatic index 59.29, grand average of hydropathicity -0.551. The protein secondary and third structures of CBF3 were forecast and analyzed, and its protein is unstable.
2. The prokaryotic expression vector pGEX-4T-CBF3 of *Vitis amurensis* was constructed. It was transformed into the expressing host cell *Escherichia coli* BL21(DRE3). The bacteria was induced by 1mM IPTG, the result showing that transformed bacteria expressed 52KD fusion proteins after SDS-PAGE.
3. The plant expression vector pRCBF3 of *Vitis amurensis* was constructed, and it was transformed into *Agrobacterium* LBA4404, the gene being introduced into poplar genome now.

According to the function of CBF genes, we consider that CBF transcriptional activator over-expression in transgenic plants will lead to various physiological and biochemical changes under low temperature and other stress environments if the CBF gene is introduced into poplar. Many kinds of LEA protein or hydrophilic polypeptide-encoding production, proline and many kinds of simple carbohydrate macro-molecules can synthesize and accumulate. These may transfer into the vacuole through vacuole encytosis, which means that poplar can acquire more cold tolerance through “over cold”. Moreover, studying cold tolerant poplar through CBF gene application may provide good technical support for xylophyta stress resistance research and application.

Key words: *Vitis amurensis*, CBF3 gene, gene clone, prokaryotic expression.

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EFFECT OF PLYWOOD TECHNOLOGY ON POPLAR VENEER LINEAR EXPANSION COEFFICIENT

Zhiqiang Wang[1], Xiaoning Lu[1] and Guobing Xiong[1]

In an environment of constant temperature and increasing humidity, the hygroscopic deformations of poplar veneers, which were treated by different glue spreading and hot pressing technologies, were tested in the longitudinal, transversal and thickness directions.

The results showed that in the range of moisture content from 0 to 25%, the veneer hygroscopic expansion coefficient can be regarded as constant. Besides, the technology factors including glue spreading, pressure and adhesive type affected veneer transversal and thickness hygroscopic expansion coefficients significantly. The lower molecular weight of Phenol-formaldehyde (PF) affected veneer hygroscopic expansion property more than that of Urea-formaldehyde (UF). The compressed veneer showed higher hygroscopic expansion in the thickness direction, but a lower hygroscopic expansion in the longitudinal and transversal directions.

Key words: plywood technology, linear expansion, poplar veneer.

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ID-245

BREEDING FOR HIGH AND SUSTAINABLE BIOMASS PRODUCTION OF *SALIX*: BRIDGING MOLECULAR GENETICS, ECOPHYSIOLOGY AND ECOLOGY

M. Weih[1], A-C. Rönnberg Wästljung, C. Björkman, S. Larsson, J. Stenlid, I. Åhman and S. v. Arnold

The culture of perennial biomass crops, such as *Salix*, on agricultural land is a viable alternative for the production of bio-fuels. Commercial production systems for willow short-rotation culture have been developed and put into practice in Sweden. However, breeding histories of the most promising perennial crops, among them *Salix*, are short and there is still a great potential for significant crop improvements. A national Swedish breeding project was started in 2007, in close collaboration with a commercial *Salix* breeder, and the focus is to develop breeding tools for rapid improvement of *Salix* grown for energy purposes. The final goal is to develop molecular markers and tools to introduce the marker-based information into the commercial breeding process.

A first subproject focuses on the genetic background for important plant traits affecting the long-term biomass production. Genetic linkage maps are being constructed for two *Salix* families using SNP and micro-satellite markers. The linkage maps will be used for quantitative trait loci (QTL) analysis. In perennial crops, a pre-requisite for successful breeding is the availability of simple test methods for rapid assessment of long-term genotype performance in large breeding populations. Thus, a separate subproject addresses the identification of relevant growth and resource economy traits easy to measure in populations of many genotypes.

Heavy defoliation by leaf beetles and their larvae or infestation with leaf rust may greatly reduce *Salix* biomass production. One aim of a third subproject is to analyze the heritability of and identify genetic markers for resistance against leaf beetles. Particular focus is on the part of the resistance that may operate indirectly through natural enemies. Also improved resistance to leaf rust is addressed within this part of the project.

Another important part of the project is the application of genetic markers in practical breeding, and a final synthesis subproject will focus on the integration of the various project parts.

Key words: biomass production, breeding, leaf beetles, leaf rust, marker-assisted selection, development of methods, nutrient-use efficiency, pest control, QTL, *Salix*, water-use efficiency.

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THE USE OF FAST-GROWING WOODY ENERGY CROPS FOR BIOREMEDIATION OF SEWAGE EFFLUENT

Astrid Werner[1] and Alistair McCracken[2]

The concept of using short rotation energy crops as biofilters to polish nutrient-rich waste-water addresses two important environmental problems: nutrient-enrichment of natural water-bodies and atmospheric carbon enrichment due to the use of fossil fuels. Short rotation coppice (SRC) willow and poplar have the ability to take up large volumes of water and therefore are well suited to be used as biofilters for treating effluents containing high levels of inorganic nutrients. In Ireland, there are large numbers of small, inefficient water treatment works and septic tanks producing sewage effluents, which cannot be discharged safely into waterways. A SRC biofiltration system may offer a cost-efficient way for treating such effluents in order to comply with European Water Directives. At the same time, SRC energy crops offer a carbon-neutral biofuel source.

As part of the EU-funded project "Water Renew", a trial site was established in 2005 at Culmore, Co. Londonderry, Northern Ireland at a short distance from a wastewater treatment plant. SRC willow and poplar, and grass as a non-woody control, were compared in their efficiency to remove inorganic nutrients from primary sewage effluent, which was applied via a drip-feeding irrigation system. A non-irrigated block served as a control. Soil water was collected every two weeks and analysed for different plant macro- and micro-nutrients, and selected heavy metals. Groundwater was monitored frequently for potential leaching. Soil and plant tissue samples were taken periodically for analysis. In 2007, sewage effluent was applied from mid-June until the end of October, suspended during the winter and resumed in June 2008.

In 2007, high volumes of sewage effluent were applied with 223 kg ha^{-1} N and 90 kg ha^{-1} P over 14 weeks of effective irrigation. Soil water analysis showed that nitrogen and phosphorus were removed efficiently from the effluent applied to the three test species. No leaching into groundwater was observed. There were significant changes in the levels of some macro-nutrients, such as potassium, magnesium and calcium, which increased with the onset of effluent application. However, the increase was not in every case the consequence of high input levels but rather altered ion-exchange ratios. Nutrient levels remained elevated for some weeks after the end of irrigation but no increased nutrient levels were found in groundwater. A decrease in soil water pH and a significant increase in electrical conductivity were observed with progressing irrigation. High sodium input via sewage effluent application led to these changes in conductivity. Highest levels of sodium were found in soil water and soil samples from the poplar plot compared to willow and grass plots indicating that poplar has the least ability to remove/utilise sodium. During winter, high rainfall resulted in waterlogging of extended areas of the whole trial. But groundwater and soil analysis showed that sodium accumulation in the soil did not lead to leaching into the groundwater. Effluent volumes were increased during the irrigation period in 2008 to investigate when nutrient overload of the plant/soil bioremediation system leads to leaching.

Key words: SRC willow and poplar, sewage effluent, bioremediation, inorganic nutrients.

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ID-095

STUDY ON VARIATIONS OF MODIFYING POPLAR WOOD WITH PF RESIN

Yan Xia[1] and Xiaoning Lu[1]

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Poplar wood is modified with PF resin, that is fixed in wood by drying, resulting in modified poplar wood. The results show that PF resin can impregnate into poplar wood efficiently. As such, the physical and strength properties are improved. The density of modified poplar wood is more homogeneous, and the variability in impregnation uptake (WPG) was large. Analyzing the relationships between wood properties and different dimensions with the WPG, the impregnation result was influenced significantly by different plants and wood textures. Effects on the physical strength properties are different; the method chosen should be based on the importance of the properties needed for a specific production.

Key words: PF resin, poplar wood, modified poplar wood, impregnation, diversity of impregnation.

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GENOMIC SURVEY AND GENE EXPRESSION ANALYSIS OF THE COBRA GENE FAMILY IN *POPULUS TRICHOCARPA*

Ye Xia[1] and Zong-Ming (Max) Cheng

The COBRA and COBRA-like genes encode plant-specific glycosylphosphatidylinositol (GPI)-anchored proteins. COBRA genes play important roles in primary cell wall formation, and in the regulation of cell expansion orientation and cellulose deposition in the secondary cell wall in plants, as well as in root morphology. They are regulated developmentally and in response to a variety of environmental stimuli.

In the research described in this paper, we extracted all 18 COBRA genes from the completely-sequenced *Populus trichocarpa* genome database, and compared them with those in *Arabidopsis* in terms of sequence similarity, phylogeny, gene structures, and protein motif structures. The 18 members of the poplar COBRA family are divided into two subgroups, with 14 and 4 members respectively. PtCOBRA genes are dispersed across the genome, with nine of the 18 being located on seven chromosomes and nine of the 18 being in four scaffolds which have not been assigned to specific chromosomes.

The subgroup I proteins have similar protein structures to the AtCOBRA subgroup I, and possess a significant potential for the GPI-modification site. The subgroup II proteins are 45% longer than subgroup I proteins, lack a ω-attachment site at the C terminus, and are more similar to the AtCOBL7 subgroup. MEME-MAST motif analysis of poplar and *Arabidopsis* COBRA genes showed that the two subgroups are quite divergent, but motifs 1 and 2 are universally present in all COBRA protein sequences from *Arabidopsis* and poplar.

Analysis of hydrophobicity indicated that all the PtCOBRA members, except those without full lengths, had a highly hydrophilic region between two terminuses and a hydrophobic N and C terminus. Based on the GPI modification site and N-terminal signal peptide probability analysis, the subgroup I PtCOBRA proteins subgroup were found to have a significant potential for the GPI-modification site, while members from subgroup II lacked a ω-attachment site at the C terminus. Therefore, from analysis of the CCVS motif, signal peptide, hydrophobicity and specific features around ω-attachment site, it appeared likely that all the PtCOBRA family members from subgroup I were suitable candidates for GPI addition.

The real-time PCR analysis showed that the COBRA family genes in poplar expressed in a tissue-specific manner. The high levels of expression were particularly found in shoot tip and young root tissues. The PtCOBRA genes also responded differentially to inductions by hormones and environmental stimuli, which suggested that the COBRA gene family members are likely driving forces for plant cell expansion.

Key words: COBRA, gene expression, poplar, *Arabidopsis*.

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ID-065

CONCURRENT DIVERGENCE IN CODING AND PROMOTER REGIONS OF THE POPLAR GENE FAMILY ENCODING XYLOGLUCAN ENDOTRANSGLUCOSYLASE/HYDROLASES

Ye Xia[1], Qin Xu[2], Suhua (Joshua) Yuan[1], Hong Guo[2], Feng Chen and Zong-Ming (Max) Cheng[1]

Xyloglucan endotransglucosylase/hydrolases (XTHs) have been believed to modify the cell wall structure by cleaving (endohydrolase or XEH) and then transferring (xyloglucan endotransglucosylase or XET) cross-linking xyloglucan polymers. Because the DEIDFEFLG, the active site sequence, has been identified in all XTH proteins, it has been generally believed that an individual XTH enzyme has the potential to carry out both XEH and XET functions. The *in vitro* assays of some XTH proteins seem to support this dual-mode function because both or a spectrum of activities were detected. However, characterization of other XTHs purified from plants or recombinant proteins have shown either XET or XEH activity to be predominant. It remains unsettled whether individual XTH functions predominantly as either XET or XEH, or both, and whether the phylogenetic groups are associated with the biochemical or/and physiological functions.

We report here the detailed analysis of 40 poplar (*Populus trichocarpa*) XTH genes/proteins, which were divided into four major subfamilies (SFs) (10, 19, 10 and 1 members in SF I, II and III, IV, respectively), based on their divergence in both coding and promoter regions. The single active site sequence – DEIDFEFLG - was present in every XTH. Homology modeling of all member proteins in the loop 1 and 2 regions, which modulate the substrates in the active sites, supports the hypothesis that each XTH functions predominantly as either XET or XEH, and that the function divergence is associated with phylogenetic subfamilies. The SF I/II/IV protein models matched well with that of the known XET. The SF III members were more likely functioning as XEH with three subgroups. The SF III-A models matched well with that of the known XEH. The homology models of SF III-B with a truncated loop 2, support the same argument for the origin of the XEH. The SF III-C member based on the lichenase model seems to have a higher probability of being an XEH because some sidechains on the loop 3 region might interfere with the substrate binding.

Concurrently, the PtXTH gene promoters also diverged extensively as shown by expressions in tissue-specificity and in response to various hormones. In five tissues, there was no overall association between tissue-specific expression and phylogenetic subfamilies, more SF III genes seem to be up-regulated in root tissues, and the majority of SF I and II XTHs are up-regulated in bark tissues where the cell wall expansion is fast. In contrast to lack of overall association of tissue-specific expressions with the SFs, the SF II, but not SF I and III, genes showed clear expression patterns in response to various hormones treated for 2 and 8 hours. The expressional divergence suggests that the promoters may have concurrently evolved to "guide" the specific XET or XEH function.

Key words: xyloglucan endotransglucosylase/hydrolases (XTHs), protein modeling, evo-devo, gene duplications and divergence, gene expression, poplar, *Arabidopsis*.

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POPLAR DISEASES CAUSED BY *CERATOCYSTIS* SENSU LATO FROM INCISIONS OF *ANOPLOPHORA NOBILIS* IN POPLAR BARK IN YANGLING

Shou-an Xie and Shu-jie Lv[1]

Thirty-nine strains of fungi belonging to six species were isolated from 60 incisions of *Anoplophora nobilis* (Ganglbauer) in eight poplar trees using the PDA medium, including streptomycin. Among them, 20 isolates were identified as Fungi Imperfecti and the others were Ascomycetes. The fungus *Ceratocystis* sensu lato (s.l.) is pathogenic to poplar in China. The damage mechanism in poplar after inoculation with *Ceratocystis* sensu lato was examined based on anatomical studies of the phloem and xylem of periodically harvested trees. In a field experiment, the blue-stained sapwood area of poplar was measured in response to inoculation with *Ceratocystis* s.l., a virulent fungal associate of the longhorned beetle, *Anoplophora nobilis*. Four vigorous, mature poplar trees were mass-inoculated with *Ceratocystis* s.l. at a density of four inoculations per dm^2 within a 120-cm-wide band on the lower bole. Four other poplar trees were inoculated with sterile agar and served as controls. In four trees that had been inoculated with the fungus, the blue-stained sapwood area increased dramatically within the first weeks after inoculation until no blue-stained sapwood area was measurable 4–6 weeks after inoculation. No marked blue-stained sapwood areas were recorded in the four control trees that had been inoculated with sterile agar. Biochemical analysis and histochemical localization techniques were used to assess changes and distribution of cellulase in the xylem fraction.

It was shown that, in maturing xylem tissue inoculated with sterile agar and serving as controls, a small amount of the cellulase activity signal was found. However, high cellulase activity was detected in the xylem tissue of four trees that had been inoculated with *Ceratocystis* s.l. An isoelectric-focusing electrophoresis of the extracted protein displayed three obvious isozyme bands of cellulase. This proved that *Ceratocystis* s.l. can secrete cellulase to utilize cellulose of xylem in host poplar trees. The results confirm the ability of *Ceratocystis* s.l. to kill mature poplar trees in the Yangling area of China.

Key words: poplar, anatomical characteristics, blue-stain fungi, cellulose activity, *Ceratocystis* s.l., *Anoplophora nobilis*, isoelectric-focusing electrophoresis, xylem dysfunction, China.

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ID-137

RESEARCH ON TECHNOLOGY OF COLOR UNIFORMITY FOR INNER DYING OF FAST-GROWING POPLAR

Guobing Xiong, Zhiqiang Wang, Jun Xu and Xiaoning Lu[1]

Color uniformity is an important appraisal item, which is directly related to the modifications to value-added products.

In this paper, effects of the temperature, application time and concentration of dying liquid on inner dying of fast-growing poplar by vacuum pressure impregnation and heat were analyzed. As a result of the research, the level of dying and dye-uptake of specimens based on operational principle of the WSC-S colorimeter, the optimum dying process condition was available and a level dying effect was obtained.

Key words: fast-growing poplar, inner dying, level dyeing, dye-uptake, colorimeter.

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ID-226

MANUFACTURE OF PF POPLAR FLAKEBOARD WITH A STEAM-INJECTION-VACUUM PRESS

Changyan Xu and Yukun Hua[1]

Besides reducing the pressing time, allowing to cure thick resin-bonded panels, steam-injection-vacuum pressing technique presents opportunities for increased panel dimensional stability, control of the density gradient, possibility for gas injection of fire retardant, preservatives, and catalysts.

This study focused on the steam-injection-vacuum pressing technique of aqueous PF adhesive bonded poplar flake-board with an experimental lab press. The results showed that PF bonded poplar flake-boards could be produced with steam-injection-vacuum pressing technique, and vacuuming time, steam pressure, steam time and steam timing all had major impact on the properties of the boards. In the paper, the optimizing steam-injection-vacuum pressing factors within the range of the experiments are presented.

Key words: **s**team-injection-vacuum-pressing, poplar, flakeboard.

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ID-227

RESEARCH ON GENE EXPRESSION AND REGULATION OF ADVENTITIOUS ROOT DEVELOPMENT IN *POPULUS*

Meng Xu, Bo Zhang, Wang Mingxiu and Huang Minren[1]

Rooting ability is one of the target traits in *Populus* genetic improvement. Therefore, research on the molecular mechanism of adventitious root development in *Populus* is important in both theory and practice. As adventitious root development in cuttings is a highly complex biological process, in this study, Affymetrix poplar whole-genome arrays were used to elucidate molecular biological events of adventitious root development in hardwood cuttings from a hybrid *Populus* clone of *Populus* ×*euramericana* cv. 'Nanlin 895', and some related genes were cloned and identified. In addition, expression QTL analysis based on genetical genomics explored the relationship between gene expression regulation and rooting traits of *Populus* hardwood cuttings.

Fifteen GeneChip® poplar whole-genome arrays were used to monitor gene expression profiles during adventitious development stages of hardwood cuttings, and then 14,630 significant differentially-expressed genes were identified at five different development stages according to Mulclass SAM comparison. To confirm gene expression data of poplar arrays, thirty-three of the 14,630 differentially-expressed genes were verified by quantitative real-time RT-PCR. The results suggested that the poplar array experimental method for adventitious root development was feasible and credible. Integrating molecular biology resources to annotate poplar genome arrays in various biological contexts, furthermore, parts of these differential expressed genes were enumerated. Undoubtedly, the outcome would contribute new ideas to the study of the molecular mechanism for adventitious root development in *Populus* hardwood cuttings. Based on the results above, ten full-length cDNA of genes, possibly related to adventitious root development, were cloned from emerging roots of cuttings, and the corresponding promoter of the *PeAux/IAA2* gene was obtained. Moreover, sequence analysis indicated their potential biological function in the rooting of cuttings. Plant expression vectors for eight genes of *PeAux/IAA1*, *PeAux/IAA2, PeAux/IAA3, PeAux/IAA4, PeABP1, PeRHD3_1, PeRHD3_2*, and *PeRHD3_3* and one promoter *PeAux/IAA2* were constructed and used for *Agrobacterium*-mediated transformation of *Arabidopsis thaliana*, *Populus* ×*euramericana* cv. 'Nanlin 895 and *Populus tremula* × *Populus tremuloides* Michx. clone T89). Some transgenic plants were obtained and further phenotypes identified. Finally, the molecular mechanism of adventitious root development in *Populus* hardwood cuttings was outlined based on the results of functional mapping and eQTL analysis of these associated QTLs.

Key words: *Populus* hardwood cuttings, adventitious root development, poplar whole-genome arrays, transformation, eQTL analysis.

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ID-140

MANUFACTURE, PERFORMANCE AND APPLICATION OF ORIENTED STRANDBOARD CEMENT FORMWORK

Xinwu Xu, Ling Chen and Haiyan Xu[1]

A new cement formwork was developed by overlaying veneer and/or PF/UF resin impregnated paper on oriented strandboard (OSB). The impact of processing factors, i.e., veneer thickness (1.7 mm *vs.* 0.8 mm), veneer species (Masson pine *vs.* Poplar), and veneer overlaying direction (parallel *vs.* perpendicular), on properties of cement formwork were investigated. The cement formwork was industrially produced, and was utilized in high building application trials.

The products were tested according to specifications in GB/T17657-1999, and were assessed according to GB/T17656-1999 for plywood cement formwork. Generally, OSB cement formwork achieved satisfactory mechanical and physical performances comparable to traditional plywood, and showing higher bending strength, bending modulus, and lower thickness swelling than OSB panels. Masson pine veneer overlaid OSB showed better performance than poplar ones. The newly-developed formwork can be used repeatedly in cement engineering for 6 to 9 times.

Key words: oriented strandboard, cement formwork, poplar, masson pine.

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ID-228

SEQUENCE ANALYSIS OF CELLULOSE SYNTHASE GENE CesA FROM POPLAR

Yong-chang Xue and Chang-bin Liu[1]

A CesA (cellulose synthase) gene was amplified by RT-PCR from poplar (*Populus ×euramericana* cv. 74/76) developing second xylem total RNA. The sequence of the CesA (accession number AM921697) was 883 bp and it had a 867bp ORF. The identity of the nucleotide sequence with *Populus tremula* × *Populus tremuloides* CesA1, *Populus ×canescens* cel1 and *Populus tremuloides* xylem-specific cellulose synthase gene CesA3 sequence were 99%, 99% and 98% respectively.

The predicted amino acid sequence analyzed by SMART and TMHMM software showed that seven α-helices, one zinc finger domain (CRVCGDEIGVKEDGEVFVACHVCGFPVCRPCYEYER SEGNQSCPQC), two trans-membrane segments and a part of the first hyper-variable region which are conserved in cellulose synthases (CesA) were found in the putative amino acid sequences. It has the same 3D structure as the ring-finger in the catalytic subunit of CesA in *Populus tremula* × *Populus tremuloides*, and has high similarity to the catalytic subunit of IRX3 in *Arabidopsis*.

Key words: cellulose synthase, sequence analysis, *Populus ×euramericana* cv. 74/76.

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ID-032

BIOINFORMATICS ANALYSIS OF LIGNIN BIOSYNTHESIS GENES IN POPLAR

Yong-chang Xue, Wen-chao Zhao and Xue-xia Wang[1]

Six lignin biosynthesis enzyme genes - *pal, ccr, comt, hct, c3h* and *f5h* - were amplified from the poplar *Populus ×euramericana* cv. 74/76 developing second xylem mRNA by RT-PCR, and the sequences of *ccr* (accession number AJ224986) and *c3h* (accession number AM920690) were analyzed and predicted, using bioinformatics tools.

The results showed that the *c3h* gene was 994bp in size and contained a 495bp ORF; it had no leader peptides and no trails-membrane topological structure in its amino acid sequence; it had the same secondary structure and functional protein domains as P450, and had also an active center with ferrous haemachrome and cysteine; it can be primarily classified as a member of the CYP98A3 family. The *ccr* gene had a complete open reading frame which encoded 301 amino acids in its 961 bp *ccr* sequence; its mature protein was hydrophilic, mainly localized on the plasma membrane, and had the KNWYCYGK motif sequence conserved in CCR protein in most plants; its secondary structure had 12 α-helices, 20 β-strands and 11 coils. Phylogenetic trees were constructed based on *c3h* and *ccr* gene sequences from different plants, and their molecular evolutions were also analyzed.

Key words: lignin, *ccr*, *c3h*, bioinformatics, *Populus ×euramericana* cv. 74/76.

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ID-031

GENETIC MODIFICATION IN *POPULUS DELTOIDES*: AN ANTISENSE APPROACH FOR LIGNIN REPRESSION

Rakesh Yadav[1], Dharmender Kumar[1], Pooja Arora[1], Saurabh Raghuvanshi[2], Neeraj Dilbaghi[1] and Ashok Chaudhury[1]

Eastern cottonwood (*Populus deltoides*), belonging to the family *Salicaceae* and its hybrids, is one of the most valuable hardwood species in countries comprising the North America, Mexico, Europe, Asia and Northern India. Its wood is highly prized for furniture, architectural woodwork, matchstick and paper industry. The presence of lignin in wood fiber is a limiting factor for the production of good quality paper and its removal by the chemical bleaching method is necessary, yet causes enormous environmental pollution. Lignin is derived from oxidative polymerization of three different monomers, namely coumaryl, coniferyl and sinapayl alcohol.

There is a need to establish genetically-modified improved trees with low lignin content. Several genes responsible for lignin biosynthesis pathway have been reported, such as PAL, C_4H, 4CL, OMT, CCoAOMT, out of which the 4-coumarate: coenzyme A ligase (4CL) gene has been employed for down-regulation in the present study. An antisense construct, *Pd4CL,* has been designed as a model system for repression of lignin content. Protocols have been developed for isolation of total RNA from young internodes of one-year-old healthy plus trees of *Populus deltoides* by employing the GITC method of Chomczynski *et al.,* 1987 with minor amendments. The total RNA was used for RT-PCR with quaking aspen 4CL gene-specific primers to amplify a cDNA fragment of ~1.6 Kb. The cDNA fragment was further sequenced and submitted to NCBI (Accession No. DQ093070), cloned in a vector in antisense orientation. Protocols have been optimized for high frequency direct plant regeneration and genetic transformation in *Populus deltoides* by employing leaf and internodal explants using disarmed *Agrobacterium tumefaciens* strain LBA4404 containing the pTOK233 (50.35 kb) plasmid. This plasmid harbours *vir* genes, *nptII* for bacterial selection, *hpt* for plant selection and reporter gene *GUS*. The explants with several wounds were co-cultured with *A. tumefaciens* and selected on MS media supplemented with 0.25 $mg.l^{-1}$ KIN, 0.25 $mg.l^{-1}$ IAA and 50 $mg.l^{-1}$ hygromycin for obtaining putative transformants. Putative transgenic poplar explants were assayed for histochemical localization of GUS expression. The whole leaves and internodal segment sections were examined under a stereomicroscope and found to exhibit transient expression of GUS. Genetic transformation of poplar with the *Pd4CL* antisense construct is in progress.

Key words: cotton wood, lignin content, transgenic poplar.

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IN SILICO IDENTIFICATION OF NUCLEAR FACTOR Y SUBUNIT B GENES WITH POTENTIAL DROUGHT TOLERANCE IN THE POPLAR GENOME

Dong-hui Yan[1,2], Hechen Zhang[1], Hongshuang Ma[1], Xinlin Xia[1] and Yin Weilun[1]

The blue revolution to save water has been promoted through biotechnology. More and more genes which acclimatize plants to drought stress have been discovered. Recently, new functions of the transcription factor genes, nuclear factor Y(NF-Y) B subunit responsive to water deficit were found in *Arabidopsis thaliana*, *Zea mays*, and *Triticum aestivum*. Furthermore, their up-regulation is able to increase crop tolerance to limited water conditions which raises the possibility of agricultural benefits in the field. Based on the performance of the genes, we are attempting to find their homologues in the model tree, *Populus trichocarpa*. Using the bioinformatics approach, 14 homologues to *AtNF-YB1, ZmNF-YB2, TaNF-YB2* were found in the tree. Phylogenetic analysis of the NF-YB protein domain encoded by these homologues has indicated that four homologues have a close relationship with AtNF-YB1. In addition, we also hit three homologues from public EST databases of *P. euphratica*. The function of the poplar homologues in relation to drought stress needs to be determined further.

Key words: *Populus trichocarpa*, *Populus euphratica*, plant nuclear factor Y B Subunit, drought.

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ID-069

BREEDING STUDY OF *POPULUS ALBA* L. × *ULMUS PUMILA* L.

Cheng-chao Yang[1], Sheng-dong Wang[1] and Zhi-yan Yang[1]

An out-crossing experiment of *Populus alba* L.× *Ulmus pumila* L. was conducted. By using techniques of pollen inducement and puerile ovary culture, the out-crossing barrier was conquered and hybrid seedlings of *P. alba* × *Ulmus pumila* were successfully produced. The hybrids of *P. alba* × *Ulmus pumila* are named *P.* × *alba* L. 'yinyu'.

The interfamilial hybrids between *P. alba* × *Ulmus pumila* were described by morphological characters. In order to identify the hybrids and analyse further the genetic relationship between the hybrids and their parents at the molecular level, the technique of AFLP markers was used. The results were as follows: (1) Both gene markers of *P. alba* and *U. pumila* were exhibited on the bands of hybrids and some new extra bands were detected in the hybrids; (2) the gene marker bands of the hybrids from *P. alba* were more than those from *U. pumila*, which showed that the hybrids were maternal progenies and the analysis of UPGMA showed similar results; (3) *P. alba* from Liaoning station was inferred as the female parent of the hybrids. Since genetic distance was the least between the clone LP-2 and the hybrids, and the analysis of variance indicated that there was no significant difference among all the samples of *U. pumila*, the male parent would be the clone LP-2, also from Liaoning station; (4) although the genes of *U. pumila* were prevalent in the hybrids, the genetic relationship between the comparison clone (BP) and the hybrids was more distant.

Sterility is usual in hybridization of distant taxa. Sexual reproduction of *P.* × *alba* L. 'yinyu' was studied in male and female as follows: (1) The number of inflorescences, weight of pollen and vitality of pollen were recorded in evaluating sexual reproduction. *P.* × *Liaonignica* sp. Nov., *P. alba* L. var. *pyramidalis* and (*P. simonii* × *P. euphratica*)× *P. nigra* L. var. *italica* (Moench.) were used as controls. Pollen viability was detected by aceto carmine, culture medium and hybridization. The results indicated that the number of inflorescences of *P.* × *alba* L. 'yinyu' was the greatest, while the weight and vitality of pollen were the lowest among all tested cultivars. There were about 30% pollen tubes that were tortuose-forficate in culture medium. Collating the results of dye and crossing, cross incompatibility was possible when *P.* × *alba* L. 'yinyu' was the male parent; (2) an inpollination test of *P.* × *alba* L. 'yinyu' was conducted and *P.* × *alba* L. was used as a control. The results indicated that female *P.* × *alba* L. 'yinyu' were inpollinated, but diversely according to the difference of male parents.

The recombination techniques, genetic composition of the hybrids and the reasons for pollen tube abnormality of *P.* × *alba* L. 'yinyu' are discussed. Some recommendations are also made on using *P..* × *alba* L. 'yinyu' as a parent.

Key words: interfamilial hybrids, *Populus alba* L., *Ulmus pumila* L., AFLP markers, genetic relationship, sexual reproduction, pollen tube abnormality.

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ID-037

PHOSPHOPROTEOMIC ANALYSIS OF *POPULUS SIMONII* × *P. NIGRA* CHLOROPLASTS

Chuan-Ping Yang, Rui-Juan Ni, Kai-Long Li, Gui-Feng Liu
and Bai-Chen Wang[1]

In the present study, we initiated phosphoproteomic analysis of the proteins expressed in *Populus simonii* × *P. nigra* chloroplasts using the shotgun method. The total protein extracted from young *Populus simonii* × *P. nigra* leaves was short peptides digested with trypsin. Phosphopeptides were enriched with a TiO_2 column and then analyzed with ESI-MS/MS. A total of 36 phosphopeptides containing 48 phosphorylation sites were successfully identified.

Based on their annotation in the NCBI database, these phosphoproteins are involved in signal transduction, protein synthesis, protein degradation, and energy production as well as photosynthesis. As far as is known, this is the first paper to describe protein phosphorylation in tree chloroplasts.

Key words: protein phosphorylation, chloroplast, proteomics.

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ID-156

RESEARCH ON CONCRETE FORMWORK FROM POPLAR PLYWOOD

Rui Yang[1], Yukai Fan[1] and Yukun Hua[1]

With the development of the economy and architecture scale in China, the demand of concrete formwork in the building industry is also increasing. Plywood, as an important concrete formwork in architecture industry, is facing shortage of natural tree resources, and fast growing poplar is an ideal substitute. In the paper, PF-bonded poplar plywood was made using three processing factors, i.e., resin content, hot pressing time, and compressibility. Every factor has three levels.

Results showed that the mechanical properties of plywood formwork increased with the resin content at a low level, then decreased afterwards, related to the inner stress by the cured resin body. Accordingly, the best level of resin content is 275g/m². Similarly, the best hot pressing time is 1mm/min, and the optimized compression ratio is 31.5%.

Key words: poplar, plywood concrete formwork, hot pressing technology.

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GENOME-WIDE IDENTIFICATION OF LINEAGE SPECIFIC GENES IN *ARABIDOPSIS, ORYZA* AND *POPULUS*

Xiaohan Yang[1], Sara Jawdy, Timothy J. Tschaplinski
and Gerald A. Tuskan

The three fully-sequenced reference plant genomes, *Arabidopsis, Oryza* and *Populus*, represent three major types of higher plants: annual monocots, annual eudicots, and perennial woody plants. The identification of specific proteins in these three taxa can provide insight into the molecular features distinguishing between monocots and eudicots, or herbaceous and woody plants.

In this study, we identified three differential gene (DG) sets in the context of the three taxa: (i) 917 *Arabidopsis* genes without homologues in *Oryza* or *Populus*, (ii) 2781 *Oryza* genes without homologues in *Arabidopsis* or *Populus*, and (iii) 594 *Populus* genes without homologues in *Arabidopsis* or *Oryza*. Furthermore, we used the three DG sets to query a customized database containing the transcript assemblies (TA) of more than 250 plant species followed by querying the nr protein database, and identified three sets of species-specific (SS) genes: 193 *Arabidopsis*-specific, 653 *Oryza*-specific, and 109 *Populus*-specific genes. A relatively higher proportion of the DG set in *Arabidopsis, Oryza* and *Populus* showed homology to herbaceous eudicots, herbaceous monocots and woody eudicots, respectively. Analyses of microarray/digital Northern data revealed that some of the SS genes were preferentially expressed in flowers and roots (in *Arabidopsis, Oryza* and *Populus*), xylem and cambium (in *Populus*) or up-regulated by heat stress in *Arabidopsis*. Six conserved protein motifs were identified in the *Arabidopsis* and *Oryza* SS proteins and were also found to be present in other distant lineages. The SS sets were enriched with intronless genes as compared to the whole-genome annotation.

Key words: lineage-specific genes, gene expression, eudicots, monocots, perennial plants, woody plants.

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ID-204

ELIMINATION OF SWINE WASTEWATER BY EVAPOTRANSPIRATION IN A 5-YEAR-OLD POPLAR PLANTATION

Jin-Kie Yeo, Yeong-Bon Koo, Won-Woo Lee, Hyun-Chul Kim, Jung-Hyun Park and Kwan-Soo Woo[1]

This study was conducted to evaluate the amount of swine wastewater (SWW) eliminated by evapotranspiration and growth responses of poplar clones growing in a plantation irrigated with SWW. Sixty-six one-year-old trees of each of *Populus alba* × *P. glandulosa* 'Clivus' and *P. euramericana* 'Eco28' were planted on a 200 m^2 area. Average height and DBH of the clone 'Clivus' were 7.8 m and 6.5 cm respectively, and those of the clone 'Eco28' were 6.7 m and 6.0 cm before application of SWW. SWW in five plastic containers (0.7 m in height, 1.0 m in width, 25.0 m in length) installed at 0.6 m depth in the ground was used for irrigation. Loss by percolation of the input SWW was completely intercepted by a vinyl sheet placed 2 m deep in the ground under the plantation. The poplar plantation evapotranspirated a total 179.5 m^3 of SWW and precipitation from May to October. The amount of daily evapotranspiration was the greatest in May and October when relative humidity was low. The net evapotranspiration of SWW by the plantation was estimated at 59.5 m^3. The diameter growth of clones 'Clivus' and 'Eco28' treated with SWW was 32.6% and 32.1% less, respectively, than that of untreated controls. Height growth of the same treated clones was 16.0% and 26.3% less, respectively, than that of controls. Leaf area of the clone 'Eco28' grown under SWW decreased sharply, while the number of leaves on both clones increased compared to the control. The nitrogen content of leaves of 'Clivus' and 'Eco28' was 22.0% and 19.3% higher, respectively, than that of the control.

From this experiment, the poplar plantation seems to eliminate by evapotranspiration much of the SWW, a major source of water pollution, although the growth characteristics of the trees were negatively affected by the high level of absorption of nutrients from the SWW.

Key words: poplar, swine wastewater, evapotranspiration, growth response, N content.

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ID-049

EFFECT OF SOIL WATER CONTENT ON ECO-PHYSIOLOGICAL CHARACTERS OF *POPULUS ×EURAMERICANA* CV. '74/76' SEEDLINGS

Jianting Yin and Mingpu Zhai[1]

To illustrate the mechanism of adaptation to arid conditions and the range of soil water conditions suitable for growing Poplar, we set up five series of soil moisture gradients with potted seedlings of *Populus ×euramericana*.cv. '74/76'. The photosynthesis characteristics, water use rate, osmotic adjustment substances, protective enzyme activity, mineral nutrient content, growth parameters and allocation of photosynthesis products under different water conditions were determined and analyzed, to provide a basis for establishing the key considerations for supplying water to poplar seedlings in a practical way.

The main conclusions were as follows: as soil water content (SWC) increased, basal diameter and height growth increased, the growing period was prolonged, and width, length and area of leaves increased. Water had a very strong influence on indices of growth. Soil moisture also had a strong influence on accumulation and allocation of photosynthesis products. When SWC decreased, the ratio of root to shoot was reduced, with roots increasing, but stems stabilizing at some level. The range of SWC keeping the 90% upwards of maximum of net photosynthesis rate was 11.4% to 16.6%, and the optimum SWC was 14.2%. As SWC decreased, the indices of light compensation point, photorespiration velocity and carboxyl efficiency were reduced. The diurnal course of photosynthesis rate under different soil water contents showed a double-peak in August, the peak value being greater as SWC decreased. With regard to factors limiting the net photosynthesis rate, when SWC was >11.4%, it was not a primary limiting factor. Stomatal conductivity was a primary limiting factor under different water disposals except 8.5% by Ci. As SWC decreased, the content of chlorophyll increased and then fell; it was greatest at 11.7% SWC, and lowest at 17.1%. There was no significant correlation between net photosynthesis rate and chlorophyll content. Considering leaves and individual plants, 11.5% to 15.5% can be taken as the range of suitable SWC. At the level of leaves, results indicated that the curve of diurnal variation of transpiration rate had a single peak, and this peak occurred earlier as SWC decreased. Furthermore, the diurnal average transpiration rate fell with SWC, the differences among the 5 disposals were significant. The most important factors affecting transpiration rate differed under different water conditions. At the single-line level, the results showed firstly that the diurnal variation in transpiring rates was either a single- or double-peaked curve, the peak value appearing earlier as SWC decreased. Secondly, when SWC was up to 11.7%, the water use rate was highest in August, whereas the highest rate appeared in July if the SWC was less than 11.7%. Moreover, single-line water use was seen to be correlated with increased biomass as the SWC increased. The diurnal variation in water-use efficiency of leaves had a double-peaked curve. Average WUE was highest at 10.1% SWC, and the relationship between SWC and WUE showed that SWC had no significant effect on WUE in the range of 10.1% to 15.3%. On the individual level, WUE increased and then fell as SWC decreased; it was greatest at 10.1% SWC. Water stress can be considered to start when SWC is at 10.1%. Proline and MDA content increased as SWC decreased; when SWC ＞10.1, proline content changed slowly. Moreover, the activities of SOD, POD and CAT varied without any relation to SWC, owing to the concurrent functions of these three kinds of enzymes. It made reactive oxygen free radicals keep balance in the trees.

Key words: *Populus ×euramericana* cv. '74/76', net photosynthesis rate, transpiration rate, water use efficiency, chlorophyll, enzyme activity.

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ID-072

EFFECTS OF PRUNING ON GROWTH OF POPLAR (*POPULUS ×EURAMERICANA* CV. '74/76')

Weilun Yin[1], Senkun Chen[1], Xiaodong Liu[1], Xinli Xia[2] and Shangwei Sun[1]

Pruning, a basic technique for forest management, plays an important role in improving the tree trunk shape, wood properties, etc. Afforestation is taken into account in managing fast-growing and high-yielding plantations at present, while forest management is ignored, which limits the quality and productivity of woodland. We established a scientific pruning model for forest management. Pure plantations and intercropping poplar plantations were pruned at five different levels in Hebei and Shandong Provinces in China. The five levels were low-grade P1 (1/6 of the crown was pruned), medium P2 (2/6 of the crown was pruned), strong P3 (3/6 of the crown was pruned), severe P4 (4/6 of the crown was pruned) and the control (unpruned crown). Height and diameter at breast height under different pruning levels were analyzed. Diameter growth and basal area increment after one year were measured on ten sample trees. The stem volume increment (up to 9 m) was also calculated.

The results showed that differences in relative height growth were not obvious ($P<0.05$) for different pruning treatments. This showed that nutrition for tip growth came mainly from the branches and leaves at the top of the crown. Differences in relative diameter growth was very significant ($P<0.01$) which showed that relative diameter growth decreased as pruning intensity increased. The stem growth of sample disks at different heights was fluctuant on different treatment levels. From root (0.0 m) to trunk (9 m), the amount of stem increasing underside reduced along with the increasing of pruning intensity. However, the amount of stem increasing upper part was increased at the treatment of pruning. Differences in volume growth among different treatments were significant: all of the pruning treatments had greater volume growth than the control. The best was medium P2, the order being control<P4<P1<P3<P2. This means reasonable pruning can improve the volume growth and pruning excessively reduced volume growth. Pruning reduced the relative taper of trunks, making trunks straight and satiety and increasing the outturn rate of trees largely. Considering the impact of pruning on tree growth as part of the production process, a reasonable pruning level would be moderate intensity pruning P2, removing 1/3 of the crown.

Key words: pruning, poplar, growth rate, volume, stem taper.

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ID-169

TRANSGENIC PLANTS OF *POPULUS* ×*EURAMERICANA* CV. 'NANLIN 895' WITH TWO KEY GENES (PEPC AND PPDK) IN C4 PLANT PHOTOSYNTHESIS

Wu Yin, Lisa Li, Xindong Gong, Lina Xu, Weidong Wang, Junfeng Zhu, Minren Huang, Mingxiu Wang and Qiang Zhuge[1]

Phosphoenolpyruvate carboxylase (PEPC) and private orthophosphate dikinase (PPDK) play a key role in C4 plants with highly efficient photosynthesis. Compared to C4 plants, *Populus* species are C3 plants with low-efficiency photosynthesis. In this study *Populus* ×*euramericana* cv. 'Nanlin 895' was selected as material for genetic transformation mediated by *Agrobacterium tumefaciens* with two key genes in C4 plant photosynthesis.

A highly efficient procedure for genetic transformation was established by optimizing such factors as pre-culture time, infection time, co-culture time and selection pressure concentration. The most suitable conditions were as follows: pre-culture time 3 days, co-culture time 4 days, concentration of *Agrobacterium* OD_{600} = 1.0, infection time 15 min, hygromycin selection concentration 1.5 mg/l. Over 100 hygromycin-resistant poplars were obtained, about 40 of which were PEPC-positive, 15 PPDK-positive and 3 both PEPC- and PPDK-positive by PCR assay. The initial results showed that height and leaf size of some transgenic plants increased obviously compared to that of control plants, 20 days after the plants were transplanted to pots. Photosynthetic characteristics were determined in leaves of transgenic poplars with the C4 phosphoenolpyruvate carboxylase gene (PEPC) and untransformed poplar 50 days after transplanting to pots. The results indicated that the levels of net photosynthesis (Pn) of some transgenic poplars increased as much as about 21% compared to untransformed poplars The carboxylation efficiency of PEPC transgenic poplars increased by 62.29% and the CO_2 compensation point decreased by 22.22%, 44.44% that of untransformed poplar. The activities of enzymes of the C4 photosynthetic pathway, i.e. phosphoenolpyruvate carboxylase (PEPC), pyruvate orthophosphate dikinase (PPDK), NADP+-malate dehydrogenase (NADP+-MDH), and NADP+-malic enzyme (NADP+-ME), were found to be increased significantly compared with the controls. This proved that the C4 phosphoenolpyruvate carboxylase gene (PEPC) had been expressed in the transgenic poplars. These results will provide scientific evidence for genetic breeding to improve photosynthetic efficiency in poplars by gene engineering.

Key words: PEPC, PPDK, transgenic poplars, breeding for high photosynthetic efficiency.

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ID-142

P.×EURAMERICANA CV. 'NEVA ' TRANSFORMATION WITH A TYROSINE-RICH *HRGP* GENE

Yajun Yu[1,2], Xinli Xia[1], Weilun Yin[1], Haiying Liang[3] and John Carlson[4]

Lignin removal is an essential process in the pulp and paper industry because its presence reduces the quality of paper. Traditional strategies for removal of lignin by harsh chemicals have environmental problems. The genetic manipulation approach has been used to alter the biosynthesis of lignin, but reducing lignin content without compromising tree health and vigor can be difficult because lignin plays an important role in plant growth and development.

In order to further 'fine-tune' lignin profiles in economically important poplar species in a rational manner, we used a novel target gene applied in lignin genetic engineering to alter the chemical nature of lignin by introducing peptide crosslinks without decreasing lignin content. This approach permits lignin removal by the action of protease, which should save energy and reduce the use of strong acid or alkali solutions in the pulp and paper industry. The hybrid poplar clone 'Neva' has been transformed with a transgene encoding a high tyrosine-content peptide. This is an important cultivar for industrial use. An efficient regeneration system and micropropagation system have been optimized and established for the poplar. A total of 1,206 explants (including stem segments, leaf discs and stem apexes) were co-cultivated with *Agrobacterium* strain *EHA105* having *HRGP* gene and *NPT Ⅱ* gene on the disarmed T-DNA. Four lines (independent transgenic events) derived from stem segments excised from 3- to 6-month-old greenhouse-grown plants were obtained. The trees with genetically modified lignin are morphologically indistinguishable from untransformed trees and more susceptible to papain digest than the control. Overall, these studies suggest that alteration of lignin structure will increase the degradability of poplar wood for industrial use. In ongoing work, we are studying the re-optimized protocol of transformation, tissue-specific expression of the gene in transgenic poplar, and application in the pulp and paper industry without destroying the plant growth or the environment around us.

Key words : *HRGP* gene, *Agrobacterium*-mediated transformation, transgenic plants, *P.×euramericana* cv. 'Neva', lignin.

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ID-012

DIFFERENTIAL PROTEOMIC ANALYSIS OF LEA-TRANSGENIC AND NON-TRANSGENIC *POPULUS SIMONII* × *P. NIGRA* UNDER SALT STRESS

Hong-Mei Yuan, Bai-Chen Wang and Jing Jiang[1]

In the present study, the LEA (late embryogenesis abundant) gene cloned from *Tamarix androssowii* was transformed into *Populus simonii* × *P. nigra* pollen plantlets through *Agrobacterium*-mediated genetic transformation. Eleven resistant lines were obtained of which T11 presented the highest resistance to salinity stress. To better understand the molecular mechanism of T11 salt tolerance, a comparative proteomic approach was applied to analyze differential expression of proteins between T11 and the non-transgenic control plant under different concentrations of NaCl.

About 550 protein spots were detected on each 2-DE gel of which 30 spots showed more than 2-fold changes in abundance between the control and transgenic plants treated for 2 days. The changed proteins were analyzed using matrix-assisted laser-desorption/ionization time-of-flight mass spectrometry (MALDI-TOF-MS) from which 27 proteins were identified. Based on their annotation in the NCBI database, these proteins are involved in cell defense, cell structure, protein synthase, degration, and signal transduction. These findings will be important clues to explain the molecular mechanism of resistance to salinity stress in LEA protein.

Key words: *Populus simonii* × *P. nigra*, LEA gene, proteomics, two-dimensional gel electrophoresis (2-DE).

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ID-155

STUDY ON CREEP PERFORMANCE OF FAST-GROWING POPLAR MODIFIED WITH ACQ-D

Kong Yue and Xiaoning Lu[1]

People have paid more attention to continuous developing environmental quality since the new century. Now, designers attach importance to wood materials that could be used in construction. However, wood is liable to be attacked by fungi and insects. It is necessary to enable wood materials with strong anti-decay ability when the material is to be used in exterior applications. The major wood materials which could gain easily are based on wood from fast-grown trees. Therefore, fast-grown poplar was chosen for this experiment. Fast-grown poplar samples were modified with ACQ-D.

Furthermore the static mechanical and creep performance of this modified wood should be emphasized and measured when used as structural materials.

The results showed that the mechanical strength of modified samples is almost equal to that of the unmodified. However, the anti-creep performance of modified samples was lower than that of the unmodified under the same bearing scales. Wood samples were much more affected by relative humidity after treatment with ACQ-D.

Key words: fast-grown poplar, anti-decay, mechanical performance, creep.

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ID-230

MICROCUTTING PROPAGATION TECHNIQUE FOR HYBRID ASPEN (*POPULUS TREMULA* × *P. TREMULOIDES*)

Fan-Suo Zeng and Ya-Guang Zhan[1,2]

In the research described in this paper, elite plants of *Populus tremula* × *P. tremuloides* were used. A series of experiments was carried out in order to develop a microcutting propagation technique for hybrid aspen.

The results showed that hormone, substrate, moisture and temperature were the major factors affecting propagation of softwood cuttings of hybrid aspen. The best substrate was a mixture of humus and sand, which was sterilized by high temperature or agricultural chemicals. The optimum air temperature for transplanting was 18-26°C. The humidity of the air should be kept above 60% by leaf spraying during the first five days after cutting. Softwood cuttings were treated with IBA and NAA at different concentrations for different times. Results showed the best concentration of hormone for propagating softwood cuttings was 100 mg/l of NAA+IBA for 10 minutes. In summary, the microcutting propagation technique for hybrid aspen involves the following: transplanted tissue culture seedlings were used as a cutting orchard; the branches were sheared and shaped; the length of cuttings was l cm; the best hormone treatment for cuttings was soaking in 100 mg/l of NAA+IBA for 10 minutes. The rooting rate was 93.75%.

Key words: *Populus tremula* × *P. tremuloides*, softwood cutting propagation, hormones, rooting rate.

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ID-096

CARBON SEQUESTRATION IN SHORT ROTATION FORESTRY AND TRADITIONAL POPLAR PLANTATIONS

Terenzio Zenone[1,2], Mirco Migliavacca[3], Leonardo Montagnani[4], Guenther Seufert[1] and Riccardo Valentini[2]

In recent years, the increasing funding of non-food crops provided by the Community Agricultural Policy (CAP) has brought about a series of changes in the traditional land use in Europe. In this light, considering that Short Rotation Forestry (SRF) could allow Italy to increase its quota of renewable energy production, several Italian regions, in which biomass thermoelectric power plants are under construction, have included in their Programme for Rural Development (PRD) a series of financial incentives to support the establishment and maintenance of SRF plantations. As a result, SRF for energy purposes is rapidly expanding in Italy. In order to evaluate carbon sequestration in traditional plantations and Short Rotation Forestry (SRF) with poplar, we measured the CO_2 exchange between atmosphere and canopy from 2002 to 2005 using the eddy correlation (EC) technique. EC allows determination of Net Ecosystem Production (NEP) in terms of carbon stored by the ecosystem. The areas of study are located in the northwest of Italy in the basin of the Ticino river: the poplar plantation (*Populus ×euramericana* clone I-214, spacing 6m×6m, density 270 plants ha^{-1}) occupies an area of 120 ha. The SRF (*P. generosa* × *P. nigra* clone Pegaso) occupies an area of 80 ha: trees were planted in March 2004 using 1-year-old seedlings in a double-row design with a spacing of 2.8m×0.75m×0.45 m corresponding to a density of 12,500 plants ha^{-1}.

The three years of observation in the poplar plantation showed that carbon uptake was stronger in 2003 than in 2002 for a period ranging from bud break till about DOY 160 (early June). Afterwards, the 2003 Net Ecosystem Exchange (NEE) was severely reduced. This trend may reflect the precipitation trends of 2003 that were comparable to 2002 until April while, from May onwards, precipitation was much lower in 2003. The total annual sequestration of CO_2 was 22.9, 19.1 and 23.2 tons ha^{-1} respectively for the years 2002, 2003 and 2004. In SRF the annual carbon sequestration has been estimated as 11.2 and 27.5 t CO_2 ha^{-1}, respectively for the first and second growing season. In addition, in order to calculate an overall GHG budget for the test SRF plantation, CO_2, CH_4 and N_2O emissions from agricultural machine use (ploughing, harrowing, planting, harvest, irrigation, fertiliser and pesticide spreading) were estimated according to IPCC methodology. The resulting annual GHG emissions in terms of tons of CO_2 equivalent ha^{-1} was estimated as 1.03 and 0.59 for the first and second growing season respectively. To further extend the GHG budget analysis, we modelled the GHG emissions/absorptions for 10 years in SRF and in a conventional, non-coppiced, poplar plantation. Based on data obtained from experimental experience and from literature, two levels of productivity were hypothesized based on the level of potential productivity and the intensity of cultural practices: high (H) and low (L) inputs. The resulting CO_2 uptake was calculated as 130 (L) and 183 (H) t CO_2 ha^{-1} for the poplar plantation and 134 (L) and 235 (H) t CO_2ha^{-1} for SRF. On the other hand, the CO_2, CH_4 and N_2O emissions from agricultural treatments and pesticide/fertilizer production resulted in 7.7 (L) and 11.5 (H) t of CO_2 equivalent for the poplar plantation and 9.2 (L) and 23.4 (H) for SRF. Overall, these results indicate a very good GHG balance for both types of cultivation and the different scenarios analyzed.

Key words: carbon sequestration, greenhouse gas balance.

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ID-254

TRANSFORMING *POPULUS TREMULA* × *P.TREMULOIDES* WITH AN INSECT-RESISTANCE GENE USING THE *AGROBACTERIUM TUMEFACIENS*-MEDIATED METHOD

Yaguang Zhan[1], Caihua Li[2] and Fenghui Qi[1]

Using the *Agrobacterium tumefaciens*-mediated method, the gene-encoding toxin of spider and partial C-terminate of *Bt* was transformed into the genome of *Populus tremula* × *P.tremuloides* in order to promote the insect resistance of this poplar species. The optimal transformation procedure was as follows.

After pre-culture for 2 days, leaf discs were infected with bacteria, co-cultured for 3 days, then transferred to the medium with 800mg/l cefotaxime and cultured for 7 days before 20mg/l kanamycin was added to the medium for selection. As a result, a transformation rate of 2.1% was obtained. PCR-Southern assay showed that the exotic gene had integrated into the poplar genome and Southern assay after single endonuclease cutting showed that there was only a single copy of the exotic gene in the genome of the transgenic poplar.

Key words: *Agrobacterium tumefaciens, Populus tremula* × *P.tremuloides*, PCR-Southern.

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ID-157

A NEW AFFORESTATION TECHNOLOGY INVOLVING SOAKING POPLAR SEEDLINGS AT LOW TEMPERATURE

Cunyi Zhang[1], Yushan Dong[2], Qing Zhou, Na Zhang, Guohua Cheng, Shoujiang Xie, Shuli Wang and Donghuan Ren

Two new afforestation technologies were studied: (i) soaking whole poplar seedlings and storing them at water temperature in order to extend the dormant period and postpone bud-break for one month; and (ii) afforestation during the bud-break period (shoots not more than 5 centimeters in length and more than 97% in survival rate).

These two new techniques are easy to promote and have a low cost and high survival rate of seedlings; they play a leading role in raising further the quantity and quality of poplar afforestation.

Key words: soaking poplar seedlings, germinating period.

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ID-019

Ca^{+}/CALCINEURIN B-LIKE SIGNAL PATHWAYS IN *POPULUS*

Hechen Zhang[1], Xinli Xia[2] and Weilun Yin2

Most notably, plant signaling processes under stresses are accompanied by changes in cellular calcium concentration. Although the specific signature of the calcium transients can encode information on its own, an additional level of regulation in calcium signaling is achieved via the action of calcium-binding proteins. Calcineurin B-like proteins, as the plant calcium-binding proteins recently identified, must function by binding and regulating a group of serine-threonine protein kinases called CIPKs (CBL-interacting protein kinases) and provide a signal network to adapt various stresses. The calcium signal pathways have been well studied in *Arabidopsis*. However, such a signal network remains to be elucidated in poplar, a model tree species with complete sequencing of the whole genome.

Here, we have characterized 10 CBL candidate genes and 27 CIPKs in the genome of *Populus trichocarpa* and presented a comparative genomics analysis of them in poplar, rice and *Arabidopsis*, including gene structures, conserved motifs and phylogeny. Comparative genomic analyses showed that the families in poplar appear to be rather conserved in the size and structure, and the duplication events might significantly contribute to the amplification of the two gene families. In addition, analysis of their intron distribution revealed that the genes might have an ancient origin, which formed earlier than the separation of these two eudicot species. Our data will provide important evidence for further studying the functional dissection of the Ca^{+}/CBL signaling network in plants.

Key words: calcium signaling, CBL, CIPK, *Populus trichocarpa*, signal transduction.

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ID-036

SOIL RESPIRATION DYNAMICS IN FOUR POPLAR PLANTATION PATTERNS IN THE NORTHERN AREA OF JIANGSU PROVINCE

Huanchao Zhang, Qianggen Zhu and Sengzhuo Fang[1]

In order to understand the carbon sequestration capacity of poplar plantation systems, soil respiration was measured monthly using the static alkali absorption method (AA) from April 2006 to April 2007 in four 4-year-old poplar plantation patterns (*Populus deltoides* cv. 35), in north Jiangsu Province, China. An agricultural ecosystem was used as a control. The four patterns were the wide-narrow row pattern (PW) in which trees were planted at 4×4 m at intervals of 16 m, the popular pattern (PP) in which trees were planted at 6×10 m, the 2 ha-grid pattern (PG) in which trees were planted at 3×4 m around 2 ha (100×200 m) of cropland, and the 2-ha grid dyke pattern (PGD) in which trees were planted at 2×3 m on a raised causeway 1.8 m high and 3 m wide around a 2-ha (100×200 m) cropland area. Soil temperature at 5 cm depth and soil moisture at 10 cm depth were determined with an HH2 moisture meter, while soil respiration was measured, as well as root respiration of poplar using the trenching method in PW and PP.

The results showed that soil respiration in all patterns was in the order of summer>spring>autumn>winter and only one peak was found during the year. Soil respiration rate in the period of fast poplar growth (July-August) peaked at 153.00 to 253.62 mg CO_2 m^{-2} h^{-1}, and during the period of poplar dormancy (December-January), the rate was at a lower value of 46.75 to 54.48 mg CO_2 m^{-2} h^{-1} for the four poplar plantation patterns and the agricultural ecosystem. Soil respiration increased exponentially with soil temperature at 5 cm depth (p<0.001), and explained 64.6% to 80.7% of soil respiration variation in the four poplar plantation patterns and the agricultural ecosystem. However, no significant relationship was observed between soil respiration and soil moisture (p>0.05). Annual soil respiration in PW, PP, PG, PGD and the control was 1395, 1492, 1482, 1088, and 1361 g CO_2 m^{-2} yr^{-1}, respectively. Annual total CO_2 flux in the agricultural ecosystem was marginally but significantly lower than that in the PP and PG patterns (p=0.09), while significantly higher than that in the PGD pattern. This was probably attributable to the lower content of soil organic matter and soil moisture in the PDG pattern. Annual root respiration of poplar in the PW and PP patterns was estimated at 260 and 292 g CO_2 m^{-2} yr^{-1} respectively, and accounted for 18.7% and 19.6% of the annual total CO_2 flux in the PW and PP patterns, respectively.

Key words: poplar plantation pattern, soil respiration, static alkali absorption method, soil temperature, soil moisture.

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ID-076

MECHANISMS OF 2n POLLEN FORMATION OF POPLAR IN SECTION *AIGEIROS*

Jin-Feng Zhang, Zun-Zheng Wei, Dan Li, Bai-Lian Li and Zhi-Ti Zhu[1]

Polyploid breeding is important in poplar breeding since polyploid trees generally display characteristics of heterosis over normal diploids. For example, triploid white poplar trees not only grow fast but also have low lignin and high cellulose content. Thus, polyploid poplar varieties are excellent feedstock for pulp and paper production and beneficial to general environmental protection. Poplar in section *Aigeiros* has a great proportion in the forestry production and ecological environmental protection in China. A few triploid clones have been found in poplar clones in section *Aigeiros* and have been inferred from unreduced gametes. So, utilization of 2n gametes has been shown to be an effective way to obtain triploidy. Previous reports showed that 2n gametes can be produced naturally or by artificial induction in poplar. However, it is little known about the cytological mechanisms of 2n gamete formation in poplar.

The objective of this study was to detect and elucidate the mechanisms of 2n pollen formation in diploid poplar in section *Aigeiros*. *Populus deltoides, P. nigra, P.* ×*euramericana* and *P.* ×*'popularis'* were used as plant materials. Abnormalities during microsporogenesis were detected by cytological observation. Polyploid hybrids were scanned in the offspring from different controlled crosses by flow cytometry and chromosome counting. The genetic constitution of 2n pollen which has polyploid offspring was studied by SSR marker analysis. The main results can be summarized as follows:

1. Many meiotic abnormalities were found related to 2n pollen formation and both first division restitution (FDR) and second division restitution (SDR) 2n pollen were formed in poplar in section *Aigeiros*. Disoriented spindles, including parallel, fused and tripolar spindles were found at metaphase Ⅱ and anaphase Ⅱ. Fusion of adjacent polar nuclei was also found during microsporogenesis. These mechanisms were supposedly responsible for forming FDR 2n pollen. Early division of cytoplasm was found at metaphase Ⅱ and anaphase Ⅱ and was supposedly responsible for forming SDR 2n pollen.
2. Two *Aigeiros-Tacamahaca* intersectional triploid hybrids and one tetraploid hybrid in section *Aigeiros* were obtained in controlled crosses.
3. SSR marker analysis results indicated that both FDR and SDR occurred in 2n pollen formation in poplar in section *Aigeiros*.
4. A FDR 2n female gamete of poplar in section *Aigeiros* was discovered by SSR marker analysis.

Key words: poplar, ploidy breeding, 2n pollen, cytological mechanisms, SSR markers, flow cytometry.

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ID-162

MANUFACTURE OF LAMINATED VENEER LUMBER WITH STARCH-BASED ADHESIVES

Lifang Zhang[1]

A starch-based adhesive was made with corn starch through hydrolyzation, oxidation, and co-reaction with propylene monomer. Solid content of the adhesive was controlled at 40 to 50 percent, and dry bonding strength of plywood with the adhesive achieved 0.8MPa. The starch-based adhesive was further mixed with melamine formaldehyde resin (MF, 5~30%) or diphenylmethane diisocyanate (MDI, 5~10%) to produce laminated veneer lumber (LVL) in different trials. Hot-pressing technical data were: pressure 0.8~1.0MPa, temperature 120~130°C, and period 20~30min.

LVL products were tested following the Chinese national standard GB/T20241-2006. It was demonstrated that mechanical properties, e.g., peeling strength, are in line with the specifications in GB/T20241-2006, and that formaldehyde emission meets E1 grade.

Key words: starch-based adhesive, laminated veneer lumber.

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ID-232

CHARACTERIZATION OF RESISTANCE GENE ANALOGS WITH A NUCLEOTIDE BINDING SITE ISOLATED FROM A TRIPLOID WHITE POPLAR

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H.-X. Li and Z.-Y. Zhang[1]

The majority of cloned plant-disease-resistance genes (R genes) encode a nucleotide binding site (NBS) and a leucine-rich repeat (LRR) domain. In this study, for a better understanding of the R genes in white poplar, 59 resistance gene analogs (RGAs) were identified from a triploid white poplar [(*P. tomentosa* × *P. bolleana*) × *P. tomentosa*] based on the conserved NBS regions. The 59 RGAs were phylogenetically classified into 10 subfamilies and 54 RGAs with open reading frames (ORFs) were further grouped into two classes, toll and interleukin-1 receptor (TIR) and non-TIR. BLAST searches with reference to the genomic sequence of *P. trichocarpa* found 96 highly homologous regions distributed in 37 loci, suggesting the abundance and divergence of NBS-encoding genes in the triploid poplar genome.

Within subfamilies 1 to 3, the average nonsynonymous/synonymous substitution (ω) rates were <1, indicating purifying selection on these RGAs, but some sites were clearly under diversifying selection with ω >1. Many intergenic exchanges were also detected among these RGAs, indicating the probable role in homogenizing the NBS domains. Quantitative real-time PCR analysis revealed dramatic variations in the transcript level of 18 RGAs in the mature leaves, bark and roots of the triploid poplar and identified 2 RGAs that had significantly higher levels of transcripts in bark, 4 RGAs in mature leaves, and 14 in the above-ground portion of poplars, suggesting their probable roles involved in resistance against the diseases attacking these organs.

Our results shed light on genetic resources of poplar resistance and will be helpful for further resistance-gene isolation and exploitation.

Key words: NBS-LRR, *Populus tomentosa* Carr. RGA, phylogenetic analysis, quantitative real-time RT-PCR.

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ID-194

SELECTION AND EXTENSION OF NEW POPLAR VARIETIES FOR INDUSTRIAL WOOD PLANTATION IN CHINA

Qiwen Zhang[1] and Jinhua Li[1]

Superior varieties are very important for high yield of poplar plantations. Based on more than 15 years of collecting germplasm of Section Aigeiros, hybridization and selection from introduced cultivars, clones 107 (*P.* ×*canadensis* cv 'Neva') and 108 (*P.* ×*canadensis* cv 'Guariento'), introduced from Italy, were selected for improvement because of their fast growth, high yield, narrow crowns, straight stems, high survival rate, strong resistance to pests and diseases, and superior wood quality. With suitable sites and growing conditions, their yields could be up to 30 cubic meters per ha per year, more than twice the yield of the control cultivar, *P.* ×*canadensis* cv 'I-214'. On the Northern plain of China, these two cultivars have been widely planted on a total area of more than 600 million ha with a total volume up to 30 million cubic meters, which makes China a world leader in cultivar productivity.

In relation to improvement method, the combination of two poplar selections of Italy with multi-step selection increased the clone selection rate by more than 10%. Based on genetic variation and correlation analysis of many clones of Section Aigeiros, genetic variation in growth and wood quality among clones of Section Aigeiros was found to be significant and the correlation between growth and wood density was weakly negative, while the correlation between growth and fiber length was weakly positive. Superior cultivars with fast growth and good wood quality were selected using the index selection method. Based on growth and wood character analysis of clones of Section Aigeiros planted on sites, 4 to 12 years was thought to be the most suitable age at which to harvest pulpwood, when growth rate was greatest and density and fiber length were optimal. These results provide recommendations for managing poplar pulp plantation. The P-RC APMP method was used to produce wood pulp from these varieties. Results showed that chemical and mechanical pulps had high density and whiteness and the cultivars were superior for pulp. Amplified fragment length polymorphism (AFLP) analysis was used to identify ten superior varieties widely planted in Northern China, including clones 107 (*P.* ×*canadensis* cv 'Neva') and 108 (*P.* ×*canadensis* cv 'Guariento'). DNA fingerprints of ten varieties were developed from 12 selected bands amplified with 2 primer combinations (M-CAG/E-TA and M-CAG/E-TC). AFLP analysis is the preferred technique for identification of poplar varieties identify and was used to develop the forestry industry standard for molecular identification of poplar varieties.

Key words: *Populus*, Section Aigeiros, new varieties, selection breeding, genetic improvement, variety identification.

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OPTIMIZING DESIGN FOR GLULAM BEAM MADE OF MODIFIED WOOD OF FAST-GROWING POPLAR

Rui Zhang[1], Zhiqiang Wang[1], Xiaoning Lu[1] and Kong Yue[1]

This research focused on modified wood of fast-growing poplar for structural applications. A mathematic model was established in accordance with material mechanics and composite mechanics. The model was proved to be able not only to calculate the stiffness and strength of glulam beam, whose configuration of materials by layer was given in advance, but also to optimize the configuration of materials by layer of the beam on the premise of exceeding certain rigidity and strength. It helps to avoid redundancy of rigidity and strength and save the production cost of glulam beam.

Key words: fast-growing poplar, glulam beam, mathematic model, optimizing design.

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ID-233

CONSTITUTIVE EXPRESSION OF A LEA GENE FROM *TAMARIX ANDROSSOWII* CONFERS SALT TOLERANCE IN TRANSGENIC POPLAR

Ruiping Zhang, Shuang Bai, Jing Jiang, Yucheng Wang, Baichen Wang, Guanzheng Qu and Guifeng Liu[1]

A LEA gene from *Tamarix androssowii* was transformed into Xiaohei polar (*Populus simonii* × *P. nigra*) and 11 transgenic lines were randomly selected for further analysis. The experimental results of PCR and Northern blotting indicated that the LEA gene had been integrated into the poplar genome and expressed. The parameters of salt damage index, relative height growth rate, and malondialdehyde (MDA) content were assayed in both transgenic and control plants. Compared with control plants, relative height growth rates were higher and numbers and severity of wilted leaves were less in transgenic plants. Further analysis showed that under salt stress the MDA content in transgenic plants is much lower than that in non-transgenic plants, suggesting that the LEA gene may enhance salt tolerance by protecting cell membranes from damage.

These results indicate that the *T. androssowii* LEA gene is an excellent salt tolerance gene and may possess considerable potential for the genetic improvement of salt tolerance in plants.

Key words: LEA gene, transgenic poplar, salt tolerance.

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ID-154

TURBULENT FLUX OF CARBON DIOXIDE OVER POPLAR FOREST IN EASTERN CHINA

Xudong Zhang and Yuan Wei[1,2]

A two-year campaign of turbulent flux measurements of CO_2 and water vapour was undertaken, in order to help evaluate the role of poplar plantations in carbon sequestration. Net Ecosystem Exchange (NEE) was measured in two temperate forests during 2005 and 2006. The two sites were located along the Yangtze River. Climate at both sites was generally a wet monsoon climate with gentle summer-winter gradients in temperature. Marked seasonal and inter-annual differences in NEE were observed at both locations, with contrasting rates and patterns.

In this paper, results of the fluxes are presented, including seasonal and daily variability. The mean yearly net ecosystem exchange was -579g.cm^{-2}yr^{-1}, compared to temperate forest year-long assimilation, showing that the plantations were a strong C sink. Data quality and results are compared with other obtained by the US-China Carbon Consortium (USCCC) network. A decrease in carbon uptake occurred during spring, which is not a usual event in other sites but is probably due to stomatal closure associated with water vapour deficit and a peak in soil respiration.

Key words: flux, poplar plantations, carbon sequestration, seasonal cycles, data quality control.

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ID-105

STUDY OF THE SEASONAL DYNAMICS OF NET ECOSYSTEM EXCHANGE OVER A POPLAR PLANTATION IN YUEYANG CITY, HUNAN PROVINCE

Xudong Zhang[1], Yuan Wei[1], Lianghua Qi[2], Yuxi Tang[3], Zhaoyan Wang[1], Shuai Han[1] and Lingling Huang[1]

The dynamics of Net Ecosystem Exchange (NEE) over different time scales in poplar forest of the Yangtze River was studied using an eddy covariance method. The following results were obtained:

Daily CO_2 flux was found to be closely related to growth stage and photosynthetically active radiation (PAR), and night CO_2 flux showed an exponential regression relationship with soil temperature at 5 cm depth. The CO_2 flux between forest and atmosphere ranged from -2 mg $C.m^{-2}s^{-1}$ to 2 mg $C.m^{-2}s^{-1}$. In regard to diurnal change in NEE during the growing season, the forest began to absorb carbon dioxide increasingly after 7:00 a.m., remained stable from 11:00 a.m. to 1:00 p.m. due to decreasing PAR, and after 6:30 p.m. there was a change to discharge of carbon dioxide to the atmosphere, changing gradually at night. The maximum uptake occurred about 10 a.m. local time on a clear day. The NEE also had obvious seasonal variation that was mainly controlled by temperature. Significant uptake occurred during the flowering season and weak respiration occurred in the dormant season. Assimilation and respiration were nearly balanced during the transition between growing and dormant seasons. Poplar forests are a carbon sink. The annual carbon uptake of the ecosystem was -579C/m^2 in 2006, a year in which serious water logging occurred, but the plantation still absorbed carbon dioxide from the atmosphere throughout the year. This shows that poplar forest plays an important role in improvement of carbon sinks in the terrestrial ecosystem.

Key words: CO_2 flux, eddy-covariance, dynamic variation, net ecosystem exchange, poplar forest.

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ID-208

THE WETTABILITY CHANGE OF PF RESIN ON THE SURFACE FOR WOOD STRAND UNDER DIFFERENT DRYING CONDITIONS

Yang Zhang[1] and Siqun Wang[2]

In this paper the changes in surface wettability of wood strands by PF resin were tested by the Wilhelmy plate method after different drying conditions. Commercial strands of southern yellow pine, which were usually used as raw materials for OSB manufactures in the USA, were used in this study. The measurements included the surface contact angle (θ) and changes in the sample weight. Thirty industrial strands were randomly collected for each condition.

The research results showed that the surface contact angle of oven dried and microwave dried strands was smaller than of the air dried ones. There was also a good relationship between the wettability of the wood strand and mass change.

Key words: surface contact angle, wettability, absorbed liquid.

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ID-229

CYTOLOGICAL CHARACTERIZATION OF THE FORMATION OF UNREDUCED POLLEN IN *POPULUS TOMENTOSA* CARR.

Zhenghai Zhang[1] and Xiangyang Kang[1]

Unreduced gametes - gametes with a number of somatic chromosomes - play an important role in plant sexual polyploidy. The production of unreduced pollen has been reported in *Populus tomentosa*, but more research is needed to reveal the mechanisms of unreduced pollen formation.

Microscopic examination of mirosporogenesis revealed that, although the first meiotic division occurred normally, the second division was characterized by frequent abnormal spindles (parallel, tripolar and fused spindles) and premature cytokinesis which have been claimed to lead to dyad and triad production at the tetrad stage. An indirect immunofluorescence study of microtubule cytoskeleton patterns during meiosis of pollen mother cells suggested that the abnormal spindles in some microsporocytes may cause irregular operation of microtubules leading to fusion of spindle poles, so that dyads and triads were induced by the fusion of spindles and finally unreduced pollen occurred. The unreduced pollen caused by abnormal spindles was genetically equivalent to the first-division restitution (FDR) mechanism, while that from premature cytokinesis was genetically equivalent to the second-division restitution (SDR).

Key words: *Populus*, cytology, unreduced gamete, triploid breeding.

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CONSTRUCTION OF HYBRID POPULATIONS AND EMBRYO RESCUE OF *POPULUS TOMENTOSA* CARR.

Xiyang Zhao, Kaifeng Ma and Zhiyi Zhang[1]

Populus tomentosa Carr. is an indigenous tree species of white poplar (in section Leuce) in China. Having rapid growth, superior wood quality, strong adaptation and a handsome tree form, it is widely employed for forestation and landscape applications in North China. Meanwhile, the broad genetic variation of *P. tomentosa* contributes to resources of new poplar cultivars, and enables further study of heterosis in cross-breeding.

In the present study, two male clones and three female clones were selected as parents, and controlled-pollination of six combinations was performed. As a result, 1 134 seeds were obtained. Being premature and falling early, the seeds were cultured *in vitro* in 1/2MS medium to obtain more seedlings. Using *P. tomentosa* var. truncate as male parent in crossing, no seedlings were produced, whereas, for the other, *P. tomentosa* 'pt-1' × *P. tomentosa* 'LM50' produced 53 seedlings from 495 seeds. *P. tomentosa* 'pt-2' × *P. tomentosa* 'LM50' produced 24 seedlings from 171 seeds and *P. tomentosa* '5082' × *P. tomentosa* 'LM50' produced 21 seedlings from 468 seeds. The frequency of emergence of seedlings from the above three combinations was 71.3%, 14.0%, 4.4% respectively. The embryo rescue rate of inbred embryos of *P. tomentosa* might be affected by multiple factors such as combining ability, genetic distance and environment, and remains to be studied further.

Key words: *Populus tomentosa* Carr., inbred, embryo rescue.

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ID-186

A PRECISION WATER-SAVING AUTOMATIC IRRIGATION SYSTEM CONTROLLED BY THE NEEDS OF POPLARS

Yandong Zhao[1], Weilun Yin[2], Jinfeng Guan[1] and Junfu Zhang[1]

The 2008 Olympic Games are not only a world sports event of the highest level, but also a rare opportunity to show the current level of economic development in China and its strength in modern science and technology. The precision water-saving automatic irrigation system controlled by the water needs of poplar trees which this paper describes is part of the Olympic Games facilities. It is based on the physiological standards of water requirements in poplars and soil water content. Through a combination of independent research, the development of an irrigation monitor and controller, and wireless data transmission, a system has been developed with drip irrigation, sprinkler irrigation, micro-irrigation, and low-pressure pipelines, as well as different methods of automatic irrigation control. The system is monitored through GSM remote wireless communication, automatically entering all irrigation incidents into the database, and generating a variety of reports of the irrigation data for statistical analysis.

The paper describes the structure of the system, including hardware and software design, which is characterized by a flexible mode of operation, reliable control and data transmission, and a distinctive, low-cost water-saving effect. The preliminary trial of the precision water-saving irrigation project at the National Olympic facilities shows that this new type of superior water-saving irrigation control system with independent intellectual property rights has a high value for promotion.

Key words: physiological water requirements, soil water content, water-saving irrigation, automatic control.

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ID-074

SALT TOLERANCE MULTIGENE ASSEMBLY VECTOR CONSTRUCTION AND TRANSFORMATION OF *POPULUS*

Yangling Zhao, Guirong Qiao, Yin Chen, Ye Yang, Jin Zhou, Haiying Li, Luanyin Pan, Honggai Song and Renying Zhuo[1]

Salinity affects almost every aspect of plant physiology and biochemistry and a large number of genes involved in salt tolerance in plants. It has been shown that some transgenic plants with relational genes have increased salinity tolerance, but there is still little knowledge of how multigenes act to transform plants and which genes are most important for improving transformation.

Seven multigene assembly vectors for salt tolerance were created using a multigene assembly vector system kindly provided by Prof. Yaoguang Liu. This system consists of a TAC-based acceptor vector together with two donor vectors. By utilizing the Cre/*loxp* recombination system and homing endonucleases, multiple rounds of gene assembly cycling can be carried out with alternate use of the donor vectors, and the multiple genes are sequentially delivered into the TAC vector. With this system, the *AVP1-D* (*Arabidopsis thaliana* vacuolar-type H+-pumping pyrophosphatase 1 induced with CaMV35S promoter, and other five genes *AtNHX1* (*Arabidopsis thaliana* Na+/H+ antiporter gene of *Arabidopsis thaliana*), Ipt (*Agrobacterium tumefaciens* isopentenyl transferase gene), CodA (*Arthrobacter globiformis* choline oxidase gene), *DREB2A* (*Arabidopsis thaliana* transcription factor), *Cu/Mn-SOD* (*Gossypium hirsutum* putative cytosolic copper/zinc superoxide dismutase) promoted by *Rd29A* promoter were in turn recombined to the acceptor vector pYLTAC747H. The multigene assembly vectors pYL-AVP-NH-IPT-CodA, pYL-AVP-NH-IPT-DREB2A, pYL-AVP-NH-IPT-SOD, pYL-AVP-NH-IPT-CodA-SOD, pYL-AVP-NH-IPT-DREB-SOD, pYL-AVP-NH-IPT-CodA-DREB and pYL-AVP-NH-IPT-CodA-DREB-SOD were transformed into *Populus* 'NL895' (kindly provided by Prof. Qiang ZhuGe) via *Agrobacterium*.

Key words: multigene assembly vector, *Populus* NL895, *AVP1-D, AtNHX1, Ipt, CodA, DREB2A, Cu/Mn-SOD*.

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ID-051

ISOLATION OF A TIR-NBS-LIKE GENE PROMOTER FROM TRIPLOID WHITE POPLAR AND ITS CHARACTERIZATION IN TRANSGENIC TOBACCO PLANTS

Huiquan Zheng, Shanzhi Lin, Qian Zhang, Yang Lei
and Zhiyi Zhang[1]

The *PtDrl02* gene (Accession: DQ324361) was initially isolated from the triploid white poplar (*Populus tomentosa* × *P. bolleana*) × *P. tomentosa* and was characterized as a TIR-NBS disease-resistance-like protein gene in *Populus*. RT-PCR results indicated that the *PtDrl02* gene was active in the leaves, petioles and green, young stems of triploid white poplar, while there was no evidence of expression found in bark and roots. Quantitative analysis by Real-time RT-PCR assays suggested that expression of the *PtDrl02* gene was positively induced by wounding, MeJA and SA. To gain further insight into the mechanisms that regulate the expression of *PtDrl02* gene, we first isolated the *PtDrl02* promoter (Accession: EF424611) from triploid white poplar clone L9. Computer search of putative *cis*-acting elements in this promoter region revealed the presence of three W-boxes, two GT-1 motifs and one ABRE motif homologous to those involved in the activation of defense genes in plants. For functional characterization, the *PtDrl02* promoter and its derivatives were translationally fused to the β-glucuronidase (GUS) reporter gene and genetically transferred into tobacco plants.

It was found that the *PtDrl02* promoter directed the GUS reporter gene expression mainly in the cortex tissue of leaf veins and petioles as well as stems, stem piths and even the meristematic zone of some developing roots, showing typical tissue-specific pattern, which was compatible with the expression profile of the *PtDrl02* gene in triploid white poplar. Deletion of 5' progressive portions of the *PtDrl02* promoter identified two positive regulatory regions (–985 to –669 and –669 to –467) and one negative fragment (–467 to –244) responsible for *PtDrl02* promoter expression in transgenic tobacco plants. Furthermore, the sequences from –669 to –467 and –244 to 0 were shown to contain novel *cis*-elements in response to wounding and MeJA, while the –467 to –244 fragment was required for SA- and NaCl-inducible expression of the *PtDrl02* promoter, and additionally it was found that the –985 to –669 sequence was the promoter region essentially for ABA-induced expression. These regulatory regions correspond closely to the predicted motifs (W-boxes, GT-1 motifs and ABRE) within the promoter sequence and point to the presence of unknown motifs, implying that the *PtDrl02* promoter functions by multiple *cis*-regulatory elements in distinct and complex patterns to regulate *PtDrl02* gene expression.

Key words: TIR, NBS, promoter, poplar, *cis*-regulatory elements.

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ID-193

HEAT TRANSFER CHARACTERISTIC OF OSB-STRAWBOARD SANDWICH WALLBOARD

Xiaoyan Zhou[1], Dingguo Zhou[1], Xianye Liang[1] and Jian Li[1]

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The thermal transfer properties of strawboard were tested. The heat conductivity (λ) of OSB-Strawboard Sandwich Wallboard was evaluated with a finite difference method and an integral transformation method. Furthermore, the indoor environment in a building based on OSB-Strawboard Sandwich Wallboard was investigated. It was indicated that OSB-Strawboard Sandwich Wallboard has good thermal insulation performance compared with traditional construction materials. The wallboard had steady heat transfer characteristics. The thermal properties are as such that the wallboard withstands the differences of the outdoor environment better than the brick wall, even with a thickness half of the brick wall.

Key words: OSB, strawboard, heat transfer characteristic.

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ID-235

NANO-MECHANICAL PROPERTIES OF THE PRE-COMPRESSED POPLAR CELL WALL-BASED ON NANO-INDENTATION

Zhaobing Zhou[1], Yang Zhang[1] and Siqun Wang[2]

Heating and pressing play a very important role in the utilizing and processing of wood and wood-based composites, especially in manufacturing compressed wood.

The objective of this study was to measure the longitudinal elastic modulus and hardness values of the samples pre-compressed in transverse direction based on nano-indentation. Focus was on the influence of various compression ratios, the platen temperature and the pressing time on the nano-mechanical properties of the cell wall. It was shown that the nano-mechanical properties were significantly affected by the compressing parameters. The elastic modulus and hardness values were linearly increased with either the compression ratio or the pressing time. A cubic polynomial trend for the relationship between the platen temperature and elastic modulus or hardness was found. This means that the impact of the platen temperature was more complex than both other parameters, the compression ratio and the pressing time. More attention should go to the platen temperature when studying and manufacturing compressed poplar.

Key words: poplar, compressing process, cell wall, elastic modulus, hardness, nano-indentation.

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ID-234

CHINESE RED-LEAVED POPLAR: A NEW POPLAR VARIETY

Yanlin Zhu[1] and Xiangjun Cheng[2]

Chinese red-leaved poplar is a bud mutation poplar variety which was found in a one-year-old stumping seedlings in April 2005. In 2007, it obtained the State New Tree Variety Certificate.

After a few years of observation, we have found that it shows a good stable characteristic: its leaves and twigs have a pretty rose colour from spring to early summer, turning vivid violet-red from early summer to mid-autumn, then gradually becoming apricot-red after mid-autumn until leaf-fall. Throughout the annual growing cycle, it presents a diversity of colours at different seasons. It is also a fast-growing tree variety, one-year-old cuttings reaching a height of 3.1 m, with average basal diameter about 2.3cm. Its total chlorophyll content is 30.1% higher than that of variety '2025', chlorophyll-a and chlorophyll-b content being 26.2% and 41.9% higher respectively, though chlorophyll a/b is 11.1% lower. Its carotenoid and anthocyanin contents are 23.2% and 1086% higher, respectively, than '2025'. When sprayed with 3‰ KH_2PO_4, 3‰ citric acid and 3‰ sucrose nutrient solution under conditions of full sunlight, the leaf anthocyanin content increased 76.1%, 27.4% and 56.4% respectively. With spraying of 3‰ KH_2PO_4, the anthocyanin content can reach as much as 1.02525g^{-1}FW.

Key words: poplar, variety, Chinese red-leaved poplar.

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