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INTERNATIONAL POPLAR COMMISSION

24th Session
Dehradun, India, 30 October-2 November 2012

IMPROVING LIVES WITH POPLARS AND WILLOWS

Abstracts of Submitted Papers

Forest Assessment, Management and
Conservation Division
Forestry Department

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FAO, Rome, Italy

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The Abstract 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.

For further information, please contact:

Mr Walter Kollert
Secretary
International Poplar Commission
Technical Statutory Body
Forestry Department
Food and Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla
I-00153 Rome
Italy
E-mail: Walter.Kollert@fao.org

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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 http://www.fao.org/forestry/ipc and highlights of the 24th Session of the International Poplar Commission, 2012, can be viewed on http://www.fao.org/forestry/ipc2012.

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Organized by
Food and Agriculture Organization of the United Nations (FAO)
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ACKNOWLEDGEMENTS

These abstracts of submitted papers are the product of an international team of dedicated people willingly giving their time and specific experience to evaluate, review and allocate more than 200 submitted abstracts for plenary, oral or visual presentations. It is encouraging to see the diversity of topics submitted by the authors, reflecting the topical issue of more than 20 countries, in all temperate and boreal regions of the world. The Scientific Committee headed by its chairman P.P. Bhojvaid (India) and vice-chairman Stefano Bisoffi (Italy), were professionally supported by its members Y.P. Singh (India), Marijke Steenackers (Belgium), Arun Pratap Singh (India), Sylvie Augustin (France), Vimal Kothiyal (India), Joris van Acker (Belgium), P.K. Pandey (India), N.B. Singh (India), Ian McIvor (New Zealand), Dinesh Kumar (India), Teresa Cerillo (Argentina), H.S. Ginwal (India), Lu Meng Zhu (China), Catherine Bastien (France), A.S. Rawat (India), Jim Richardson (Canada), R.C. Dhiman (India), Enrico Brugnoli (Italy), Gulshan Ahuja (India), S. Nautiyal (India), Manisha Thapliyal (India), Santhan Barthwal (India), Martin Weih (Sweden), Jud Isebrands (USA), and Julia Kuzovkina (USA).

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FOREWORD

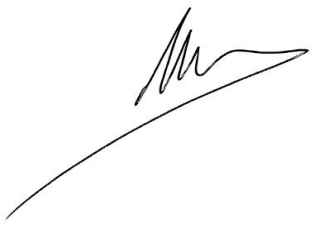
The 24th Session of the International Poplar Commission, hosted by India in Dehradun, will bring together a number of international stakeholders, poplar scientists, researchers, growers, processors and traders to address topical issues related to the theme ***"Improving Lives with Poplars and Willows".***

In India, poplars and willows are the most popular tree species in agroforestry production systems where they are intercropped with agricultural crops like wheat, sugar cane, paddy rice and shade-tolerant fodder crops due to their fast growth, outstanding properties and quick and high financial returns. Smallholders and farmers own an increasing area of poplar plantations and depend on them for the improvement of their livelihoods. A large number of people, among them many women, gain employment and income from poplar cultivation, particularly in remote areas where forestry and agroforestry are the only economically viable land use options. Timber from poplars often forms the backbone for the development of vibrant plywood, composite board, match, paper and sports goods industries, which further contribute to the improvement of rural livelihoods, especially when a significant portion of the wealth of such value-added activity remains in the local economy and among the forest-dependent workforce.

The more than 200 paper abstracts from more than 20 industrialized and developing 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 IPC 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.

This Book of Abstracts will help to facilitate fruitful discussions between stakeholders at the 24th 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.



Eduardo Rojas-Briales
Assistant Director-General
Forestry Department

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SUB-COMMITTEE ON NOMENCLATURE AND REGISTRATION

USING MORPHOLOGICAL TRAITS FOR IDENTIFICATION OF POPLAR (*POPULUS ALBA*) STANDS IN IRAN (ESFAHAN AND ZANJAN PROVINCES)

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

Genetic diversity is important for long-time survival of poplar cultivations and their adaptation against changing environmental condition are due to genetic diversity level. Therefore, 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 this study, for estimating genetic diversity between and within seven stands of *Populus alba* established in Iran (Esfehan and Zanjan provinces), morphological traits were measured. In order to assimilate environmental conditions, cuttings were planted under randomized complete blocks design with three replications. In middling of growing season, 17 morphological traits were measured and data were analyzed using analysis of variance, t-test and cluster.

Results showed significant differences observed between stands. By using cluster analysis, stands were classified in two groups on the basis of two different provinces. In homogeneous conditions, morphological traits could reveal diversity and similarity in poplar stands.

Keywords: *Populus alba*, morphological traits, genetic diversity.

[1] Scientific Board Member of Payame Noor University, Iran. E-mail: afrooz_viva@yahoo.com
[2] Scientific Board Members of Research Institute of Forest and Rangelands, Iran. E-mail: F.asadi@rifr-ac.ir
[3] Scientific Board Members of Azad Islamic University, Iran.

ID-013

INVESTIGATION ON GENETIC DIVERSITY IN *POPULUS NIGRA* PLANTATIONS USING MOLECULAR AND MORPHOLOGICAL MARKERS

A. Alimohamadi[1], F. Asadi[2] and R. Tabaie Aghdaie[3]

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 poplars in Iran.

In this study, genetic diversity between eight stands of *Populus nigra* established in Kermanshah province was evaluated on the basis of molecular and morphological markers. In order to assimilate environmental conditions, seedlings were planted under randomized complete blocks design with three replications. To amplify microsatellite loci (WPMS09, WPMS16 and WPMS18), following DNA extraction from young and fresh leaves, various conditions of the PCR assay were examined. To evaluate morphological variation, leaves morphological characters (consisting of 19 traits) were measured. In addition, height growth was measured to evaluate growth function of stands in homogeneous conditions.

Results showed monomorphic at three investigated microsatellite loci. No significant differences between mean values of all morphological characters and height growth were revealed. Observed genetic similarity gave indication that same remets had been selected to plant in poplar plantation established in Kermanshah province.

These results suggest the need for initial evaluation of genetic diversity in selected ramets for planting in plantation to avoid repetition.

Keywords: Genetic inventory, microsatellite markers, leaf traits, height growth, *Populus nigra*, Iran.

[1] Scientific Board Member of Payame Noor University, Iran. E-mail: afrooz_viva@yahoo.com
[2] Scientific Board Member of Research Institute of Forest and Rangelands, Iran. E-mail: F.asadi@rifr-ac.ir
[3] Scientific Board Member of Research Institute of Forest and Rangelands, Iran. E-mail: R.Tabaei@rifr-ac.ir

ID-012

VARIATION IN THE GROWTH AND WOOD PROPERTIES OF *POPULUS DELTOIDES*

Massarat Aziz[1] and P.K Pande

Wood is a highly variable material which could be well utilized for tree improvement program, as to reduce the wood variations is an essential component of tree improvement programs. In order to produce and use wood efficiently, the variation patterns within trees, among trees within species, among provenances within species and among species must be understood. Because of its importance, numerous studies have been carried out, relative to wood properties and the causes of wood variation. The variability in wood anatomical characteristics has profound influence on the properties of wood.

Variance ratio (F) test showed that variations for growth (DBH and height) were significant for clones and non-significant for ramets of both parents and F_1 hybrid clones. Among the parents (G48, female parent and G3, male parent) and hybrids (females and males), DBH (diameter at breast height) and tree height were higher in female parent (G48) than in the male parent (G3). DBH and height were higher in male F_1 hybrid than in the female F_1 hybrids and parents showing hybrid vigour. The wood properties showed that inter-clonal difference between the means for both parents and F_1 hybrid clones were significant for all the wood traits.

The dimensions of wood element were higher in F_1 hybrids than of the parents showing hybrid vigour. The fiber and vessel dimensions were found higher in female F_1 hybrids however specific gravity was found higher in male hybrids than females. The female F_1 hybrids showed dominance for wood traits over male F_1 hybrids. The female and male F1 hybrid clones were significantly different from each other hence provide an opportunity for the selection of hybrids for the desired wood properties for further cloning under tree improvement program. The female clones, in general, showed better wood properties than of the male ones. So, female hybrids may be preferred for the development of new clones as per the desired wood properties.

Keywords: Ramets, DBH, G48, G3.

[1] Wood Anatomy Discipline, Botany Division, Forest Research Institute, Dehradun, Uttarakhand, India. E-mail : masrat.012@gmail.com

GENETIC IMPROVEMENT AND NEW CULTIVARS BREEDING OF *POPULUS DAVIDIANA*

Xingyajuan Baihui[1] and Shuping Guo

Populus davidiana has a number of good characteristics such as excellent resistance to drought and infertile soil, white timber colour, and super quality of wood. Therefore it is highly valued and considered as one of the best among the native poplar species in China. In 1983, a national program of selection and breeding of *Populus davidiana* was established. Since then much work has been done.

First of all, collection and conservation of gene resources and the establishment of a clonal archive and arboretum has been done. In 1992, 171 different plus trees from 15 provinces were selected and collected, and the clonal archive and clonal arboretum of *P. davidiana* were established with four different approaches. This is of great significance for gene resources conservation and breeding work.

Secondly, provenance test and clonal selection for pulpwood and constructive timber were studied. The 66 best clones for pulpwood and construction timber among the best seven provenances have been selected. Twenty to thirty per cent of the genetic gain for wood increment of these clones can be obtained.

Thirdly, the wide-cross and back-cross breeding for pulpwood were examined. In order to improve the quality of *P. davidiana*, wide-cross *Populus davidiana* × *P.tremuloides* was adopted and the four best clones were selected from these combinations. *P. alba*×*P. davidian* CL.'1333'and *P. davidiana* Dode×(*P. alba*×*P. davidiana*) CL.'1132' were also adopted , being faster compared with other wild *P. davidiana*. In March 2011, the six clones for pulpwood were accepted and identified by the Forestry Ministry of Heilongjiang province of China.

Lastly, the rapid system of vegetative propagation was taken into account. On the basis of tissues culture, a very new system of propagation has been developed. With this new system, one million ramets of *P. davidiana* can be obtained from one ortet in three years, and much cheaper then before.

Keywords: *Populus davidiana,* genetic improvement, new cultivars breeding.

[1] Forestry Science Research Institute of Heilongjiang Province, Harbin 150081, China.

IN VITRO ROOTING INDUCTION AND TISSUE CULTURE OF *P. DELTOIDES* AND *P. CANADENSIS* IN ORDER TO GENETIC TRANSFORMATION

M.V. Briones[1, 2], R.M. Rangel Cano[3], S. Galarco[1, 4], G. Ciocchini[1,5] and S. Sharry[1]

Forest biotechnology, and more specifically genetic transformation of trees, is an option for achieving some genetic improvement. The next steps in transgenic trees are aimed at enhancing traits related to biotic and abiotic stress, wood quality, CO_2 capture capability, productivity, rapid growth, production of compounds of pharmacological interest and phytoremediation. Success in forest species is, so far, limited by the problems associated with plants regeneration, especially considering that many species are still considered recalcitrant to *in vitro* culture. The genus *Populus* has become a model organism for tree biotechnology. There are several reports of genetic transformation of poplar, but the "*deltoides*" and "*canadensis*" genotypes have not been genetically transformed yet; thus, the optimization of a protocol for *in vitro* regeneration and its subsequent genetic transformation is a challenge for research groups and a topic of great interest among Salicaceae wood producers in Argentina, Mexico and the world. The rooting of clones with *deltoides* genotype is very difficult, and this feature is reflected in the *in vitro* propagation. Therefore, the aim of this research is to set a protocol for genetic transformation rooting of *P.deltoides* and *P. canadensis*.

We worked with nodal sections and leaves of *Populus deltoides* cv. Australia 129/60 from Argentina and *Populus canadensis* from Mexico. The explants were disinfected by gasification using hydrochloric acid and sodium hypochlorite. The basal medium used was Murashige-Skoog (MS) and several concentrations of growth regulators were tested in order to search for shoot proliferation, both in the nodal sections and in the leaves. For rooting of shoots formed *in vitro*, high concentrations of auxin and indole butyric acid (IBA) were tested, and a strategy of transformation with *Agrobacterium rhizogenes* was proposed. The environmental conditions of cultivation were obtained in environmental chambers. Strains of *Agrobacterium tumefaciens* with three different constructions were used for genetic transformation assays. For both *P. deltoides* Australia 129/60 and *P. canadensis*, the best result was obtained with times of 20 minutes of disinfection by gasification. In the particular case of *Populus Canadensis*, 70% of explants without contamination were obtained. The response of each poplar to the concentrations of the growth regulators and combinations was different. In the case of nodal sections for *Populus deltoides*, the number of shoots formed *in vitro* increased when increasing the concentration of 6-benzylaminopurine (BAP) to 3 and 4 mg/l. For *Populus canadensis*, we found a greater number of shoots in less time, with a concentration of BAP 2 mg/l. When leaves were used as explants for *P. deltoides*, the shoots were originated at a concentration of BAP at 2 mg/l, GA3 1 mg/l. Shoots were rooted in an MS medium supplemented with 10 mg/l IBA for 48 hours and then were placed in a regulator-free MS medium. As it was not possible to achieve an adequate control of the contamination and death of explants, the agroinfection was difficult. The induction of rooted shoots of woody species is

[1] Universidad Nacional de La Plata, Argentina. E-mail: ceprove@agro.unlp.edu.ar
[2] Consejo Nacional de Investigaciones Cientificas y Técnicas (CONICET), Argentina.
[3] Centro de Investigaciones y Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV), México.
[4] Dirección de Bosques y Forestación, Ministerio de Asuntos Agrarios de la Provincia de Buenos Aires, Argentina.
[5] Comisión de Investigaciones Científicas de la Provincia de Buenos Aires, Argentina.

a major challenge and a goal to overcome so as to obtain transgenic plants of poplar clones with *deltoides* genotype.

The knowledge gained on an efficient and reproductible transformation method will make it possible to generate transgenic plants with technology aimed at solving the current problems of the forestry sector of Argentina and the world.

Keywords: micropropagation, poplar, rooting induction, genetic transformation.

BEHAVIOR OF CLONES OF *POPULUS* SPP., IN TUNUYÁN, MENDOZA, ARGENTINA

A. Calderon, J. Bustamante, N. Riu, S. Pérez[1], and P. Zanetti[2]

In order to study the behavior of poplar clones in different sites of the central-western Argentina, the Forestry Institute of the Faculty of Agricultural Sciences set up a test network. One was established in 2001 in the Department of Tunuyán, Province of Mendoza.

This paper describes the behavior of three clones of *Populus x canadensis '* NNDV', 'Guardi' and 'Neva' and four clones of *Populus deltoides* : '582-4', '562-11', 'Stoneville 70' and 'INTA 67/67'. The property is located at 33°64 '51" South latitude and at 69°06'73'' West longitude, altitude 930 meters. The main climatic data of the site are: absolute maximum temperature: 38ºC, absolute minimum temperature: -14°C. The soil is sandy loam, deep, pH 7.8, with an electrical conductivity of 1.04 dS/m.

Normal work was carried out on the crop. In all trees of the test, pruning was carried out and was also required to reach a trunk free of branches from the base and up to 7 meters. Planting distance was 6 meters between rows and 4 meters between plants, the total area of the assay was 2 hectares. Diameter at breast height and tree height were measured annually and timber volume in cubic meters per hectare was estimated. Observation was performed in parallel with plant health of each of the clones tested.

At 10 years of age of the forest, the average volume of wood produced by the clones was 504 m^3.ha-1, ranging from 619-1 of the 582 m^3.ha-4 at 360 m^3.ha-1 of 'Neva'. The 'Neva' is very sensitive to "canker" produced by *Septoria musiva*, while the 'NNDV' and 'Guardi' showed medium sensitivity and the other clones behaved very resistant to this disease. We did not observe the presence of other pests or diseases of relevance.

Keywords: poplar, clones, behavior.

[1] Docentes-Investigadores de la Cátedra de Dasonomía de la Facultad de Ciencias Agrarias de la Universidad Nacional de Cuyo, Mendoza, República Argentina. E-mail: acalderon@fca.uncu.edu.ar

[2] Personal de Apoyo Académico de de la Cátedra de Dasonomía de la Facultad de Ciencias Agrarias de la Universidad Nacional de Cuyo, Mendoza, República Argentina.

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

A. Calderon, J. Bustamante, N. Riu, S. Pérez[1], and P. Zanetti[2]

In order to study the behavior of poplar clones in different sites of the central-western Argentina, the Forestry Institute of the Faculty of Agricultural Sciences set up a test network. One was established in 2003 in the Department of Lavalle, Province of Mendoza.

This paper describes the behavior of six clones of *Populus x canadensis*: 'Enza', 'Soligo', 'S683-24', 'Zhongling 28', 'Zhongling 23' and 'Zhongling 46', one clone of *Populus deltoides*: "Harvard" and two clones of *Populus x generosa*: 'Donk' and 'Beaupre'. The property is located at 32º81'00" South latitude and at 68º51'25" West longitude, altitude 580 meters, absolute maximum temperature 41.2°C, absolute minimum temperature: -9.4°C. A characterization of soil and water was used for irrigation (household wastewater). Normal work on culture and pruning of trees were made.

The design used for statistical analysis of data was a randomized block with four replications. Each cell contained nine plants. Planting distance was 4 meters between rows and 4 meters between plants. The annual diameter at breast height and tree height were measured and the volume of wood produced, expressed in cubic meters per hectare, was estimated. Observation was performed in parallel with plant health of each of the clones tested.

At 8-year old, the clone 'Enza' produced 240 m^3.ha-1, the timber volume of the clones 'Zhongling 23', 'Zhongling 28' and 'Harvard' reached between 201 and 210 m^3.ha-1, and the volume of the rest of the clones was less than 143 m^3.ha-1.

The plant health was generally good; to date the presence of pests or diseases of importance on the test plants was not detected. Only water stress symptoms were observed in some leaves during the last growing season.

Keywords: poplar, clones, behavior, sewage.

[1] Docentes-Investigadores de la Cátedra de Dasonomía de la Facultad de Ciencias Agrarias de la Universidad Nacional de Cuyo, Mendoza, República Argentina. E-mail: acalderon@fca.uncu.edu.ar

[2] Personal de Apoyo Académico de de la Cátedra de Dasonomía de la Facultad de Ciencias Agrarias de la Universidad Nacional de Cuyo, Mendoza, República Argentina.

ADVANCES ON THE WILLOW BREEDING PROGRAM IN ARGENTINA

Teresa Cerrillo[1]

In Argentina, willows (*Salix* spp) are mainly cultivated in the Delta of Paraná, a region with excellent ecological conditions for this genus and that is located near the consumption centers. The area of willow plantations in Delta is more than 83,000 hectares (approximately 82% of the total Salicaceae plantations). Delta region has 20% of high sites (more appropriated to poplars) and 80% of low lands (where willows growth in good conditions). Willows and poplars do not compete in this territory because of their different ecologic exigencies. On a lesser scale in the country, there are other willow cultivation areas in the irrigated lands of Patagonia and Cuyo.

More than 90% of willows plantations in Argentina are applied for pulp industry (to manufacture newspapers) and production of particleboard, but in the last years an increasing industrial demand of willows for sawing (secondary use since today) is observed. It is well known that willow wood is appropriate to uses of quality, such as furniture components and veneer for plywood. However, the availability of willow plantations in Argentina, considering the total area planted and the quality, is not enough to supply this demand. In this context, it is necessary to increase the potential of the willow plantations by means of different factors, being the genetic improvement one of the main important. In this context, a breeding program is being developed since 2003 by INTA (*Instituto Nacional de Tecnología Agropecuaria*), with the fundamental aim to provide a range of genotypes of more variability by means of inter- and intra-specific hybridisation. On the other hand, the program has also continued researches and has capitalized results of a project started in 1986 by CIEF (*Centro de Investigaciones y Experiencias Forestales*) in agreement with INTA.

Recently, six new willow cultivars were selected because of their good adaptation to different site conditions (including critical flooding periods) and the good performance on the selection criteria: fast growth, disease resistance, stem form, apical dominance and wood quality were selected. The selected clones, "Agronales INTA-CIEF" (hybrid between *S. matsudana* and *S. alba*); "Los Arroyos INTA-CIEF" *(S. matsudana* x *S. alba*); "Ibicuy INTA-CIEF" (*Salix nigra*); "Géminis INTA-CIEF" *(S. matsudana x* ?*)* "Lezama INTA-CIEF" *(S. matsudana x S. nigra)* y "Yaguareté INTA-CIEF" (*S. alba x* ?) are in the registration process in the *Registro Nacional de Cultivares* of the *Instituto Nacional de Semillas* (INASE). Wood evaluation of the six selected clones showing good pulp mechanical resistance for newspaper industry and interesting performance for sawing uses, complementary evaluations are necessary in order to have a complete characterization of the selected genotypes.

In earlier phases of the program, germoplasm is under evaluation, involving the species: *S. amygdaloides, S. bondplandiana, S. fragilis, S, humboldtiana* and *S. babylonica*, in addition to those involved in the six selected, in order to provide new options for the future willow plantations in different regions of Argentina.

Keywords: willows, *Salix*, breeding program, selected clones, Argentina.

[1] Instituto Nacional de Tecnología Agropecuaria (INTA), EEA Delta del Paraná, Campana, Argentina. E-mail: tcerrillo@correo.inta.gov.ar

WOOD EVALUATION OF WILLOWS FOR PAPER INDUSTRY

Teresa Cerrillo[1], Jorgelina Grande[2], José Vaschetto[2], Ricardo Bratovich[2], Gerardo Mujica[1], Juan M. García Conde[2] and Silvia Monteoliva[3]

Willow wood is appropriate to several different industrial uses, including pulp and paper, production of particleboard, veneer for plywood and furniture components. In Argentina, more than 90% of willows plantations are used for the manufacture of pulp (for newspaper) and for the particleboard industry; secondary, for sawing. In order to improve the quality of the willow plantations, for the different applications, INTA (*Instituto Nacional de Tecnología Agropecuaria*) is developing a breeding program that has reached different phases of selection, with over 3,000 genotypes in evaluation. Selection criteria include fast growth, adaptability, resistance diseases, stem form and wood quality for paper industry and sawing.

To carry out the growth and wood evaluations of the willow clones in the selection process, since 2003 a technical working group has been progressively integrated, through agreements between INTA and private and public institutions: *Papel Prensa SA* (a company that consumes more than 60% of willow products in the Delta of Paraná, the main core of the genus *Salix* production in the country) and the *Universidad Nacional de La Plata* (in this case, through its Wood Laboratory).

The work included 1,774 willow genotypes in different phases of selection, which were studied on basic wood characteristics: moisture content, basic density and bark thickening. Additionally, 100 of the more advanced clones in the selection process were studied on their wood brightness and 32 of them on the fiber length. Also, the chemi-mechanical pulp of 18 clones obtained in the last selection phase was evaluated on their property for the manufacture of newspapers: tear strength, tensile strength and scattering.

The results showed the supremacy of 10 clones with excellent industrial performance for newsprint, 7 of which are originated in controlled combinations*: Salix matsudana x S. alba*, *S. matsudana x S. nigra* and *S. babylonica* var *sacramenta x S. bondpandiana* and 3 genotypes from open-polinization: *S. alba* x?, *S. matsudana* and *S. babylonica* var *sacramenta*. Also, 5 of these willow clones were evaluated preliminary on their ability for sawing and highly satisfactory result were obtained. Therefore, it is expected to reach interesting material value dual purpose for the industries, which would have major positive implications for the future, with benefits for the entire production chain.

Keywords: willow, *Salix*, wood properties, breeding program, selected clones, Argentina.

[1] Instituto Nacional de Tecnología Agropecuaria (INTA), EEA Delta del Paraná, Campana, Argentina. E-mail: tcerrillo@correo.inta.gov.ar
[2] Papel Prensa SA, San Pedro, Buenos Aires, Argentina.
[3] Facultad de Ciencias Agrarias y Forestales, Universidad Nacional de La Plata. CONICET, Argentina.

COMPARATIVE GROWTH OF WILLOW CLONES IN NORTH PATAGONIA, ARGENTINA – PRELIMINARY RESULTS

Teresa Cerrillo[1] and Esteban Thomas[2]

In the irrigated valleys of Northern Patagonia, Argentina, forestry is mainly based on the utilization of Salicaceae (especially poplar clones) as windbreaks to protect crops of fruits and vegetables. Salicaceae cultivation, for quality timber plantation at low densities, is often combined with other activities as agroforestry. Willows (*Salix* spp) have good prospects for wood production in the region, showing significant adaptability to the ecological and soil conditions, even on sites with specific problems, such as salinity and water table near the surface. Although the region of the Delta of Paraná is the main core of willows production, this area in the South of the country also offers excellent opportunities to produce willow wood of good quality.

One focus of the willow breeding program of INTA (*Instituto Nacional de Tecnología Agropecuaria*) is to obtain productive clones adapted to different regions of the country. In this context, fourteen experimental clones were planted in August 2010 in a field trial in EEA Alto Valle, Río Negro, Patagonia, with the aim to compare *in situ* the growth of the new genotypes on the basis of certain selection criteria, which include: adaptability, disease resistance, fast growth, stem form, and wood quality. A randomized block design was applied, with single plots and sixteen replications.

At the second year of the trial, total height of all treatments was measured and the genotypes were evaluated preliminary on this variable. ANOVA showed significant variation between clones and statistically different groups were identified by a mean contrast test. The new hybrid "Los Arroyos INTA-CIEF" (*S. matsudana x S. alba*), which was recently selected for the Delta Region, had the highest height (4,27m ± 0,84m), being statistically equivalent to the group of the following 10 experimental clones under evaluation in the trial. The best clone had significant differences with the control clone "Ragonese 131-27 INTA" (*S. babylonica x S. alba*), which had a lower height of 33,2%. Clone"97.24.03" (*S. amygdaloides* x?) was the treatment of lesser height, with a mean of 2,52m (± 0,61m), which did not differ significantly from the control "Ragonese 131-27 INTA". Experimental clones "94.08.43", "94.13.06", "98.07.71" and "96.01.12" (all originated in the crossing: *S. matsudana x S. alba*) did not differ from the best clone, showing good prospects of productive potential. Although it is an early-age evaluation and the genotypes characterization should be completed in successive next selection phases, this preliminary height study provides useful information about the initial growth of the experimental clones and, therefore, advantages in the effective establishment of the crop in the region.

Keywords: willow, breeding program, evaluation, clones, Patagonia Argentina.

[1] Instituto Nacional de Tecnología Agropecuaria (INTA), EEA Delta del Paraná, Buenos Aires, Argentina. E-mail: tcerrillo@correo.inta.gov.ar
[2] INTA, EEA Alto Valle, Río Negro, Argentina. E-mail: ethomas@correo.inta.gov.ar

ID-088

ISOLATION AND CHARACTERIZATION OF A NOVEL PLANT PROMOTER FROM POPLAR (*POPULUS TOMENTOSA* CARR.) DIRECTING MODERATE CONSTITUTIVE EXPRESSION OF TRANSGENES IN PLANTS

Zhong Chen[1], Meixia Ye[1], Hao Li[1], Lexiang Ji[1], Jia Wang[1], Ying Li[1], Bin Guo[1], Weihua Liao[1] and Xinmin An[2]

New constitutive promoters are essential components of plant biotechnology and widely used in basic research of molecular biology. We isolated a new sequence that functions as a promoter element for moderate constitutive expression of transgenes, designated the *PtMCP* promoter, from the woody perennial *Populus tomentosa*. The *PtMCP* promoter was linked to the *GUS* reporter gene and transformed into *Arabidopsis* and tobacco. Transcripts of the *GUS* reporter gene could be detected by using RT-PCR in the root, stem, leaf, flower and silique in stable *Arabidopsis* transformants. Further, histochemical and fluorometric GUS activity assays demonstrated that the promoter could direct transgene expression in roots, stems, rosette leaves, cauline leaves and flowers of seedlings and mature *Arabidopsis* plants. Its constitutive expression pattern was similar to that of the CaMV35S promoter, but the level of GUS activity was significantly lower than in CaMV35S promoter: *GUS* plants.

We also characterized the promoter through transiently transgenic tobacco and observed similar expression pattern. Histochemical GUS staining and quantitative analysis detected GUS activity in all tissues and organs of tobacco, including roots, stems, leaves, flower buds and flowers. Compared with the CaMV35S promoter, the level of GUS activity in transgenic plants was significantly lower when the transgene was driven by the *PtMCP* promoter.

Our results suggested that the *PtMCP* promoter from poplar is a constitutive promoter which leads to a moderate level of expression and that its function is presumably conserved in different species. In the future, the *PtMCP* promoter may be a valuable new tool in basic research of molecular biology and could be widely used in plant biotechnology.

Keywords: constitutive promoter, moderate expression, RT-PCR, GUS, transgenic plants.

[1] National Engineering Laboratory for Tree Breeding, NDRC; Key Laboratory of Genetics and Breeding in Forest Trees and Ornamental Plants, MOE; The Tree and Ornamental Plant Breeding and Biotechnology Laboratory, SFA; College of Biological Science and Biotechnology, Beijing Forestry University, Beijing 100083, China. E-mails: sharazhonger@gmail.com; yemeixia123@163.com; fire0329@163.com; thomasji26@hotmail.com; jiajia87519@163.com; liying105527@126.com; guobin531188058@163.com; liaoweihua1990@163.com.

[2] Beijing Forestry University, Qinghua Eastern Road No.35, Haidian District, Beijing 100083, P.R. of China. E-mail: anxinmin@bjfu.edu.cn. Tel/Fax: +86-10-62336248. (Corresponding author)

ID-072

IDENTIFYING EFFECTOR PROTEINS FROM POPLAR FUNGAL PATHOGEN *MARSSONINA BRUNNEA*

Qiang Cheng[1], Sheng Zhu, Li'an Xu and Minren Huang[2]

Marssonina brunnea is an important fungal pathogen of the *Populus* genus. To further our understanding of the pathogenesis of *M. brunnea*, we initiated a proteome and genome-level studies to identify putative effector proteins.

Using de novo peptide sequencing by MS/MS, we obtained peptide sequences for 32 secreted proteins in artificial liquid medium. Four proteins were identified by sequence homology to conserved proteins in public databases using MS-driven BLAST. To identify additional protein spots, we combined a degenerate PCR method, based on the Consensus-DEgenerate Hybrid Oligonucleotide Primer (CODEHOP) method, and a rapid amplification of cDNA ends method to clone the full-length cDNA fragments encoding the proteins identified in the gel. Using this method, we cloned the full-length cDNA fragments encoding 11 *M. brunnea*-specific proteins. Furthermore, we analyzed the expression patterns of these genes during infection.

Recently, with the rapid advances in next-generation sequencing, we sequenced the genome of *M. brunnea* with a combination of Roche 454, ABI SOLiD, and Illumina/Solexa GA-II technologies. Sequences were assembled into 89 scaffolds and suggested a genome size of 52Mb. A total of 10,027 protein-coding genes were identified in the genome of *M. brunnea*. By deep sequencing, we also investigated the *M. brunnea*'s genes expression pattern during infecting process. The results showed 91 genes encoded secreted proteins up-regulated at 3dpi.

Based on these proteomic and genomic data, 223 putative effector proteins have been identified for further analysis with poplar and tobacco transient assay methods.

Keywords: *Marssonina brunnea*, poplar, genome, proteome, effectors.

[1] Jiangsu Key Laboratory for Poplar Germplasm Enhancement and Variety Improvement, Nanjing Forestry University, Nanjing, China 210037, E-mail: chengqiang@njfu.edu.cn

[2] Jiangsu Key Laboratory for Poplar Germplasm Enhancement and Variety Improvement, Nanjing Forestry University, Nanjing, China 210037, E-mail: njmrhuang@njfu.edu.cn

ID-076

CONTROLLED CROSSING (HYBRIDIZATION) AMONG TREE WILLOWS (*SALIX* spp.) IN INDIA

Punit Choudhary[1] and N.B. Singh[2]

Controlled crossing among species of willows have greatly increased the hybrid combinations beyond those from spontaneous hybridization. Controlled crossing (hybridization) among commercially important tree willows *viz*. *Salix tetrasperma*, *Salix alba* and *Salix matsudana* was carried with the objective to develop a hybrid possessing a wider adaptability and higher productivity under Indian conditions. The hybridization was carried among different indigenous and exotic clones of three *Salix* species using 5x5 in-complete diallel mating design. Out of twenty-five controlled crosses attempted, twenty-one successfully produced the viable seeds. Analysis of variance revealed significant variation among males, among females and among interaction (crosses) for the crossability parameters *viz*. per cent successful crosses, seeds per catkin, seeds per capsule (fruit) and germination percentage. The per cent successful crosses varied between 69.80% for *S. tetrasperma* (LP) x *S. tetrasperma* (TFB) and 7.30% for *S. tetrasperma* (LNF) x *S. alba* (SI-63-007). High percentages of successful intra-specific crosses were obtained when *S. tetrasperma* (TFB) was used as pollen parent with *S. tetrasperma* (LP) as female parent. Similarly, high percentages (42.46%) of successful inter-specific crosses were obtained when *S. alba* (Kashmiri) was used as male parent with *S. matsudana* (PN-227) as female parent. Average seeds per catkin varied between 15.50 to 74.24 seeds and 1.75 to 4.05 seeds, respectively. Among intra-specific hybrids highest average seeds per catkin (92.40) was recoded for cross involving *S. tetrasperma* (LP) and *S. tetrasperma* (TFB) whereas, *S. matsudana* (Pn-227) x *S. alba* (Kashmiri) exhibited highest average seed production (41.40) among inter-specific hybrids. Maximum average germination percentage (86.60%) was recorded among intra-specific cross {*S. tetrasperma* (LNF) x *S. tetrasperma* (TFB)} whereas, inter-specific cross between *S. matsudana* (Pn-227) and *S. alba* (Kashmiri) recorded maximum (80.20%) average germination. The relatively high fertility and viability demonstrated by some inter-specific hybrids indicates the potential of species crossability, relatedness and gene flow among selected species.

Keywords: willows, in-complete diallel, intra-specific, inter-specific, crossability parameters

[1] Subject Matter Specialist, Agro Forestry, KVK, Rajouri, Sher- e- Kashmir University of Agricultural Sciences and Technology-Jammu , J&K, India. E-mail: pmd.choudhary@gmail.com

[2] Professor and Head, Department of Tree Improvement and Genetic Resources. College of Forestry, Dr. YSPUH&F, Nauni Solan, HP, India.

CROSSABILITY RELATIONSHIP AMONG SOME INDIGENOUS AND EXOTIC WILLOWS (*SALIX* spp.)

Punit Choudhary[1], N. B. Singh[2] and J. P. Sharma[3]

Willows with unique opportunities for manipulation through hybridization and selective breeding, ease of vegetative propagation offers itself a great potency for its genetic improvement. After initial screening of the promising clones of different *Salix* species *viz*. *Salix tetrasperma*, *S. matsudana*, *S. alba*, *S. nigra*, *S. babylonica*, *S. udensis* and *S. jessonensis* from India, New-Zealand, USA and Italy, controlled crossing was carried out to determine the crossability pattern among different species. Several intra- and inter-specific matings were successful and resulted in eight intra- and 10 inter-specific full-sib families. *S. tetrasperma* from section *Humboldtianae* successfully crossed with members belonging to section *Salix*, *Subalbae* and *Nigrae*. *S. babylonica* of section *Subalbae* successfully crossed with member of section *Humboldtianae* and *Salix*. Similarly *S. matsudana* produced viable seed after crossing with *S. tetrasperma* and *S. alba* of section *Humboldtianae* and *Salix* respectively. Also *S. alba* successfully crossed with members of section *Humboldtianae* and *Subalbae*. As specific function, compatibility rate was highest (100%) among intra-specific crosses for *S. tetrasperma* x *S. tetrasperma* and *S. matsudana* x *S. matsudana* followed by compatibility rate of 50% for *S. babylonica* x *S. babylonica*. Inter-specific crosses involving species from different section of subgenus *Salix* (*S. alba* x *S. matsudana* and *S. matsudana* x *S. alba*) recorded higher compatibility when species of section *Salix* and section *Subalbae* were used as female. Compatibility rate among inter-specific crosses was lower as compared to intra-specific crosses attempted. However, inter-specific cross between *S. alba* and *S. matsudana* recorded higher (100%) compatibility rate as compared to many intra-specific combinations. Compatibility rate of 33.33% was recorded for inter-specific crosses *viz*. *S. jessonensis* x *S. tetrasperma*, *S. nigra* x *S. tetrasperma* and *S. matsudana* x *S. tetrasperma*. Two combinations involving *S. udensis* as male parent were non-compatible as no viable seeds were obtained after crossing with *S. tetrasperma* and *S. alba* females suggesting easy and grater possibility of hybridization and gene flow with-in the sub genus.

Keywords: willows, compatibility rate, intra-specific, inter-specific, full-sib families.

[1] Subject Matter Specialist, Agro Forestry, KVK, Rajouri, Sher- e- KashmirUniversity of Agricultural Sciences and Technology-Jammu , J&K, India. E-mail : pmd.choudhary@gmail.com

[2] Professor and Head, Department of Tree Improvement and Genetic Resources. College of Forestry, Dr. YSPUH&F, Nauni Solan, HP, India.

[3] Assistant Professor, Department of Tree Improvement and Genetic Resources. College of Forestry, Dr. YSPUH&F, Nauni Solan, HP, India.

ID-006

OVERVIEW OF POPLAR BREEDING PROGRAM IN ARGENTINA

S. Cortizo[1,2] and S. Monteverde[2,3]

In Argentina, there are 40,500 ha of poplar plantations and 23,500 ha under agroforestry systems, mainly distributed in the regions of the Delta del Paraná, Cuyo and Río Negro Valley. From an economical point of view they provide an average of about 350,000 tons/year of roundwood for consumption. Afforestation programs need a continuous production of high quality reproductive material. As Argentina does not have any native poplar population, commercial plantations began in the late nineteenth century using clones introduced mainly from the United States of America and Italy. The species and hybrids better adapted to the different regions were: *Populus deltoides* in the Delta del Paraná and *P. x canadensis* in Cuyo and Río Negro Valley.

In the sixties, the National Institute of Agricultural Technology (INTA) began a breeding program with the objective of producing clones with potential high growth for solid wood industries. Two basic strategies were used: the introduction of seeds collected from plus trees of *P. deltoides*, selected in their natural range, and intraspecific and interspecific hybridizations of *P. deltoides* and *P. deltoides* x *P. nigra* respectively, using the introduced clones that had proved good adaptation and performance under our ecological conditions. The selection of progeny is based on the method of independent culling levels, focusing on rooting ability, *Melampsora spp*. and *Septoria musiva* tolerance, growth rate, stem form, wide adaptability, and wood quality as main selection criteria. In order to get an accurate estimation of genetic values, the evaluation of performances was a combination of nursery and clonal tests planted at high density, laboratory tests and multi-site field plantations with single or multiple tree plots. After that, clones that proved to be good in all aspects were tested on larger plots of 50 to 100 plants in different places with local controls and characterized using morphological and phenological descriptors and SSR molecular markers before their commercial release. From this group only *P. x canadensis* 'Ragonese 22 INTA' and *P. deltoides* 'Carabelas INTA' are currently planted.

Nowadays, 5,700 genotypes originated by hybridization between 2009 and 2011are being tested in nursery banks; 164 clones of *P. deltoid*es, selected on progeny banks obtained in 2006 and 2008 are being evaluated in clone banks, and 78 clones of *P. deltoides* and *P. x canadensis* are being compared in 27 trials. From poplar seeds, that had been formerly introduced from the USA, we obtained six *P. deltoides* clones (2-82, 20-82, 21-82, 89-82, 149-82 and 150-82) which are close to be commercially released in the Delta of Paraná region. Finally, two clones of *P. x canadensis* belonging to open-pollinated populations obtained in 1986 (Pudu INTA and Pangui INTA) had an outstanding performance in the Río Negro Valley region. In the future genomic selection and transgenesis for useful agronomic traits will be applied in our breeding programs in order to reduce selection time and optimize work.

Keywords: poplar breeding, hybridization, clonal selection, *P. deltoides*, *P. x canadensis*.

[1] INTA, E.E.A. Delta del Paraná, Cátedra de Genética FA-UBA. Argentina. E-mail: scortizo@correo.inta.gov.ar
[2] Programa de Domesticación y Mejoramiento de Especies Forestales Nativas e Introducidas para Usos de Alto Valor (PROMEF). BIRF 7520-AR. SAGyP. Argentina.
[3] Cátedra de Genética y Mejoramiento Vegetal FCA-UCU. Argentina. E-mail: smonteverde@correo.inta.gov.ar

EVALUATION OF GENETIC VARIABILITY IN IMPORTANT TRAITS OF NORTH-TYPED *POPULUS DELTOIDES* MARSH GERMPLASM RESOURCES

Changjun Ding[1], Qinjun Huang[1], Xiaohua Su[1] and Bingyu Zhang[1]

As an important gene donor of many poplar varieties, *Populus deltoides* Marsh plays an important role in genetic improvement of poplars. Aigeiros gene resource is scarce in China. In recent years, lots of *P. deltoides* Marsh germplasm resources have been introduced to China. Full understanding of these gene resources would provide strong scientific evidence and proper germplasm for poplar breeding.

We comprehensively analyzed and evaluated *P. deltoides* Marsh germplasm resources from growth, photosynthetic productivity, water use efficiency (WUE) and nutrient use efficiency (NUE) for the first time. The main results are described as follows: 1. Abundant variation of growth, photosynthetic productivity, WUE and NUE are selected among different genotypes in the same provenance and among different provenances of North-typed *Populus deltoides* Marsh, which is to provide a basis for breeding parents in the provenances and individuals levels. 2. The traits of North-typed *Populus deltoides* Marsh. are closely related to growth, including total leaf area, leaf number, leaf number growth rate, internode length, respiration rate, N transfer rate, N content in leaf and WUE in the suitable growth period. They can be used as selection index. 3. According to comprehensive evaluation, the superior germplasm resources of North-typed *Populus deltoides* Marsh are as follows: high growth is M-6, Q-1, Q-5, M-5, Q-7; high growth and photosynthetic productivity are M-6, Q-1, Q-2, M-5, Q-5; high growth and WUE are Q-5, Q-1, W-9, M-5, Q-7; high growth and NUE are Q-9, Q-5, Q-3, Q-8, Q-1. 4. Based on the analysis of principal components, clones M-6, Q-5, Q-1, Q-2 and Q-9 with high growth and high environmental resources use efficiency are ultimately selected. After a further test, they would be directly applied.

Keywords: North-typed *Populus deltoides* Marsh, seedling variation, photosynthetic productivity, water use efficiency, N use efficiency.

[1] Research Institute of Forestry, Chinese Academy of Forestry. Qinglongqiao Street, Haidian District, Beijing, People's Republic of China. E-mail: changjund@126.com

ID-103

INTERSPECIFIC CROSSING BREEDING OF *POPULUS* IN *LEUCE* SECTION OF CHINA

Junfeng Fan[1]

Poplars in *leuce* section, characterized by its high stress resistance (dry-resistance, cold-resistance etc.), good wood quality and ornamental value, are most important tree species applied in the afforestation for shelter forest establishment in Northwest region of China. However, some of these species grow slowly and some species are difficult to propagate by cutting, which has hindered the wider extension. It is of great significance to do interspecific crossing breeding in *leuce* section to collect the beneficial genes of the parents, and to select the superior hybridized combinations and clones with the fast growth rate and good rooting ability by cutting for commercial use.

The research has been undergoing for seven years, with 38 hybridized combinations conducted and 28,000 hybrid-seedlings obtained. The nursery test showed that the hybridized combinations of *P. alba* L.× *P. alba* × *P. glandulosa*, *P. alba* L.×*P. tomentosa* Carr., *P. alba L.*× *P. davidiana* Dode, *P. adenopoda* Maxim × *P. alba* × *P. glandulosa*, *P. hopeiensis* Hu et Chow× *P. alba* × *P. glandulosa*, *P. tomentosa* Carr.× *P. alba* × *P. glandulosa*, *P. davidiana* Dode × *P. alba* × *P. glandulosa*, were of great growth vigor (with one-year seedling reaching 3m high). Of those, seedlings by cutting from the combinations with *P. alba* L .as female parent had good rooting ability by cutting (with the rooting rate reaching above 80%).

Through further flied trial and regional cultivation test, three superior clones named as 02-8-21, 02-9-22 and 02-12-29 were selected from the hybridized combinations of *P. alba L.*× *P. alba* × *P. glandulosa*, with the fast growth rate and good rooting ability by cutting. The growth in volume of five-year old trees was 30% higher than that of the average of their parents, 15% higher than that of *P. tomentosa* Carr. (a very famous variety for commercial use), and rooting rate of seedlings from cutting was above 80%.

Keywords: *leuce* section, interspecific crossing breeding, new superior clones.

[1] Northwest A and F University, 3 Taicheng Road, Yangling, Shaanxi 712100, P. R. China. Fanjf28@163.com; fanjf28@sina.com

ID-184

CHARACTERIZATION OF POPLAR CLONES BY MOLECULAR MARKERS

M.S. Ferrer[1,2,3], V. Ibañez[2], N. Riu[2] and R.W. Masuelli[2]

The correct identification of *Populus* clones is a major global problem for both nurseries and planted crops due to the number and taxonomic proximity. In the province of Mendoza, Argentina, the Faculty of Agricultural Sciences, Cuyo National University, there is a collection of mother plants of *Populus spp*, with many clones characterized phenologically and morphologically, which are used for multiplication in the nursery and subsequent implantation by local producers.

In recent years, taking into account the evolution of molecular techniques for identification, the Department of Forestry proposed to characterize its material genetically in order to certify these clones. Microsatellite Molecular Markers was developed, designed with a change in the PCR reaction allowing for fast, early and unequivocal results through the use of an automatic sequencer. So far three polymorphic markers were identified, that differentiate clones *Populus x canadensis* 'Conti – 12' and 'I-214' of 'Guardi' and *Populus deltoides* 'Harvard' and the last two clones together. To achieve the differentiation of clone 'Conti – 12' and 'I-214', we have designed more markers and it is our intention in future to add more clones to the genetic identification.

Keywords: poplar, identification, microsatellites.

[1] Instituto de Ciencias Básicas, UNCuyo, Argentina. E-mail: ferrerms@gmail.com
[2] Facultad de Ciencias Agrarias UNCuyo, Argentina.
[3] IBAM, Instituto de Biología Agrícola Mendoza-CONICET. Almirante Brown 500, Luján de Cuyo, Mendoza, Argentina.

ID-050

INTERCLONAL VARIATION OF *POPULUS NIGRA* LINN. (BLACK POPLAR) CLONES GROWING IN THE KASHMIR VALLEY

Sajad Ahmad Gangoo and Mushtaq Ahmad Mir[1]

The screening of promising clones of Populus nigra Linn. (Black poplar) was carried out at the Faculty of Forestry, SKUAST-K, Shalimar during 2006-07 to detect interclonal variation for various morphometric traits and select the best clones. For this purpose, a detailed survey was carried out in all the districts (Anantnag, Pulwama, Budgam, Baramulla and Kupwara) of Kashmir valley from October onwards and clones retaining leaves till late autumn were selected and tagged. Nine trees were selected randomly from each panchyats of three blocks from each district. Thirty cuttings were cut from each selected tree and planted at two sites, Wadura and Shalimar. Selected clones were evaluated for growth characteristics like progressive height, progressive collar diameter, monthly height increment, monthly diameter increment, number of leaves/plant, number of roots/plant, sprouting, survival, sprouting commencement days, leaf area, leaf length, leaf breadth and branch angle. Heritability and coefficient of variation were estimated through proper statistical procedure.

Investigation revealed that a significant interclonal variation exists for all these characters. Maximum loading (0.48) was found for height, followed by number of leaves (0.44), while as minimum loading (0.31) was found for leaf area, accordingly height contributed maximum (30%) while leaf area contributed minimum (3%) to total variance. The site is having a significant effect on all these characteristics, except branch angle. Wadura outperformed Shalimar in terms of progressive height, collar diameter, number of leaves/plant, number of roots/plant, sprouting, monthly height and diameter while Shalimar outperformed Wadura in terms of leaf dimensions (leaf area, leaf length, leaf breadth) and sprouting commencement days. Average height, collar diameter, number of leaves per plant and number of roots per plant at Wadura were 101.36 cm, 9.94 mm, 38.37 and 42.24 respectively, while at Shalimar, the respective values were 80.78 cm, 9.63 mm, 34.06 and 37.95.

Interclonal ranking of clones was done on the basis of principal component score, which ranged from -5.17 (A1, worst clone) to 5.48 (A2, best clone). Progressive height ranged from 58.79 cm (A1, worst clone) to 132.40 cm (A2, best clone), branch angle ranged from 20o to 45.55o, number of roots/plant ranged from 14.42 to 72.92. Maximum number of leaves/plant (83.14), monthly diameter increment (3.96 mm) and monthly height increment (48.12 cm) were obtained during July. Heritability ranged from 60.13% (minimum) for collar diameter to 93.05% (maximum) for branch angle. Maximum genetic gain as per cent of mean (48.24%) was recorded for number of leaves per plant, while minimum genetic gain as per cent of mean (23.84%) was recorded for collar diameter. Genetic advance ranged from a maximum of 29.24 for height to a minimum of 9.72 for branch angle. Based upon principal component score and superior growth characteristics, the ten best clones are: A2 (5.48), Bd6 (5.04), Bd9 (4.30), A6 (3.85), S1 (2.22), Ba1 (1.93), Bd8 (1.89), P7 (1.88), A4 (1.33) and Ba7 (1.02).

Keywords: *Populus nigra*, Kashmir Valley, interclonal variation.

[1] Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar-191121, India.

ID-121

GENOME-WIDE COMPARISON OF TWO POPLAR GENOTYPES WITH DIFFERENT GROWTH RATES

Shuang Hao, Teng Zhao, Xinli Xia[1] and Weilun Yin[1]

The ecologically dominant and economically important genus *Populus*, with its available full genome sequence, has become an ideal woody species for genomic study. Rapid growth is one of the primary advantageous features of *Populus*, and extensive physiological research has been carried out on the growth of *Populus* throughout the growing period among different clones. However, the molecular information related to the mechanisms of rapid growth is rather limited.

In this study, an Affymetrix poplar genome array was employed to analyze the transcriptomic changes from the pre-growth to the fast-growth phase in two poplar clones (*P.deltoides* × *P.nigra*, DN2, and *P.nigra* × (*P.deltoides* × *P. nigra*), NE19) with different growth rates. A total of 1,695 differently expressed genes were identified between two time points in NE19 and DN2 (two-way ANOVA, $P<0.01$ and fold change ≥ 2). Except for genes changing in common for both clones, many transcripts were regulated specifically in one genotype. After functional analysis of the differentially expressed genes, distinct biological strategies seemed to be utilized by the two genotypes to accommodate their fast-growth phase. The faster-growing clone NE19, which has a higher photosynthetic rate and larger total leaf area, emphasized growth-related primary metabolism. However, the slower-growing DN2 tended to have more up-regulated genes involved in defense-related secondary metabolism and stress response. Emphasis of such divergent biological processes in two clones may explain their significant growth differences during the fast-growth phase.

Keywords: microarray, poplar, genotype, growth rate.

[1] National Engineering Laboratory for Tree Breeding, College of Biological Sciences and Biotechnology, Beijing Forestry University, No. 35, Tsinghua East Road, Beijing 100083, People's Republic of China. E-mails: xiaxl@bjfu.edu.cn; yinwl@bjfu.edu.cn

ID-052

EVALUATION OF ARBORESCENT WILLOW CLONES FOR GROWTH AT NURSERY STAGE

Santoshkumar A. Huse[1], N.B. Singh, J.P. Sharma and R.K. Anand

Investigations were carried out to determine the clonal variations and workout the relationships of physiological and wood characteristics with growth characters with view to identify the superior clones. In total, twenty three clones of arborescent willows were studied, out of which twenty-one were collected from Italy, Croatia and the United States of America whereas two indigenous local clones, namely Kashmiri willow (*Salix alba* cultivar *coerulea*) and local Indian willow (*Salix tetrasperma*) were used as local checks. The experiment was laid out in augmented randomized complete block design at the Departmental Nursery of College of Forestry, Nauni, Solan, Himachal Pradesh.

The data were collected on growth and biomass traits, wood characteristics and physiological parameters. Among growth and biomass traits, plant height and dry shoot weight were found significantly correlated at genotypic level with the rest of all growth and biomass parameters except intermodal length with plant height. Higher heritability (b.s.) corresponding with higher genetic gains were observed for dry shoot weight, dry root weight, total dry biomass, plant height, collar diameter, volume index, number of branches and leaf area. Estimates of genetic correlation coefficient (rG) on most of growth and biomass traits with photosynthesis and water use efficiency showed significant and positive correlation. Growth and biomass parameters also showed significant positive correlations with fiber length and wood per cent; however, basic density and transpiration were found negatively correlated with most of growth and biomass parameters.

Based on the analysis of the data, eight clones namely T3 (*S. matsudana:* SE-63-012), T8 (*Salix jessoensis:* SE-63-016), T10 (*S. alba:* SI-63-007), T14 (*S. alba:* SI-64-017), T4 (*S. matsudana:* SE-69-002), T1 (*S. matsudana:*SE-75-001), T15 (*S. alba:* SI-62-096) and local check *Salix alba* cultivar *coerulea* were found superior to all other test clones.

Keywords: tree willows, *Salix*, Indian willow, growth and biomass parameters, physiological parameters, genetic parameters.

[1] College of Forestry, Navsari Agricultural University, Navsari, Gujarat-396450, India. E-mail: santoshhuse@yahoo.co.uk

ID-132

VARIATION OF POLLEN FORMATION IN AN INTERSECTION ALLOTRIPLOID OF *POPULUS* AND ITS SEXUAL UTILIZATION

Wang Jun[1], Li Yun[1], Liao Ling[1] and Kang Xiang-yang[1]

Triploids are considered as part of the evolutionary dynamics of natural populations and act as a transition in the formation of new polyploids. *Populus alba* × *P. berolinensis* 'Yinzhong', an intersection allotriploid poplar between section Populus and section Aigeiros, is widely employed in landscaping of northeast China. In this investigation, variation of pollen formation of the allotriploid and its cytological mechanisms were studied by the squashed technique and indirect immunofluorescence. Furthermore, sexual hybridization using pollen of the allotriploid was carried out to produce polyploids and aneuploids.

In the allotriploid analyzed here, diameter of pollen grains ranged from 23.9 to 61.3 μm, with an average of 39.6 μm (± 4.2), suggesting a wide range of ploidy level resulted from meiosis of allotriploid. The frequency of pollen diameter approximately followed a Gaussian distribution, indicating that most microsporocytes underwent meiosis to produce tetrads. However, some jumbo pollen grains were still observed, which must be unreduced. Analysis of *in vitro* germination showed that viable of the pollen was very low, just approximately 2%, which suggested that most of pollen grains might be sterile.

In this allotriploid, a number of meiotic abnormalities were recorded, including univalents and multivalents at diakinesis, aberrant spindle and precociously migrated chromosomes at metaphase I, lagging chromosomes and chromosome bridges at anaphase I, micronuclei and premature cytokinesis, with different frequencies. In direct immunofluorescence of microtubular cytoskeletons showed that some micronuclei formed minispindles in metaphase II and underwent cytokinesis to develop into microcyte, which resulted in tetrads with microcyte were produced. Additionally, abnormal orientation of spindles, including parallel, fused, and tripolar spindles, at the second meiotic division were observed. As a result, dyads and triads were produced, which could develop into unreduced pollen.

Pollen of the allotriploid was pollinated to a highly fertile female parent *P. tomentosa* × *P. bolleana*. Just 691 seeds were collected from 22 catkins, indicating the low pollen fertility of the allotriploid. After sowing, some triploids and tetraploids were detected by chromosome counting.

Keywords: cytokinesis, intersection allotriploid, microsporogenesis, pollen, *Populus alba* × *P. berolinensis* 'Yinzhong', Sexual polyploidization.

[1] National Engineering Laboratory for Tree Breeding, Key Laboratory of Genetics and Breeding in Forest Trees and Ornamental Plants, MOE, Beijing Forestry University, 100083, Beijing, People's Republic of China. E-mail: wangjun@bjfu.edu.cn; kangxy@bjfu.edu.cn

ID-067

ADAPTATION OF BLACK POPLAR (*POPULUS NIGRA* L.) CLONES TO THE MİDDLE ANATOLIA PLATEAU

Teoman Kahraman[1], Filiz Kahraman[1] and Alptekin Karahan[2]

Black poplar is one of the main tree species used for wood production by farmers at the Middle Anatolia Plateau which has continental climate type. In order to evaluate adaptation of different black poplar clones for Middle Anatolia, two experimental plantations were established. The first trial site was Kirsehir province (altitude 1097 m), of which mean annual rainfall is 378 mm and mean annual temperature 11.4 ºC. The second was Kutahya province (altitude 1014 m) of which annual rainfall is 564 mm and annual temperature 10.6 ºC.

The experimental design was randomized complete block with five replications and five cuttings used for each row with 2.2 x 0,4m spacing. Height was measured to the nearest centimeter at the end of the first year, and diameter of clones from 1.0 m above ground level was measured to the nearest millimeter at the end of the second year. Survival rates of the clones were calculated as the number of trees in a plot over the initial number of planted cuttings at the end of the first year. Arc.Sin transformed values were used in the analysis of survival. Analysis of variance (ANOVA) was applied for comparisons of survival, height and diameter of the clones. Duncan Multible Range Test was used for grouping of the clones

Significant differences were found between trial sites and clones at 0,001 probability level for all characters and clone by site interaction was significant for diameter and height and non significant for survival. Rank orders of the clones for characters showed that mean values varied between 36,0 mm (N.62.191) to 19,0 mm (N.96.323) for diameter, 254,5 cm (N.64.014) to 132,6 (N.96.323) for height, 96% (N.62.191) to 43% (N.96.323) for survival.

Genetic differences among clones explained 44.2% (diameter), 26.4% (height) and 12.4% (survival) of total variance. Broad sense clonal mean heritability was calculated as 0,85±0,07 for diameter, 0,62±0,08 for height and 0,28±0,09 for survival. There were high differences among clones for growth and survival and significant gains can be obtained by selecting breeding methods for black poplar.

Keywords: *Populus nigra*, breeding, variation, heritability.

[1] Poplar and Fast Growing Forest Trees Research Institute, Izmit, Turkey. E-mails: teomankah@yahoo.com; filizkos_2004@hotmail.com
[2] Middle Anatolia Forest Research Institute, Ankara, Turkey.

ID-036

GENETIC PARAMETERS IN JUVENILE TRAITS OF SOME BLACK POPLAR (*POPULUS NIGRA* L.) CLONES AT THE HIGHLAND OF TURKEY

Teoman Kahraman, Filiz Kahraman and Selda Karakaya[1]

In this study, 144 clones from Black poplar gene bank were investigated at the highland (1851 m) part of Turkey, using five replicated randomized block designs in 2.20x0.4 m spacing. Clones were laid out in rows plots of five ramets each. Evaluation on height and apical dominance were made at the end of the first vegetation period, while evaluation of diameter, survival stem form and branchiness was made at the end of the second year.

The results of ANOVA for all traits showed significant differences at 0,001 confidence level. Considerable genetic variation was observed among clones for all traits, except survival. Genetic differences among clones were accounted for 10% (survival) to 40% (height) of the total variance. Broad sense clonal mean heritability values ranged from 0,36 (survival) to 0.77 (height). Selecting the best 20 clones for next breeding stage, genetic gains range from 8.9 % (apical dominance) to 23.2 % (diameter).

Keywords: *Populus nigra*, breeding, variation, heritability, genetic gain.

[1] Poplar and Fast Growing Forest Trees Research Institute, Izmit, Turkey. E-mails: teomankah@yahoo.com; filizkos_2004@hotmail.com; seldakarakaya2003@yahoo.com

ID-038

PRODUCTIVITY AND PHENOTYPIC STABILITY OF POPLAR CLONES IN THE AREA OF EASTERN CROATIA

Davorin Kajba[1] and Ivan Andrić[1]

Research into phenotypic stability, adaptability and productivity of poplar clones at younger plantation was conducted in the lower course of the Drava river and the tributary of the Danube river in the eastern Croatia. In this area, the construction of river infrastructure has led to severe changes in the water regime. It is for this reason that the selected poplar clones should be adapted to the specific new condition of low groundwater levels. The assessment of productivity and phenotypic stability for 14 poplar clones at plantation age of 2+5 years were evaluated in five clonal trials in the area of Eastern Croatia. The tests were set up at planting distances of 6 × 6 m randomized with 16 plants per block and four repetitions. At the moment of experimental plot establishment, the planting material was ½ and 2/3 years old. Statistically significant interclonal variability in production and survival was found. Mean survival in the clonal test established with plants aged ½ years was 72% on average, whereas it was 95% in the test with plants aged 2/3 years, which suggests that using of planting material at age 2/3 years is much more successful. Research on adaptability and genotype × environment interaction were conducted for the same eight poplar clones in three clonal tests. From a silvicultural standpoint, the most suitable clones for generating optimal modifications were those of high phenotypic instability. Their cultivation is justified on optimal sites, as well as on less favourable sites when are provided agrotechnical measures and applied adequate plant protection measures. Based on the size of regression coefficients and regression analysis, it can be concluded that the tested clones can be divided, in terms of phenotypic stability and productivity, into three groups: (a) phenotypically stable clones of medium productivity and a tendency to adapt to all environments ('I-214', 'M 1', 'S 6-36', 'S 6-20'; (b) moderately stable clones, of moderate productivity which manifest a tendency to adapt to all environments ('710', 'Bl Constanzo', 'Pannonia'); and (c) phenotypically very instable clones of high production capacity, with specific adaptation to optimal sites ('S 1-8'). Levels of the genetic control for the growing stock, heritability values (h^2) and genetic gain (ΔG) were assessed on the basis of selecting five or one of the best clones. The obtained genetic gain (ΔG) in growing stock production for the best five selected clones was somewhat higher than expected and ranged from 15.30 to 45.12 %, whereas it was between 30.88 and 81.03 % for one best selected clone. In order to minimize the risk of cultivating monoclonal culture and increase their stability, we will favour the cultivation of a mixture of five clones of divergent genetic constitution. The results of this research confirm that even at such a young plantation age the quality of a particular habitat has conditioned modifications in average clone production and survival.

Keywords: poplar clones, genotype × environment interaction, adaptability.

[1] Faculty of Forestry, Svetošimunska 25, Croatia, 10 000 Zagreb, e-mail: davorin.kajba@zg.t-com.hr

A STUDY ON DETERMİNATİON OF NUTRİENT IN SOME ONE-YEAR OLD POPLAR CLONES

Ahmet Karakaş[1]

This study was conducted on one-year old poplar saplings in the İzmit nursery, in the Marmara region of Turkey. Clones I-214 and I-77/51 (Samsun), which are widely produced in the Marmara region, as well as S.307/26 (İzmit) clone, were used in the study. The annual amount of leaf cast of the aforementioned clones and plant nutrients transferred to the soil in this way were determined. In the leaves, fresh and oven-dry weights and plant nutrients such as N, P, K, Ca, Mg and Na elements also were determined. The results indicate that the plant nutrient concentration in the leaves has been ranged as Samsun (I-77/51) > İzmit (S.307/26) > I-214. In terms of plant nutrient concentration level in the leaves, nitrogen shows the highest, sodium the lowest value. Availability of plant nutrient concentration in the leaves is found as N > Ca > K > Mg > P > Na.

Keywords: clones, plant nutrient.

[1] General Directorate of Forestry, Department of Foreign Affairs, Training and Research, TOBB İkiz Kuleler D Blok Kat 21 Ankara, Turkey. E-mail: ahmetcaracas@gmail.com

ID-007

DETERMINATION OF MORPHOLOGICAL AND GERMINATION CHARACTERISTICS OF SOME SEEDS AND RELATIONSHIPS OF EUPHRATES POPLAR (*POPULUS EUPHRATICA* OLIVIER) WITH THEM

Hüseyin Karatay[1]

In this study, seed morphology and germination characteristics and correlation and regression relationships between the morphological characters have been revealed of the Euphrates poplar (*Populus euphratica* Olivier). Sixteen samples of the Euphrates poplar distributing along the Euphrates River in Turkey have been chosen. The assessments are performed by bunches of seeds, seed capsules in the seed hosted drafts, and seed sizes within them, contained capsule and seed numbers in the capsules, its weights, and their correlation and regression relationships and germinated seeds.

Taken up characters in deal with Euphrates poplar samples, seed bunch length 37.8-76.1 mm, mean 60.18 mm, capsules on the seed bunches are 13-58, mean 32 determined. Positive correlation is determined (0.644) between bunch length and capsules number. Seed capsules containing seeds on average: width of capsule 5.02 ± 0.012, capsule length 15.24 ± 0,043, length of capsule10.92 ± 0,031, the capsule stalk length 4.33 ± 0.025, number of seeds in the capsule 97.8 ± 0.8, capsule oven-dry weight (with seed) 23.4 ± 0.14, oven-dry weight of seed capsule12,24 ± 0,16, are determined. Significant correlations were determined between the sizes and weight of the capsule and seed. In addition, regression relationships were determined between capsule sizes. Seed capsules were found with 3-7 parts that protected and surround the seeds and splitting into three parts, generally when mature. Capsule parts numbers as weighted average 2.50-3.63 parts and generally 3.06 parts respectively. Three parts capsules were detected in all 16 tree samples. Capsule parts can be considered as three for Euphrates poplar species. The number of seeds were between 3944-9872, with an average of 6491 ± 412 (standard deviation) in 1 g of seeds among all sample trees.

Applied in the greenhouse study, germination rate and speed differences were determined among all the Euphrates poplar seed samples for 7-day germination. Twenty-two percent of the total germinated seeds were germinated at the end of the first day, 62% at the end of the second day (48 hours), 12% at the end of the third day. Also the germination rate decreased after the third day days. According to statistical analysis (Duncan test), the second day germination percentage showed differences from other germination days.

Keywords: *Populus euphratica* Olivier, seed, seed morphological properties, germination.

[1] South East Anatolia Forest Research Institute, Tree breeding department. Elazığ, Turkey. E-mail: huseyin_karatay@hotmail.com

INVESTIGATION ON MORPHOLOGICAL VARIABILITY OF SOME BLACK POPLAR (*POPULUS NIGRA* L.) CLONES IN TURKEY

Filiz Küçükosmanoğlu Kahraman[1]

In this study, the variation of 29 black poplar clones that originated from different part of Turkey was investigated. From each clone, eight individuals and from each individual 12 leaf samples were evaluated. Variation and effective factors for discriminating clones were examined by using 14 characters which are growth (height, diameter), external morphological characters (stem form, branchiness, apical dominance and crown shape) and seven different leaf characters. Morphological characterization was determined according to the International Union for the Protection of New Varieties of Plants (UPOV) and the International Poplar Commission (IPC) criterions.

In order to evaluate the degree of variability between clones, the analysis of variance was applied. Multivariate analyses (factor analysis, discriminant analysis and hierarchical cluster analysis) were used to determine the most effective traits that can be used for clone discrimination and grouping.

According to the result of variance analysis, diameter, stem form, crown shape and seven leaf characters showed significant differences among clones. As the result of factor analysis made for black poplar clones, petiole length, leaf blade, diameter and apical dominance characters were effective for clone discrimination. Considering these four factors, discriminant analysis applied to the clones and three groups of clones were separated. However, investigation by cluster analysis was made by using all character similarities of clones. The result of cluster analysis showed three main groups.

Keywords: black poplar, clone, morphology, variability.

[1] Poplar and Fast Growing Forest Trees Research Institute, Izmit, Turkey. E-mail: filizkos_2004@hotmail.com

ID-049

EVALUATION OF SOME PROMISING CLONES OF *POPULUS DELTOIDES* IN FIELD TRIALS IN NORTH INDIA

Dinesh Kumar[1] and N.B. Singh[2]

Populus deltoides is one of the most preferred agroforestry species in fertile, irrigated lands in Punjab, Haryana, Western Uttar Pradesh and in outer plains or valleys in Uttarakhand and Himachal Pradesh. A major initiative on its introduction in Bihar has been recently launched by the Indian Council of Forestry Research and Education in Dehradun. It has an average m.a.i. of 20-25 m^3/ha/yr and is harvested at a 6 to 8 years rotation. An area of nearly 312,000 ha is under cultivation of this species in various combinations with field crops, vegetables and fruit crops. About 5.85 million tonnes fresh wood valued at Rs. 35 billion is annually produced in the country. Plywood, board, match, paper, charcoal, etc. are the major industries that consume poplar wood. Poplars provide huge cash returns to individuals engaged in its cultivation and industrial processing, contribute considerably to government exchequer, reduce pressure on forests and entail massive environmental benefits besides providing employment opportunities in transport, trade and various subsidiary sectors.

There is a huge demand from growers to provide superior germplam to them for cultivation. One of the approaches in this direction at the Forest Research Institute, Dehradun involved introduction of seeds from native stands in south and south-eastern parts of the United States of America. Superior seedlings were identified, cloned and tested up to the rotation age of six years in a field test. The best 40 clones identified on the basis of this field test were further subjected to field trials at four sites in Uttarakhand and western Uttar Pradesh.

The trials led to the identification of the most productive clones in different sites. Significant genotype-environment interaction was observed. However, top five clones of any site were present among the best eleven clones of all other sites. Overall, clone FRI-AM-59, FRI-AM-58, FRI-AM-44, FRI-AM-41 and FRI-AM-54 were the best five performers. Incidence of any significant disease or insect attack was not recorded on any of these clones. Clones G48 and S7C8, the two check clones, ranked from 12 to 26 (rank one being assigned to the best clone), and from 5 to 17, respectively. The study indicates potential for planting of the best five clones of FRI-AM series in operational plantations. Steps are needed at national level for addressing IPR issues.

Keywords: clone, *Populus deltoides*, genetic improvement, field trial, genotype-environment interaction.

[1] Silviculture Division, Forest Research Institute, Dehradun, Uttarakhand, Pin 248 006, India. E-mail: kumard@icfre.org

[2] Department of Tree Improvement and Genetic Resources, Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, Pin 173 230, India.

ID-181

MOLECULAR APPROACHES TO DISTINGUISH WILLOW GENOTYPES COMMERCIALIZED IN NORTH AMERICA USING DNA FINGERPRINTING

Aurélien Lauron-Moreau[1], Michelle J. Serapiglia[2], Frédéric E. Pitre[1], Luc Brouillet[1], Lawrence B. Smart[2] and Michel Labrecque[1]

The development of new willow cultivars both for biomass production and environmental applications (phytoremediation and environmental restoration) represents an important issue in Europe and North America. Breeding and selection have been used to obtain different cultivars with specific characters (growth, hardiness, pest resistance and morphological traits). Currently, about 35 genotypes are commercialized in North America and used in short-rotation coppice cultivation for the production of biomass. In practice, the identification of the different *Salix* species and cultivars using morphological characteristics is difficult and may lead to misidentifications.

Hence, the objective of this project is to verify the identification of different commercial willow genotypes by comparison with pure species collected in the wild. Our approach uses sequences of one nuclear and two chloroplast regions to identify single-nucleotide polymorphisms (SNPs) between the genotypes. Flow cytometry has also been used to estimate ploidy of genotypes commercialized in North America. This method allowed us to detect the hybrids and to identify the origin of the genotypes. Results are discussed with regard of the commercialization and the importation of exotic cultivars.

Keywords: *Salix*, willow cultivars, biomass production, DNA fingerprinting.

[1] Institut de recherche en biologie végétale, Université de Montréal, 4101 rue Sherbrooke Est, Montréal, QC H1X 2B2, Canada

[2] Department of Horticulture, Cornell University, NYS Agricultural Experiment Station, 630 West North Street, Geneva, NY 14456, USA.

ID-123

GENOME-WIDE CHARACTERIZATION OF NEW AND DROUGHT STRESS RESPONSIVE MICRORNAS IN *POPULUS EUPHRATICA*

Bosheng Li, Yurong Qin, Hui Duan, Weilun Yin[1] and Xinli Xia[1]

MicroRNAs (miRNAs) are small, non-coding RNAs that play essential roles in plant growth, development, and stress response. *Populus euphratica* is a typical abiotic stress-resistant woody species.

This study presents an efficient method for genome-wide discovery of new drought stress responsive miRNAs in *P. euphratica*. High-throughput sequencing of *P. euphratica* leaves found 197 conserved miRNAs between *P. euphratica* and *P. trichocarpa*. Meanwhile, 58 new miRNAs belonging to 38 families were identified, an increase in the number of *P. euphratica* miRNAs. Twenty-six new and 21 conserved miRNA targets were verified by degradome sequencing, and target annotation showed that these targets were involved in multiple biological processes, including transcriptional regulation and response to stimulus. Furthermore, comparison of high-throughput sequencing with miRNA microarray profiling data indicated that 104 miRNA sequences were up-regulated, whereas 27 were down-regulated under drought stress. This preliminary characterization provides a framework for future analysis of miRNA genes and their roles in key poplar traits such as stress resistance, and could be useful for plant breeding and environmental protection

Keywords: drought, miRNA, mirtron, *Populus euphratica*.

[1] National Engineering Laboratory for Tree Breeding, College of Biological Sciences and Biotechnology, Beijing Forestry University, No. 35, Tsinghua East Road, Beijing 100083, People's Republic of China. E-mails: yinwl@bjfu.edu.cn; xiaxl@bjfu.edu.cn

ID-053

EARLY SELECTION FOR GROWTH, BRANCH AND FROST HARDINESS OF HYBRID CLONES BETWEEN *POPULUS CANADENSIS* CV. 'NEVA' AND *P. USSURIENSIS* KOM.

Jin-hua Li[1], Jie Zhang[2] and Gang Zhang[2]

Female parent, *Populus canadensis* cv. 'Neva', was introduced from Italy and widely planted in the Northern plain of China for a variety of uses, including timber production, agroforestry, and ecological protection. Male parent, *P. ussuriensis*, naturally distributed in Changbaishan Mountain and Lesser Khingan Range area of northeast China, and characterized by good wood quality and excellent hardinesss, was used for forest regeneration in three provinces of northeast China.

Due to requirement on the ecological environment, such as acidic soil in the forest, *P. ussuriensis* was planted with difficulty in large scale on plain area. Controlled interspecific hybridization produced 62 genotypes being propagated with cuttings. After trial in nursery, 25 genotypes were selected based on their growth performance, survival rate, disease resistance, stem form, etc. The experimental plantation was established with 25 selected genotypes and 'Neva' from hardwood cuttings, spacing 0.5 x 1 m. ANOVA analysis showed significant differences among genotypes in height, diameter at basal area, branch of three-year-old plants. Frost hardiness (FH) of eight genotypes with the highest growth, perfect branch and 'Neva' during de-hardening was assessed by methods of electrical impedance spectroscopy (EIS) and electrolyte leakage (EL). Correlation between the results of the two methods was compared in order to find the optimum EIS parameters for measuring the FH of genotypes. The order of FH with eight genotypes during de-hardening was NK36 > NK41 > NK61 > NK57 > NK42 > NK60 > NK58 > NK56, superior to 'Neva'. Linear correlation between the results of EIS(τ) and EL in assessing FH was significant (R^2=0.965). However, FH of EIS was underestimated than that of EL. Without controlled freezing tests, extracellular resistance (r_e) and relaxation time (τ) of EIS were highly correlated with FH of EL (R^2 were 0.817 and 0.847, respectively). These results provided more information for early multi-traits selection of hybrid clones in future.

Keywords: *Populus canadensis* cv. 'Neva', *P. ussuriensis* Kom., growth traits, branch, frost hardiness, electrical impedance spectroscopy (EIS), electrolyte leakage (EL).

[1] State Key Laboratory of Tree Genetics and Breeding, Research Institute of Forestry, Chinese Academy of Forestry, Beijing 100091, P. R. of China. E-mail: lijinh@caf.ac.cn

[2] College of Horticulture, Agricultural University of Hebei, Baoding, Hebei 071001, P. R. of China. E-mail: zhanggang1210@126.com

ID-026

EARLY RESULTS FROM *POPULUS* AND *SALIX* CLONAL YIELD TRIALS AT SIX LOCATIONS IN MICHIGAN, USA

Raymond O. Miller[1], Daniel Keathley and Paul Bloese

Biomass productivity, climatic adaptability, and pest resistance of 15 *Populus* (poplar) and 33 *Salix* (willow) hybrids is being observed in replicated, large-plot yield trials at six locations throughout Michigan, USA. Un-rooted hardwood cuttings were planted in large clonal plots. Poplar was established at a density of 1,922 trees/ha and will be harvested on eight-year intervals (or rotations). Willow was established at a density of 14,346 trees/ha and will be harvested on three-year rotations subsequent to coppicing at the end of the first growing season. The plantations were established between 2008 and 2011. Although it will be several more years before all plantations reach rotation age, a summary of preliminary observations is presented here.

Poplar basal area and height growth rates varied significantly among clones and sites, with strong genotype by site interactions. *Populus nigra* x *maximowiczii* hybrids showed the highest growth rates at all sites. Rust incidence also varied across sites, with *Populus deltoids* x *nigra* clones showing greater susceptibility. Analysis showed consistent and statistically significant differences in clonal ranking for growth on the six sites, underscoring the importance of local testing and selection of appropriate clonal stock for attaining optimal growth in biofuel plantations.

Biomass productivity of willow clones at one site varied greatly from 2.6 to 8.4 dry Mg/ha-yr and survival was highly variable, ranging from 29 to 99%. First-year observations indicate that some clones are good "general performers" across the region while the performance of others is highly site specific, thus offering two different strategies for the production of commercial planting stock for the region. However, it is clear that many of the better clones are not good "general performers" and, as with poplar, local testing and selection will be required to optimize growth in biofuel plantations.

Keywords: biomass, growth rates, biofuel plantations.

[1] Michigan State University, Forest Biomass Innovation Center, 6005 J Road, Escanaba, Michigan, USA 49829. E-mail: rmiller@msu.edu

INVESTIGATION ON APPROPRIATE POPLAR CLONES AT SUITABLE SITES FOR WOOD-FARMING IN MOUNTAINOUS REGIONS IN THE NORTH OF IRAN

A.R. Modir-Rahmati[1], R. Ghasemi, M. Calagari and R. Bagheri

In order to rehabilitate the degraded mountainous forests in the vicinity of a village with fast-growing species, three experimental sites were selected in the east, centre and west lands of northern Iran. The selected sites were located in Farim (36 07 N Lat.; 53 18 E Long.; 2100 m elevation), Tonkabon (36 38 N Lat.; 50 43 E Long.; 1720 m elevation), and in Mazandaran and Rostamabad (36 55 N Lat.; 49 24 E Long.; 1250 m elevation) in Guilan province. Seventy-five one-year plants of 17 different species and clones of poplar were planted in 5x5 m groups in frame of randomized complete block design with three replications. Survival and growth of poplar clones were measured during five years (2006-2010). Survival percentage, diameter at breast height (DBH) and height were recorded yearly during dormancy trees.

Analysis of variance of growth characteristics showed that survival differed significantly among clones ($P<0.01$). Also DBH and height had significant differences among poplar clones at the three sites. The results of compare means using Duncan's test showed that, in Farim site, *P. trichocarpa* was the best clone with 78% survival and 5.4 cm and 5.1 m diameter and height respectively. *P. ciliata*, *P. d. 69/55* and *P.caspica* had the highest diameter (with 4.9, 4.8 and 4.9 cm respectively) and height (with 5.1, 5.6 and 5.2 m respectively) in Tonkabon site. In Rostamabad site, poplar clone of *P. eura*. triplo had the highest diameter and height, with 6 cm and 6.4 m respectively. Finally, the poplar clones mentioned were the most promising species which could be introduced for rehabilitation and wood production at our study sites.

Keywords: clone, growth, north of Iran, *Populus*, wood framing.

[1] Research Institute of Forests and Rangelands, P.O. Box 13185-116 Tehran, Islamic Republic of Iran. E-mail: modirrahmati@rifr-ac.ir

THE QUALITATIVE AND QUANTITATIVE STUDY ON *POPULUS CASPICA* BORNM IN THE NORTH OF IRAN

Jamshid Mokhtari[1]

The north forests of Iran, with an area of 1.9 million ha, are the most important for wood production in Iran. For various reasons, parts of the forests and some species are susceptible to degradation and have been threatened. One of this species is *Populus caspica* Bornm of Leuce section poplar genus and Salicaceae family. *P. caspica* is a genetic reserve. For a basic study in order to protect and preserve this poplar, a qualitative and quantitative investigation has been made with silviculture parameters.

In this study, plain forests were selected in Noor region, province of Mazandaran in the north of Iran. There are *P.caspica* either pure groups or mixed stands with other trees in these forests. The region's climate, moist and temperate, has an annual rainfall of 1097mm and an average temperature of 16.4°C. By specifying the field in the present study, the area was marked on a topographic map and the map was adapted to nature. The measurements were performed on the basis of systematic random sampling at network 200m×250m that had been drawn on the map. The quantitative and qualitative parameters were measured and recorded in circular sample plots. The analysis and results were done by collecting information of circular sample plots in these forests.

The study showed that *P.caspica* is grown in lands without slope or little gradient, and there is the highest density in alluvial soils. Quantitative and qualitative investigations indicate that the number of *P.caspica* is 10.8% per ha in research filed. In this forest, the number of other trees is as follows: *Alnus glutinosa* 29.7%, *Carpinus betulus* 20%, *Ulmus carpinifolia* 12.7% and other trees 37.5%. The mean of total wood volume per ha is equal to 333m³ and volume of *P.caspica* is 203m³ per ha. The average of diameter (dbh) and height were calculated, respectively 46cm and 24.6m. An investigation on the number of curves in diametric classes showed that the number of poplars with medium diameter is higher than in other classes. The mean diametric growth (annual increment) of poplar was calculated: 12mm per year. That growth is higher than other endemic trees in the north of Iran. The studies of natural regeneration showed that saplings of *P.caspica* are from root sucker. The saplings that are under other trees will dry during later years. For this reason poplar sapling is not much demanding. And thus growing of saplings requires enough light. From this research, it was made evident that *P.caspica* is a reserve of valuable genetic and the only native poplar in the north of Iran, also adapted to ecological conditions in this region. By some silvicultural operations, this tree is reproduced naturally and artificially. Proper protection of this exclusive species, successful reforestation and afforestation warrant the development of this tree.

Keywords: *Populus caspica*, Iran, Mazandaran

[1] Member of Scientific Board, Forest and Rangeland Research Station of Chamestan in Iran. E-mail: mokhtari_snbr86@yahoo.com

ID-122

GENETIC LINKAGE MAP OF POPLAR (*P. DELTOIDES, P. NIGRA* AND *P. x CANADENSIS*) BASED ON SSR MARKERS AND THE INNOVATIVE RAPID-SEQ APPROACH

Giuseppe Nervo[1], G. Carletti[1], Giampierro Valè[2], Marijke Steenackers[3], G. Allegro[1], A. Giorcelli[1], L. Vietto[1] and L. Cattivelli[2]

Poplar is a tree of economic importance in the temperate regions in the world where it represents the major source of domestic roundwood and has also significant potential for paper and biomass productions. Interspecific *P. x canadensis* (*P.deltoides x P.nigra*) still nowadays represents the bulk of European intensive poplar cultivation and new poplar clones characterized by fast growth, resistance to disease, wood quality for several purposes have been recently selected and proposed to the International Poplar Commission.

Nevertheless, as poplar genome has been sequenced and the introduction of new desirable traits by classical breeding is a time-consuming process, because of the long sexual generation cycles and the prolonged period required in order to evaluate adult traits, a genome mapping project has been initiated at the CRA–PLF Research Unit of Casale Monferrato.

In this work, the development of a genetic linkage map based on an F1 *P. x canadensis* hybrid population derived from an inter-specific mating of *Populus nigra* and *P. deltoides* accessions is described. In a preliminary phase of the two maps generation, 113 Single Sequence Repeat (SSR) markers, polymorphic between the parents, were screened on the 188 plants forming the population. Due to the high level of segregation distortion, only some of them were useful for mapping on the two parents, using the pseudo-testcross strategy.

The innovative Randomly Amplified Polymorphic DNA Sequencing (RAPiD-seq) approach, for Single Nucleotide Polymorphisms (SNPs) discovery, was then used to integrate SSR molecular markers data. This strategy, following up the Illumina Next Generation Sequencing (NGS) advantages, allows the discovery of thousands of SNP markers, only using PCR and sequencing-based techniques. The developed genetic linkage maps of *P. nigra, P. deltoides and P. x canadensis* will represent the base for disease and pest *(Melampsora larici populina, Marssonina brunnea,* and *Phloeomyzus passerinii)* QTL mapping, since the two parents differ for resistance response to rust, *M. brunnea* and the poplar woolly aphid.

Keywords: poplar, genetic mapping, SSR marker, Next Generation Sequencing, RAPiD-seq

[1] CRA-PLF, Research Unit for Intensive Wood Production of Agricultural Research Council, Strada Frassineto 35, 15033 Casale Monferrato (AL), Italy. E-mail: giuseppe.nervo@entecra.it

[2] CRA–GPG, Genomic Research Center, Via S. Protaso 302, 29017 Fiorenzuola d'Arda (PC), Italy. E-mail: giampiero.vale@entecra.it

[3] Research Institute for Nature and Forest (INBO), Forest Genetic Resources, Gaverstraat 4, B-9500 Geraardsbergen, Belgium. E-mail: Marijke.STEENACKERS@inbo.be

ID-092

GENETIC IMPROVEMENT, DIVERSITY AND CERTIFICATION OF POPLARS FOR AGROFORESTRY PLANTATIONS: ENHANCING SOCIO-ECONOMIC AND ENVIRONMENTAL BENEFITS

Om P. Rajora[1]

Agroforestry provides significant social, economic and environmental benefits, particularly in countries with subsistence agriculture, low forest cover and high deforestation. Agroforestry can improve the lives of resource-poor rural populations by providing increased income, diversification and sustainability of agriculture, and food security. It can reduce the impact on natural forests, and has a potential to bridge the gap in demand and supply of forest products, including pulp and paper, in a country like India. Poplars (*Populus*) are multipurpose, fast-growing trees, which are highly suitable for agroforestry plantations. Poplar wood is suitable for various forest products, and poplar foliage provides a good source of fodder. Poplars also have abilities of growing on marginal and degraded lands, high carbon sequestration and phytoremediation of contaminated sites. In India, use of poplars in agroforestry has provided the highest internal rate of return and benefit to cost ratio as compared to other forest tree species. However, potential of poplars in agroforestry remains underutilized. Only a very small number of poplar clones with narrow genetic base, especially those of *Populus deltoides* and *P. deltoides* x *P. nigra* (*P.* x *canadensis* syn *P.* x *euramericana*), are used in agroforestry. These clones were not originally developed for agroforestry but were introduced for forest plantations in many countries. For example, about five *P. deltoides* clones of American origin are most commonly used for agroforestry in India. Also, there remains a serious problem with identification and nomenclature of poplar species, hybrids, clones and cultivars word-wide, and quality control and certification of planting poplar stock. There is a great need to develop poplar clones, cultivars and hybrids that are highly suitable for agroforestry plantations with different crops at various sites in different eco-climatic regions by taking into consideration physical, biological and ecological interactions between trees and crops. This requires genetic improvement of poplars in desired traits, substantial increase in the genetic base of clones, species and hybrids, and certification of clones and cultivars for agroforestry use. By deploying genetically improved and diverse poplar clones, the profitability of agroforestry systems could be enhanced several folds. Fortunately, the poplar genome is fully sequenced and most of the genes have been identified.

I will discuss how genetics, breeding, genomics and biotechnology approaches, technologies and applications could help in developing and certifying highly productive, disease resistant and adaptive poplar clones and cultivars that are highly suitable for agroforestry plantations, increasing the genetic base and solving the identification, nomenclature and quality control problems.

Keywords: poplars, agroforestry, genetic improvement, certification, genetics, genomics, biotechnology, breeding, socio-economic and environmental benefits.

[1] Faculty of Forestry and Environmental Management, University of New Brunswick, 28 Dineen Drive, Fredericton, NB E3B 5A3, Canada. E-mail: Om.Rajora@unb.ca

ID-129

PHENOLOGICAL IDENTIFICATION OF FIVE *POPULUS x CANADENSIS* CLONES IN AN UPOV PLANT NURSERY IN MENDOZA, ARGENTINA

N. Riu, S. Pérez, S. Robledo and N. Naves[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, five *Populus x canadensis* clones were planted over a 3-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): 'Enza', 'NNDV', 'San Martino', 'B.L. Constanzo' and 'Conti 12'.

The initiation date of the different phenological phases of growth in 1/1 plants was determined. As a reference, the mean date observed for clone *Populus* × *canadensis* 'Conti 12' was used. The initiation date of phase 2 is considered a useful parameter for differentiating clones because, generally, it is the easiest way to observe, it is stable and it has a constant relationship between clones from year to year.

It was observed that clone 'San Martino' burst bud on 16 September, and clone 'B. L. Constanzo' burst bud between 2 and 19 September. Clones 'NNDV' and 'Enza' burst bud on 20 September, three days before 'Conti 12'.

Keywords: poplar clones, phenology, identification.

[1] Docentes Investigadores, Cátedra de Dasonomía, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo. Almirante Brown 500. Chacras de Coria. C.P. M5528AHB. Mendoza. República Argentina. E-mail: dasonomia@fca.uncu.edu.ar

DIFFERENT BEHAVIOR CLONES OF *POPULUS DELTOIDES* IN RIVADAVIA, MENDOZA, ARGENTINA

N. Riu[1], V. Settepani[2] and S. Cortizo[3]

The objective was to study the behavior and adaptation of nine clones of *Populus deltoides* to environmental conditions and soils of the eastern area under irrigation in Mendoza. So in the Field "The Forest" of the Agricultural Experimental Station INTA Junín, located in the Department of Rivadavia (Lat. 33 º 09 'S, Long. 68 º 28' W), province of Mendoza, a plot was planted with nine clones of *P. deltoides* 'Stoneville 67', 'Australian 106/60' and 'Carabelas INTA' and six experimental clones '2 / 82 ', '20 / 82', '21 / 82 ', '89 / 82', '149 / 82 ', '150 / 82' selected under the Program Improvement INTA poplar.

Planting distance was 5 meters between rows and 5 meters between plants, with ten plants per clone. Irrigation was surface by furrow with a frequency of 15 days. Cultural practices were made in the soil, pruning trees and ant control. Failure rate was determined, annual diameter at breast height and total height of trees were measured, and with these data we calculated the volume of wood produced.

We also assessed the phytosanitary, phenology and morphology status of each of the clones tested. The largest flaws were observed in clones '149 / 82' and '150 / 82', both being 100%, while clones 'Carabelas INTA' and 'Stoneville 67' showed no failures. In measurements made at 3 years of age, the greatest height was observed in 'Carabelas Inta`: 10 m, clones '20 / 82' and '89 / 82': 8.75 m; Stoneville 67: 8.25 m; 'Australian 106/60': 7 m, and the lower height was observed in the clones '2 / 82' and '21 / 82': 4 m. The phytosanitary condition was generally good, *Penphigus populitranversus* attack was detected in some clones.

Keywords: behavior, deltoides clones, plantation.

[1] Cátedra de Dasonomía, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo. Alte. Brown 500, Chacras de Coria, Luján de Cuyo, Mendoza, Argentina. Tel.:0261-4135010. E-mail: dasonomia@fca.uncu.edu.ar
[2] AER Santa Rosa, EEA Junín. INTA E-mail: aerintasantarosa@infovia.com.ar
[3] EEA Delta del Paraná, INTA E-mail: scortizo@correo.inta.gov.ar

ID-078

COMPARING EARLY DROUGHT RESPONSES OF ITALIAN ALDER AND HYBRID POPLAR IN A BIOENERGY FIELD TEST IN MEDITERRANEAN EUROPE

Andrea Scartazza[1], Luca Tosi[2], Massimo Tarchi[3], Pierluigi Paris[4] and Enrico Brugnoli[5]

In the context of sustainable deployment of bioenergy plantations, the selection of trees species with low water demand and, possibly, nitrogen fixing capacity is of primary importance. Italian alder (*Alnus cordata* L.) is a fast-growing, nitrogen-fixing tree, endemic to restricted areas of the north Mediterranean Basin with interesting potentialities for bioenergy plantations, also in mixture with hardwoods for fine timber production. Italian alder is considered the most drought-adapted species amongst the *Alnus* genus. Although these potentialities, little is known about the drought adaptation of this species.

An experimental plantation was recently established in central Italy, for comparing Italian alder with the hybrid poplar clone AF2, which is actually one of the most interesting new cultivar for short-rotation coppice (SRC) plantations in Italy, as well as in Europe. Alder seedlings and poplar cuttings were planted in March 2012 in an experimental site, within a network of the European Project AgroCop (www.agrocop.com), studying the intercropping of SRC with hardwood timber species.

After a rainy spring, with the onset of summer drought, plant water status, leaf nitrogen concentration and biometric and eco-physiological parameters were periodically monitored. Plant water status was assessed measuring the pre-dawn and midday leaf water potential with a Scholander pressure chamber and the Relative Water Content (RWC). Gas exchange and fluorescence parameters were measured using a Licor 6400 portable gas exchange system and carbon isotope composition of leaf material was determined with a mass spectrometer (Isoprime, Cheadle, UK) coupled in continuous-flow with an elemental analyser. Both alder and poplar showed a strong drought-induced decrease of leaf water potential and concurrent reduction in stomatal conductance. However, alder showed a stronger decrease of leaf water potential than poplar and a lower water-use efficiency. This was associated with lower values of stomatal conductance and assimilation rate per unit of leaf area and of the apparent quantum efficiency of PSII. Alder showed a much higher number of leaves per plant and a faster leaf turnover than poplar. Our preliminary results indicate that alder and poplar showed contrasting water-use strategies. Further studies are in progress to finally demonstrate which of these species are more adapted to cope with the summer drought in Mediterranean areas.

Keywords: gas exchanges, fluorescence, mixed plantations, stable isotopes, water-use efficiency, drought resilience.

[1] Correspondig Author: Consiglio Nazionale delle Ricerche (CNR), Istituto di Biologia Agroambientale e Forestale (IBAF), Via G. Marconi 2, 05010 Porano, Italy. E-mail: andrea.scartazza@ibaf.cnr.it
[2] CNR-IBAF, Italy. E-mail: luca.tosi@ibaf.cnr.it
[3] W2 Agency, Via S. Antonio 18,-60020 Sirolo, Italy. E-mail: massimo.tarchi@libero.it
[4] CNR-IBAF, Italy. E-mail: piero.paris@ibaf.cnr.it
[5] CNR-IBAF, Italy. E-mail: enrico.brugnoli@ibaf.cnr.it

ID-048

DEVELOPMENT OF NEW CLONES OF WILLOWS THROUGH BREEDING

J.P. Sharma[1], N.B. Singh[1], Punit Chaudhary[2] , M.K. Singh[1]
and Sanjeev Thakur[1]

The control breeding/hybridization work in *Salix* clones at UHF Nauni, Solan during the year 2011 and 2012 has been analyzed in the paper. The work started from last week of February to last week of March involving 8 females and 16 males. Control breeding/hybridization was carried out on female plants raised from setts as well as in trees. Due to the early receptivity of some female clones, the previously stored pollen (stored at -20^{o}C) was used. While in late flowering females fresh pollen was used. Highest percentage of successful crosses (92.38%) were obtained between clone PN 227 (*S. matsudana*) x SI-63-007(*S. alba*). Whereas, percent of catkins in which seeds were obtained was highest (82.78%) in cross between J799 (*S.matsudana* x *S. alba*) x NZ1140 (*S.matsudana* x *S. alba*). All the hybrid seedlings of cross between PN227 (*S.matsudana*) and 194 (*S.matsudana* x *S.arbutifolia* x *S.matsudana*) survived in earthen bowl containing vermiculite media (Stage I). Root trainer evaluation in sand and soil (Stage II) revealed the maximum survival of hybrids of PN227 (*S.matsudana*) x J795 (*S.matsudana* x *S. alba*). All the hybrids of crosses *S. babylonica* x J795 (*S.matsudana* x *S. alba*) and PN 227 (*S.matsudana*) x 194 (*S. matsudana* x *S.arbutifolia* x *S.matsudana*) survived after shifting to polybags containing sand, soil and compost (Stage III). These hybrids were shifted in the nursery in the winter season and growth was evaluated in the month of August 2012. Maximum mean height (322.64cm) was attained by hybrids of PN 227 x SI-63-007 followed by PN227 (*S.matsudana*) x 131/25 (*S. babylonica* x *S. alba*). Collar diameter (18.94mm) and number of branches (52.2) were also recorded highest in hybrids of cross PN 227 x SI-63-007.

The seed formed by natural pollination were collected from female clones PN 227 (*S.matsudana*), J795 (*S.matsudana* x *S. alba*), SE-69-002 (*S.matsudana*). The half sib plants obtained were directly shifted to field nursery from root trainers, excluding the poly bag stage (stage III). The half sibs of female J799 recorded maximum survival (72.805%) in earthen bowl containing vermiculite media (StageI). While half sibs of clone SE-69-002 (*S.matsudana*) survived better (69.23%) than others in root trainers containing sand and soil (Stage II). Maximum height (253.28 cm) was attained in progeny of parent SE-69-002 followed by progeny of parent J799 (248.46 cm). Basal diameter was highest in progeny of parent PN227 (15.54 mm) followed by progeny of parent J799 (13.48 mm). the number of rabches was highest (43.6) in progeny of parent J799.

In the year 2012 further breeding programmes continued with remaining crosses. The hybrids of PN 227 (*S.matsudana*) x Kashmiri willow (*S. alba* var *coerulea*) and *S. tetrasperma* (Local) x *S. alba* were obtained and maintained upto Stage II i.e. shifting in root trainers.

Keywords willow, breeding, hybrids, half sibs, full sibs, clone.

[1] Department of Tree Improvement and Genetic Resources, Dr Y.S. Parmar University of Horticulture and Forestry, Solan (HP), India. E-mail: jaiuhfrajgarh@rediffmail.com
[2] Assistant Professor, KVK, Rajouri, SKAUST, Jammu, J&K, India.

ID-167

PERFORMANCE OF SOME EXOTIC AND INDIGENOUS CLONES OF WILLOW IN NURSERY AND FIELD UNDER SUBTROPICAL CONDITIONS OF HIMACHAL PRADESH

Kamal Sharma[1], N.B. Singh[2], K.S. Verma[1] and S.D. Sharma[1]

Willows are among the fastest growing broad leaved species of the world. Due to their higher growth rate and varied uses, the willows are preferred in valleys, depressions and along water streams in lower Himachal since these are water loving species. Keeping this in view, germplasm across India and overseas was procured to test it under subtropical conditions of Himachal Pradesh to screen better genotypes. In total, 47 clones were tested under nursery conditions for further selection and field evaluation. The experiment was conducted under Randomized Block Design with three replications. Perusal of data revealed that survival of different clones varied from 66.7 to 100 per cent with minimum in clone 95311. Most of the clones, however, revealed 100 per cent survival. Wide variation was recorded with regard to growth parameters viz., height, diameter, number of branches and number of leaves per plant. The minimum plant height (43.3 cm) was recorded in clone C-Sertai whereas the maximum (226.14 cm) was observed in Kashmiri willow. The maximum collar diameter was also recorded in Kashmiri willow. However, minimum was registered in clone SN2. Kashmiri willow also produced maximum number of branches and number of leaves among the tested clones. Clone S164-036 had the minimum number of branches and leaves per plant. Overall, Kashmiri willow excelled in growth parameters over all the tested clones.

An experiment regarding field evaluation of five selected clones was also initiated. The trial was laid under RBD with four replications. Statistically no significant difference was observed with respect to survival of the clones whereas growth parameters were found to differ significantly. The maximum plant height and diameter were recorded in clone SX-67. The highest number of branches and leaves were, however, registered in clone SI-64-017 and Kashmiri. Though clone SX-67 was rated as the best in initial year yet observations need to be recorded for couple of years to reach at some conclusion.

Keywords: willows, clones, testing, nursery, field.

[1] Institute of Biotechnology and Environmental Science, Neri, District Hamirpur (HP), India, 177 001, E-mail: kamal_64in@yahoo.com

[2] Department of Tree Improvement, Dr YS Parmar University of Horticulture and Forestry, Solan (HP), India 173 230.

ID-192

EVALUATION OF WILLOW CLONES FOR THEIR GROWTH CHARACTERISTICS AND PHYSIOLOGICAL PARAMETERS AT NURSERY STAGE

Rajni Sharma[1], R.S. Arun and Sanjeev K. Chauhan

The farmers in the Punjab state are looking for a timber tree which may be suitable for raising with traditional crop rotation of rice-wheat. Poplar though is popular among the farmers but the small and medium farmers are not willing to adopt poplar at the cost of rice crop. Therefore, it was planned to introduce and evaluate good performing willow clones for their growth and adaptation from different states in India for adoption in the Punjab state itself (willow is water loving so farmers can grow rice, which is not possible with poplar).

Twenty clones of different willow species were introduced and raised in randomized block design for their evaluation w.r.t. morphological and physiological parameters. Significant differences among twenty willow clones for both the growth, biomass, wood and physiological traits were observed. All the traits showed high level of coefficient of variation, heritability values and genetic gain. The multivariate analysis on the basis of morphological parameters, grouped all the sources in four clusters with high similarity between clones from same area. Jeolikot-2 and Jeolikot-3 collected from Uttrakhand state were grouped in a separate cluster and produced higher growth and biomass. The morphological traits of clones were the resultant of physiological behaviour (photosynthesis, transpiration, water use efficiency and chlorophyll content), therefore exhibited close relationship among themselves.

However, there is a need to evaluate clones for different purposes, i.e., timber, bio-energy, agroforestry, etc. therefore, detailed assessment would be possible only after field evaluations. Ten good performing clones in the nursery have been selected for further field plantation performance. The nursery and preliminary field performance of selected clones will be discussed in this paper.

Keywords: willow, *Salix*, clones, nursery, growth, biomass, physiology.

[1] Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana 141 004, India. E-mail: rajnisharma-fnr@pau.edu

EARLY VARIATION AND GENETIC CORRELATION IN GROWTH AND BRANCHING CHARACTERS IN CLONES OF *POPULUS DELTOIDES* BARTR.

Bikram Singh[1] and N.B. Singh[2]

Populus deltoides has become an important exotic species in many plantation programmes in India as they grow fast, are easily propagated, and grown on the areas lying in the Indo-gangetic plains North of 28° N latitude. The height and diameter at breast height (dbh) in case of poplar are considered as corresponding indicators for growth potential while the genetic correlation associated with branching characteristics contribute most to the trunk thickening, competition for light, which is linked to the photosynthetic fixation of CO_2 per unit of land area. Branches per decimeter of tree height (BRPD), is an important secondary trait putting more number of branches to the whole length of tree which is the function of proleptic branch (development from dormant bud), sylleptic branch (developed from axillary non-dormant bud) and early bud-break.

The present investigation is an attempt to explore the genetical parameters and their correlation potentials for the clones from 12 provinces of the United States, so as to select them in the right direction for better productive clones/genotypes. The variance components, heritability estimates and genetic correlation for growth and branching traits was investigated at ages one and two for 100 best clones after repeated evaluation of *Populus deltoides* belonging to 17 families which were planted with seven commercial checks in Complete Randomized Block Design with three replications in Nursery at the Forest Research Institute, Dehradun, India ($30^{o}20'$N latitude, $77^{o}52'$E longitude and 640.08 msl). This investigation confirmed sufficient genetic variation for the traits studied and significant positive correlations. There was a moderate to high broad-sense heritability for BRPD (0.59), height (0.59), dbh (0.66) and bud-break (0.99) at age two. A significant negative genotypic and phenotypic correlation (rg = -28; rp = -21) exist between BRPD and bud-break which indicates that early sprouters utilize the full days in the growing season and influence the increment in BRPD. The number of sylleptic and proleptic branches showed a positive genotypic and phenotypic correlation with height, dbh and D^2h (estimated volume); and the significant genotypic correlation in case of BRPD with D^2h (rg=0.21) indicating that carbon export by the network of sylleptic and proleptic branches contribute significantly to height and diameter growth. The clones T_{43}, T_{44}, T_{33}, T_{48}, T_{45} followed by T_{38} exhibited best performances for the traits like dbh and BRPD.

The aim of this work was to determine the trends in genetic and phenotypic parameters for growth and branching traits during early stages to obtain information necessary to scrutinize and seek manageable clones for early selection.

Keywords: proleptic branch, sylleptic branch, heritability, genotypic correlation.

[1] Department of Silviculture and Agroforestry, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh, 791 102, India. E-mail: bikramfri@gmail.org
[2] Department of Tree Improvement and Genetic Resources, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, 173 230, India.

ID-160

INITIAL PERFORMANCE OF DIFFERENT *POPULUS DELTOIDES* CLONES IN JAMMU REGION

Jagdish Singh[1], Sandeep Sharma and V.R.R. Singh

Populus deltoides is highly preferred and profitable agroforestry tree which is extensively raised in farming areas, especially in northern India. It offers great scope in meeting the growing needs of wood-based industries, besides providing extra income to the farmers.

In spring 2010, cuttings of 13 *Populus deltoides* clones viz. ST-72, D-75, 57-C1, 57-C20, L-87, L-89, L-90, L-200-84, 54-C2, ST-124, S7C4, S7C15 and L30-82 were brought from FRI, Dehradun and planted at Nagbani nursery in Jammu region of Jammu and Kashmir state, to evaluate the growth performance and initial screening of different clones. After one growth season, there was significant difference amongst the different clones for height, diameter and survival percentage. The following clones ST-124, L-30-82, L-90, L-200-84, L-87, S7C15, S7-C20 attained the height of 2.89, 2.87, 2.86, 2.80, 2.77, 2.75 and 2.72 meters, and diameter of 1.97, 2.0, 1.97, 1.96, 1.82, 1.85 and 1.85 cm respectively. In general survival percentage was found to be > 80 percent in all the studied clones. Thus on the basis of nursery performance, the following clones ST-124, L-30-82 and L-90 were found to be promising under sub-tropical conditions of Jammu region (J&K).

Keywords: *Populus deltoides*, clones, performance, promising, Jammu.

[1] Himalayan Forest Research Institute, Conifer Campus, Panthaghati, Shimla (H.P.), 171 009, India. E-mail: singhj@icfre.org

ID-174

NURSERY EVALUATION OF OPEN POLLINATED HALF SIB PROGENIES (F_1 OF *SALIX* SP.) AND ASCERTAINING THEIR PARENTAGE THROUGH MOLECULAR MARKERS

M.K. Singh[1], N.B. Singh, S. Thakur and J. P. Sharma

Willows belong to family *Salicaceae* which are fast-growing tree species used for biomass production in short rotation. Trees belonging to this family are characterized by two distinguished features, i.e. they are reproduced by vegetative means as well as through seed. Willows are diocious and hybridization is frequent between trees of different types and of complementary taxa.

In 2011, pollen donators, i.e. *Salix matsudana*, *Salix tetrasperma*, *Salix alba*, *Salix udensis*, 131/25 (*Salix babylonica* x *Salix alba*) and female plants/trees PN227 *Salix matsudana*, J-799 (*Salix matsudana* × *Salix alba*), SI-67-002 *Salix matsudana* (Italy) and *Salix tetrasperma* were allowed to cross under natural conditions at germplasm nursery of Dr. Y.S. Parmar University of Horticulture and Forestry, Solan Himachal Pradesh. Half sib F_1 progenies obtained after the completion of natural pollination were tested for their paternity using molecular markers RAPD and SSR. Pre-screened RAPD markers were used to confirm the F_1 half sibs on the basis of banding pattern. The amplification of genomic DNA of the parents and their F_1 half sib progenies revealed that all the hybrids were developed from female parent such as PN227, J-799, SI-67-002 and *Salix tetrasperma.*

Our study also confirmed that 131/25 (*Salix babylonica* x *Salix alba*), *Salix alba* and *Salix matsudana* were source of potential pollen. Crosses such as *Salix matsudana* x 131/25 (*Salix babylonica* x *Salix alba*), *Salix matsudana* (Italy) x *Salix tetrasperma* produced superior F_1 half sibs under nursery trial in 2012. Superior clones of these open pollinated willow species may be used for multilocation trials in order to test genetic stability in the different agro-ecological regions.

Keywords: pollination, genomic DNA, genetic stability.

[1] Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Y.S.Parmar University of Horticulture and Forestry, Solan (H.P.), India. E-mail: mintusingh78@gmail.com

ID-126

NURSERY PERFORMANCE OF NEWLY DEVELOPED SUPERIOR CLONES OF POPLAR (*POPULUS DELTOIDES*)

N.B. Singh[1], D.K. Khurana[2], Sanjeev Thakur[1] and J.P. Sharma[1]

The paper describes the development and testing of new clones of poplar from open pollinated seed brought from the USA. Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan HP introduced seed from Texas and Davenport, USA, in 1990. Similarly, the Forest Research Institute, Dehradun, got selected 104 plus trees of *Populus deltoides* in 44 natural stands spread in 11 states in South-Eastern USA during June 1997.

Over the last fifteen years, new promising clones of poplar (*Populus deltoides*) developed in these institutes were screened with two established commercial clones (G-48 and L-200/86) in the nursery. Screening for growth traits reveals that 23 clones were found significantly superior in plant height and basal diameter against check clone G-48. While volume index of all the clones was significantly superior against the same check clone. Four clones (T-50, T-33, 5503, 6503) for plant height and two clones (H-11, 6503) for basal diameter and volume index were found significantly superior against check clone L-200/86. The clone T-50 recorded maximum plant height (378 cm) which was at par with the clones T-33, 5503,6503, H-14, H-11, 1007, 63-N, Solan-1, HYB-2, T-46, T-47, 9607, T-70, T-98, 8800, T-59, T-16 and 40-N. Highest basal diameter (22.64 mm) was recorded in the clone H-11 which was at par with clones 6503, 8800, T-40, 9607, T-47, Solan-1, 1007, T-33, H-8 and PD-48. Volume index was recorded highest in clone 6503 at par in the clones H-11, 8800, T-33, T-47, Solan-1, 9607, 1007 and T-50. Broad sense heritability (21.33 %) and genetic gain (9.33%) were found highest for volume index. These superior clones are being tested under tree improvement program through multilocation trials.

Keywords: poplar, *Populus deltoides*, heritability, genetic gain, superior clone.

[1] Department of Tree Improvement and Genetic Resources, Dr Y S Parmar University of Horticulture and Forestry, Solan (HP), India 173 230. E-mail: nbsuhf@rediffmail.com
[2] Teacher's Colony, Rajgarh Road, Solan (HP), India.

ID-162

GROWTH PERFORMANCE AND GENETIC PARAMETERS OF SIX-YEAR-OLD WILLOW CLONES

N.B. Singh[1], H.P. Sankhyan, J.P. Sharma and S. Thakur

Willow (*Salix*) being a multipurpose species across the globe is well recognized in short-rotation forestry. In India its importance is well noticed in sports industry, household timber because of its myriad uses. Willow is the lifeline in Lahaul & Spiti dry temperate region of H.P. The very ecology and economy is based on the cultivation of this plant. The productivity of present germplasm is low. Keeping in view the social and economic importance of willow, a research programme has been initiated by the department to develop more productive clones in order to replace the existing germplasm.

Over the years 200 clones/strains/species were procured from 20 different countries. These clones were subjected to a repeated nursery screening during 2003-05. Among the 200 clones, 18 clones were found promising for field trials. These clones were planted in randomized block design in February 2006 at experimental field. Data on different growth characters in six-year-old plantation of these clones was recorded in November 2011. The data revealed that maximum height (21.23 m), diameter at breast height (22.75 cm) and volume index (1.12 m^3) were observed in clone J-799. This clone had top performance for the last six years. The clone NZ-1140 was found to be second best though having a low volume index. Bole straightness was recorded maximum in clone J-795 that is at par with clones J-194, PN-721 and 131/25 followed by clones J-799, SI-63-007, NZ-1140 and SI-64-017. Overall clone J-799, NZ-1140 and 131/25 were found promising in term of growth characteristics. The genetic parameters were also calculated from the data. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were found to be high in all the characters. Heritability in broad sense value for volume index was observed to be 67.82% which is high indicating that selection for volume index will be very effective. Genetic gain of 34.57%, 31.81% and 128% were observed in plant height, diameter at breast height and volume index respectively. The stability performance of different clones was also worked out.

Keywords: germplasm, willow, heritability, genetic gain.

1 Department of Tree Improvement and Genetic Resources, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan. HP 173 230, India. E-mail: jaiuhfrajgarh@rediffmail.com

ID-168

WILLOW IMPROVEMENT IN INDIA: PRESENT STATUS AND FUTURE POSSIBILITIES

N.B. Singh[1], J.P. Sharma[1], Punit Chaudhary[2], S.K. Huse[3] and Sanjeev Thakur[1]

The paper describes willow improvement work done in the Department of Tree Improvement and Genetic Resources, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H. P.) since 2002. The objective of the programme was to develop more productive clones in order to replace the existing inferior germplasm. During 2002-04, around 200 genotypes comprising clones/hybrids of *Salix* species from twenty countries have been procured and subjected to repeated nursery screening. In the screening clones 194, NZ-1002, 084/03, PN 733, PN 722, PN 731, J795, 84/22, PN 721, NZ 1140, PN 227, 82/11 and 17-93-A scored the first rank in term of growth parameters. The morphological and genetic parameters of promising 75 clones studied with three well recognized check clones were again studied. The clones SI-63-016, J-799, PN-722, NZ-1002, PN-733, PN-731, SN-2, Sx61, 194 and NZ 1002 were found superior to check clones for the growth traits. Heritability in broad sense (91.08 %) and genetic gain (75.24 %) was found highest for leaf breadth and volume index, respectively. Principal component analysis revealed 85.03 per cent variation by three main components.

Variability in photosynthesis, transpiration and water use efficiency (WUE) of twenty-three willow clones were determined. High heritability in broad sense was recorded for transpiration (85.30%) and photosynthesis (80.00%). The variation in wood basic density and fibre length was assessed in twenty-five promising willow clones collected from five different countries. Value of basic density ranged from 0.40 to 0.58g/cc with clone SE-75-001 registering maximum value (0.58g/cc). Fibre length varied from 0.59mm to 0.81mm. The clone Kashmiri willow (U. K.) and SE-75-001(Italy) stands out because of their long fibre and high wood density respectively. Moderately high heritability values 56.10 and 55.2% for wood density and fibre length respectively indicated strong genetic control to warrant selection and breeding programme.

Based on above studies, the field experimental trial of selected willow clones was established for growth performance. After five years the maximum average plant height (19.33m) was recorded in the clone J-799 which is at par with the clone NZ-1140 (16.33 m) followed by SI-63-007(14.30 m). Diameter at breast height and volume index of clone J-799 registered first rank followed by NZ-1140 and 131/25 recording 16.50 cm and 0.554 m^3, 15.30 cm and 0.386 m^3 ; 15.30cm and 0.368m^3, respectively. Clone J-795 was observed most straight which was at par with clones 194, PN-721 and 131/25. The maximum heritability in broad sense (46.36%) for bole straightness and genetic gain (67.95%) of the volume index was found. On the basis of five year growth performance, most promising five clones namely J-799, NZ-1140, 131/25, SI-63-007 and PN-731 were found suitable for lower and mid-hills of Himachal Pradesh.

Stability analysis of superior willow clones was analysed on the basis of annual increment growth in the field conditions. With respect to plant height, clone J799, 131/25 and J194 were found suitable for rich environments. Clone SE-63-016 was found suitable for average environment for both the characters

[1] Department of Tree Improvement and Genetic Resources, Dr Y.S. Parmar University of Horticulture and Forestry, Solan (HP), India 173 230. E-mail: nbsuhf@rediffmail.com
[2] Assistant Professor, KVK, Rajouri, SKAUST, Jammu, J&K, India.
[3] Assistant Professor, Department of Forestry, Navsari Agriculture University, Navsari, Gujrat, India.

i.e. plant height and diameter at breast height. Clone SI-63-007 was adaptive to overall environments but only for plant height character. For poor environments, clones NZ-1179 for plant height and PN-722, PN-721 for diameter at breast height are found suitable. Clones NZ-1040, NZ-1140, NZ-1130 were found most adaptive to rich environments for diameter at breast height.

Molecular characterization and assessment of intra-specific relationship among 36 *Salix alba* clones were done using RAPD and SSR markers. Genotype 668 (Netherlands) appeared to be the most diverse from rest of the genotypes. RAPD-based genetic distance was maximum (0.385) within Netherlands and (0.437) between Netherlands and Yugoslavia. The similarity coefficient among 25 clones of willow ranged from 0.71 to 0.86.

In another research, 25 *Salix* clones of different species were studied with RAPD and SSR primers. Genotype PN-733 (*S. nigra* from New Zealand) appeared to be the most diverse (76 per cent) from the rest of the genotypes on the basis of RAPD dendrogram. Primers namely OPO-07, OPO-19 and OPO-16 produced unique bands present only in genotypes 17-93-A, 194, and SI-64-017, respectively. A unique band was found present only in SE-75-001 with SSR primer SB-80. Jacquards similarity correlation coefficient value ranged from 0.63 to 0.97. Clone NZ-1002 (*S. matsudana* x *S. alba* from New Zealand) was found to be most divergent clone having 68 percent similarity coefficient. The extent of polymorphism indicated was marginally higher in RAPD compared to the SSR markers and hence the former is more informative than the later. The clustering pattern exhibited that the geographic distribution does not provide true index of genetic diversity in willow clones. Therefore, willow resources have been freely exchanged all over the world and used for willow breeding for production of vigorous clones.

Multi-location trials of 18 superior selected *Salix* clones have been raised at 10 sites in HP and 26 sites in all over India to study the genotype x environment interaction at different sites for analysis of the suitability of clones for a particular site. PN 731 is performing exceeding well in tropical areas of Uttar Pradesh. Similarly, clone NZ-1002 (*S. matsudana* x *S.alba*) from Newsland and SI-64-017 (*S.alba*) from Italy are emerging out most befitting in seasonal waterlogged areas. Future thrust is subjected to towards developing hybrids by involving *S. tetrasperma* which is growing through out the country.

Halfsib progeny testing of few clones namely J799, PN227, SE-69-002 and *Salix tetrasperma* (local) is under nursery testing. Hybrids (F_1s) developed through control-pollination by involving outstanding (field tested) clones and selections of local species (*Salix tetrasperma*, *S. acmophylla*) were subjected to nursery evaluation in the field conditions.

Keywords: check clone, stability analysis, molecular characterization, RAPD, SSR, Genotype x environment interaction, Hybrids.

MOLECULAR DIVERSITY OF TREE WILLOW CLONES

N.B. Singh[1], J.P. Sharma and Sanjeev Thakur

Thirty-six clones were used for assessment of genetic diversity using ten primers, out of which five were amplified. A total of 55 RAPD markers were amplified and all were found to be polymorphic. The size range of polymorphic bands was 280 bp-1650 bp. Jacquards similarity correlation coefficient was obtained which ranged between 0.418-0.873. Genotype 668 (Netherlands) appeared to be the most diverse from the rest of the genotypes on the basis of dendrogram. Maximum similarity of 87 per cent was observed between genotypes SI-64-036 (Italy) and Veliki bajar (Hungary). RAPD-based genetic distance was maximum (0.385) within Netherlands and (0.437) between Netherlands and Yugoslavia.

In an another experiment, twenty-five promising willow clones belonging to different species from six countries were selected for molecular diversity analysis using sixteen RAPD and fourteen SSR primers. A total of 363 markers were generated and out of which 351 were polymorphic showing high (96.7%) rate of polymorphism. Out of thirty, eighteen primers showed 100% polymorphism. RAPD widely scored over SSR markers in polymorphic information content. UPGMA dendrogram based on both RAPD and SSR markers resolved into four major clusters. The similarity coefficient among 25 clones of willow ranged from 0.71 to 0.86. Maximum similarity (86%) was observed between 795 and PN-721 and SI-63-007 and V-99. Thus these genotypes showed maximum degree of similarity in their genetic makeup. However the minimum values were observed between SE-69-002and 84/11 (0.71) followed by SE-69-002 and 17-93-A (0.72). RAPD and SSR analysis proved helpful for estimating the magnitude of genetic diversity at molecular level. The clustering further indicated that the geographic distribution may not be the true index of genetic diversity in willow clones. On the basis of banding pattern RAPD's and SSR's were effectively used for molecular characterization of willow clones used in this study.

Keywords: RAPD, SSR, willow, molecular diversity, characterization.

[1] Department of Tree Improvement and Genetic Resources, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan. HP 173230, India. E-mail: nbsuhf@rediffmail.com

ID-163

BREEDING *SALIX* AS A MULTI-FUNCTIONAL CROP FOR BIOMASS, BIOENERGY AND ENVIRONMENTAL APPLICATION

Raju Y. Soolanayakanahally[1] and William R. Schroeder[1]

Willow (*Salix Spp*.) breeding programs around the world have achieved substantial yield increases through intra/interspecific hybridization and clonal selection. In Canada, with ever growing interest to use willow as multi-purpose crop, the focus has been to use native willow species, mainly *Salix eriocephala*, *Salix discolor*, *Salix interior*, *Salix bebbiana*, *Salix amygdaloides* and *Salix petiolaris*.

The willow breeding program at Agroforestry Development Centre (ADC) of Agriculture and Agri-Food Canada follows traditional strategies of selecting superior genotypes from genetically diverse base populations of native willow species. Some of the screening challenges include suitability of genotypes for both adaptive (cold hardiness, phenology, water- and nutrient-use efficiency) and productive traits (photosynthetic rates, coppicing ability, shrub architecture, wood characteristics, herbivore and disease resistance) with the aim to develop feedstocks that can deliver environmental benefits in addition to providing renewable energy. Since 2005, a total of 50 populations (~1000 distinct genotypes) have been assembled and planted into a common garden. Controlled crossing were carried out in 2008, 2009 and 2011 to generate several intra/interspecific families and the seedlings were planted into seedling nursery trails for further evaluations.

Keywords: willow, breeding, biomass, environmental application, agroforestry, bioenergy.

[1] Agroforestry Development Centre, Science and Technology Branch, Agriculture and Agri-Food Canada, Indian Head, Saskatchewan, S0G 2K0 Canada. E-mails: raju.soolanayakanahally@agr.gc.ca; schroeder.bill@agr.gc.ca

ID-046

MACRO- AND MICRO-PROPAGATION OF *POPULUS GAMBLII* DODE

Ajay Thakur[1], M. Maqbool Rather, Monika Panwar and Puran Chandra

Poplars are well known for their fast rate of growth and a variety of industrial uses, but they are quite choosy about site requirements. *Populus gamblii* Dode grows naturally within an extremely restricted area in the lower hills of North Bengal at latitude 27° 5' N parallel and elevation of 600-1100m which is mimimum for native poplar of India. A single specimen of this tree is growing in the Forest Research Institute Campus.

In the present study, two vegetative propagation techniques were investigated: (i) macro-propagation using cuttings of different thickness in different media combinations, (ii) micro-propagation (*in vitro* propagation) using shoot tip explants. The experiments were carried out during the month of November 2011 in the mist chamber with temperature maintained between 25 - 27°C along with 80% relative humidity. From the different media combinations like: vermiculite; sand + soil + FYM (1:1:1 ratio); cocopeat and cocopeat + FYM (1:1 ratio) for rooting of cuttings, cuttings of middle position with size varying from 10-20 mm planted in vermiculite proved to be best medium as maximum number (70%) followed by similarly thick cutting in coconut peat + FYM (1:1 ratio) with 50% response**.** *In vitro* experiments were conducted using Murashige and Skoog (1962) basal medium. Explants were surface sterilized using different sterilants like sodium hypochlorite (4 % available chlorine) and mercuric chloride in various concentrations and different time durations. The treatment of explants with 0.1% $HgCl_2$ for 7 minutes was found best, resulting into maximum number of contamination free viable cultures. The effect of MS supplemented with different concentrations of BAP on culture establishment was investigated. A preliminary investigation revealed that MS supplemented with 3 BAP gave higher frequency of bud break. The experiments are still going on.

Keywords: macro-propagation, micropropagation, Murashige and Skoog media, sterilants, BAP (6-Benzylaminopurine).

[1] Department of Tree Improvement and Genetic Resources, Dr Y S Parmar University of Horticulture and Forestry, Solan (HP). India. E-mail: sthakur.tigr@rediffmail.com

ID-154

GENETIC IMPROVEMENT OF HIMALYAN POPLAR (*Populus ciliata* Wall ex Royale)

Sanjeev Thakur[1], D. K. Khurana[2], N. B. Singh[1] and J. P Sharma[1]

Populus ciliata, commonly known as Himalyan poplar, is a native of Western Himalayas. It is an important poplar for hilly regions. The species is preferred in lightwood industry, serves as windbreak for orchards and as nurse crop for silver fir regeneration. The species is distributed in the temperate zone from 1,800 m to 3,000 m above sea level. The improvement programme on this species is undergoing since 1976 in the Department of Tree Improvement and Genetic Resources. The study of reproductive biology of *Populus ciliata* revealed that the species is dioecious with male to female ratio of 3:2 with rear occurrence of switching of sexes. Pollination is by wind occurs 15 days after floral bud break up with receptivity period of female catkin to be 2-3 days. Pollen reduces viability rapidly. Fruit ripens in May-June.

Provenance trials as well as half sib trials revealed that variation pattern in different growth characters in different provenances was both controlled by environmental and genetic factors. Plus tree selection started in 1984-86, during which period 22 plus trees were selected for fast growth and 15 for rust resistance. Later on, 84 plus trees were marked from area of distribution zone in the Himalayas with the help of Forest Departments of different states. Data on half sib progeny at nursery stage revealed that highest seedling growth was in Narkanda-1, followed by Amarchasma-2 and Thana-2. Field trial of best clones selected at nursery stage revealed non-significant height among the clones whereas diameter varied significantly among clones. Inter-specific hybrids between *Populus ciliata* and *P. maximowiczii* have been developed. The hybrid progeny has been evaluated at nursery and field stage and show better growth than *Populus ciliata*. Protocols have been developed for *in vitro* mass propagation of *Populus ciliata* and its hybrids. The genetic diversity among the half sib families and provenances of *Populus ciliata* has been studied through Isozymes, RAPD and AFLP markers.

Keywords: *Populus ciliata*, Himalyan poplar, genetic improvement, provenance testing, biotechnology.

[1]Department of Tree Improvement and Genetic Resources, Dr Y S Parmar University of Horticulture and Forestry, Solan (HP). India. E-mail: sthakur.tigr@rediffmail.com
[2]Teacher's Colony, Rajgarh Road, Solan (HP), India.

ID-057

STATUS OF POPLARS IN NEPAL: AN OVERVIEW

H.B. Thapa[1]

Two species of poplar are native to Nepal, *Populus ciliata* and *P. jacquemontiana* var. *glauca*. Mainly three species of exotic poplars have been introduced since the early sixties in Nepal from abroad, namely different clones of *Populus deltoides* cv., *Populus nigra* cv. 'Italica' and *Populus* x *euramericana* cv. 'I-214'. Two-stage propagation system is suitable and used for production of plants in the Middle Hills of Nepal. In community forestry and other small nurseries, the cuttings of poplars are produced in polythene bags. It is one of the most practicable methods for raising a few plants for use by farmers in the Middle Hills. For commercial scale poplar plantations, more elaborate nursery techniques are needed.

A number of institutions and projects were involved in poplar research in Nepal since mid-seventies. The Forest Survey and Research Office (FSRO), with support from different projects, carried out a number of poplar trials during 1975 to 1986 in the Terai, Mid Hills and High Hills of Nepal. Despite it, some other institutions also involved in poplar research in different years. The altitudinal range covered by the poplar research was from 150 m – 2550 m. The species used in research were *Populus ciliata*, different clones of *Populus deltoides*, *P. nigra*, and *P.* x *euramericana*. *P. ciliata* was tested at higher altitudes in different parts of Mustang and Myagdi Districts. Some of the major research areas are the identification of propagation techniques, suitable clone selection, local volume model developed for *P. deltoides*, wood properties in relation to foliar phenology of *P.* x *euramericana*, tissue culture of *P. ciliat*a, intercropping, and spacing trials. After 1992, very few research has been carried out in Nepal.

The indigenous poplar species have not been planted on a large scale, and little information is available on their performance in plantations. *P.* x *euramericana* cv. I-214 and *P. nigra* 'Italica' were planted as an avenue tree in Kathmandu valley. These species have been successful as an avenue trees in a number of localities in Nepal, but so far plantations in blocks have been unsuccessful. Now, most of these trees have been cut down a few years before due to road widening in Kathmandu valley. Different clones of *P. deltoides* were planted in different areas of some districts in the Terai and Mid Hills. Based on trials at Jogikuti, Rupandehi District, clones of *Populus deltoides* G3 and G48 from Australia, *Populus deltoides* S7/C1, S7/C4, S7/C8, S7/C15, S7/C20, D61, D67, D121 and 69/55 from America, and L39 which is a breed between G3 and G48 are suitable for planting in the Terai region of Nepal.

The formulation of policy, rules and regulations related to indigenous and exotic poplars, institutional support to farmers, establishment of industries based on poplar wood, regulatory mechanism for supply of certified nursery stock to the growers, subsidy for farmers for poplar cultivation and management, buy-back guarantee and government support in research are essential to promote poplar cultivation.

Keywords: propagation system, Nepal, Kathmandu valley.

[1] Department of Forest Research and Survey, Babarmahal, Kathmandu, Nepal. E-mail: thapa.hasta@gmail.com

ID-189

POSSIBILITY FOR DEVELOPING OF POPLAR TOLERANT TO DROUGHT IN THE REPUBLIC OF SERBIA

Branislav Trudić[1], Vladislava Galović[1], Saša Orlović[1], Saša Pekeč[1] and Bojana Klašnja[1]

On the territory of Serbia, especially in Vojvodina region, which is predominantly an agricultural region with over 75% of arable land, drought has negative impact on agricultural production. Taking into account the small distance between the northernmost and the southernmost points of Vojvodina, which is less than 2^0 of latitude, and the fact that the topographic structure is without major dissections, there are no great temperature differences between individual localities and districts. The annual precipitation in Vojvodina is between 550 and 670 mm (lower than 700 mm, which is an average value), which is the limit for the occurrence of natural forest vegetation, it is recommended to use primarily the xerothermic and thermophilous tree species, which have a well developed tap root. As a consequence of the insufficiently developed irrigation systems, the atmospheric precipitations are still the major factor in providing water to the soil for crops and trees.

Poplars are potentially the best option to increase biomass production in temperate zones, such as Vojvodina in the Republic of Serbia, but there is a need to identify clear objectives on how to use this material in the forestry wood chain. Characterization of the genetic background of poplar clones, using molecular markers systems, AFLPs and SSRs, was revealed and is one of the recent contributions of the Institute of Lowland Forestry and Environment from Novi Sad, to novel taxonomy for this type of woody plant species in Vojvodina province. To continue investigating further genomic information in *Populus* from Vojvodina, integrated genetic and gene expression data needs to be done, with phenotypic traits measured in populations of *P. deltoides* , *P. euramericana* and *P. nigra* species, which are pretty common for Vojvodina and in some parts of Western Balkans. Major challenges of future poplar breeding programmes in Vojvodina include continuous genetic gains for recognized economic traits while addressing new breeding goals and optimization of large-scale deployment of the selected genetic variation to limit economical and environmental risks associated to clonal forestry. To meet these demands for both adaptive and productivity traits, poplar breeding programmes in Vojvodina require more optimal short- and long-term management of genetic diversity. Drought is still causing negative environmental and economic consequences in the region of Vojvodina province and decision makers need to improve planning of mitigation practices and future sustainable forestry management on molecular level, especially for one of the most important woody plant species for that particular Serbian region - the Poplar species.

Keywords: drought, genes, poplars, Vojvodina province.

[1] Institute of Lowland Forestry and Environment, University of Novi Sad, Antona Čehova 13, 21000 Novi Sad, Republic of Serbia. E-mail: btrudic@uns.ac.rs

ID-077

NEW *P. × CANADENSIS* CLONES FOR WOOD INDUSTRY AND BIOMASS PRODUCTION SELECTED IN ITALY

L. Vietto[1], G. Facciotto[1], A. Giorcelli[1], G. Allegro[1], G. Castro[1], G. Nervo[1] and S. Bisoffi[2]

Activities carried out at the Research Unit for Intensive Wood Production (CRA-PLF) are chiefly aimed at developing new poplar clones characterized by fast growth, high wood production and others important characters such as adaptability to different environments and soil conditions, resistance to disease, wood quality for several purposes. Breeding strategies planned in the '80s, based on a semi-reciprocal recurrent selection of *P. deltoides* and *P. nigra*, aim at producing improved populations of both species and getting *P. ×canadensis* hybrids.

Inter-specific crossings were carried out in the first stage of the program using a poly-cross and common tester methods to evaluate *P. deltoides* females and *P. nigra* males respectively. Clones obtained by 1983 and 1984 crossing activities were evaluated in nurseries and in the first stage selection stands starting from 1992 in different localities of Northern and Central Italy, according to a complete randomized design with plots of 1to 9 plants/clone. As a result of the first selection, 22 clones were chosen for the best growth rate, rooting capability, diseases and pest resistance and were evaluated in three sites across Italy, in a second stage of selection stands, starting from 1997. A pool of 9 clones characterized also by the best plasticity of growth, stem straightness and canopy architecture were proposed to the National Poplar Commission and further evaluated in three different sites on the Po Valley with the aim to get information on the quality and technological wood characteristics. As some of these clones are widely appreciated in Italy, France, Spain and other European Countries, a grant of Community Plant Variety Rights was requested and obtained for three clones suitable for wood industry ('Aleramo', 'Diva', 'Tucano') and for two clones to be used in short-rotation coppice for biomass and particles panels production ('Orion', 'Imola').

Keywords: breeding, poplar, clonal selection, growth rate, diseases resistance, wood quality.

[1] CRA-PLF Research Unit for Intensive Wood Production of Agricultural Research Council, Strada Frassineto 35, I-15033 Casale Monferrato (AL), Italy. E-mail: Lorenzo.vietto@entecra.it. Tel: (+39) 0142 330900, Fax: (+39) 0142 55580.

[2] CRA - Consiglio per la Ricerca e la sperimentazione in Agricoltura, Via Nazionale 82, 00184 Roma (RM), Italy. E-mail: stefano.bisoffi@entecra.it

ID-074

LIGNIN MODIFICATION IMPROVES THE BIOFUEL PRODUCTION POTENTIAL IN TRANSGENIC *POPULUS*

Hongzhi Wang and Jianhua Wei[1]

Although lignin is the major structural component of the secondarily thickened cell walls of vascular plants with very important biological functions, it has been recognized for its negative impact on forage digestibility, tree pulping properties, and cellulosic biofuel production. Earlier studies have demonstrated that lignin modification improves forage digestibility and poplar pulping properties.

To determine whether lignin modification has beneficial effect on saccharification of lignocellulosic biomass, we pretreated and then enzymatically hydrolyzed the mature wood from transgenic poplar plants that expressed the antisense transgenes of monolignol biosynthesis genes 4-coumarate: CoA ligase (4CL) or caffeoyl CoA 3-Omethyltransferase (CCoAOMT). Firstly, a long-term field trial was set up for the transgenic plants. Over five years, the reduced trend of lignin content remained stable in all transgenic lines. And a total lignin reduction of up to 10% did not alter the growth rate or biomass yield of the transgenic poplars. In the mature wood, suppression of CCoAOMT increased saccharification potential, but 4CL down-regulation had no significant positive effect on saccharification. Sugar yield were negatively correlated with soluble lignin content of dried, extractive-free stem biomass.

These results imply that lignin modification can facilitate the process of saccharification for biofuel production in tree crops.

Keywords: digestibility, cellulosic biofuel production, pulping properties.

[1] Beijing Agro-Biotechnology Research Center, Beijing Academy of Agriculture and Forestry Sciences, Beijing, 100097, China.

ID-155

IDENTIFICATION AND CHARACTERIZATION OF GENES INVOLVED IN ADVENTITIOUS ROOT DEVELOPMENT IN *POPULUS*

Meng Xu, Wenfan Xie, Bo Zhang, Lei Xuan, Li'an Xu and Minren Huang[1]

Adventitious rooting is essential for the vegetative propagation of economically important woody species. A better understanding of the genetic and physiological mechanisms that promote or hinder rooting will enhance the potential for successful commercial deployment of trees. However, despite extensive physiological and anatomical studies of adventitious rooting, the genetic and developmental mechanisms that regulate this biological process are poorly understood. In this study, we used a genome-wide mRNA and microRNA analysis to quantify the temporal correlation between expression changes of genes and the initiation and progression of adventitious roots in a hybrid poplar, Nanlin895, derived from *Populus deltoides* (I-69) and *P. x canadensis* syn. *euramerican* (I-45). The main results were as follows: Using a nonparametric functional clustering approach, a total of 56,055 genes were categorized into 11 groups in terms of their expression trajectories. Some groups of genes are expressed consistently over time, although they display different extents of expression, whereas some are expressed, following a logistic curve as expected for root growth. It is interesting to find that the expression of some genes is periodic and exhibits an oscillatory behavior.

We cloned and characterized cDNAs of the two *Populus ROOT HAIR DEFECTIVE 3* (*RHD3)* genes, designated as *PeRHD3a* and *PeRHD3b*. Transcripts encoded by the two genes were detected in roots, stems, leaves and petioles. To characterize the cellular functions of the genes, *Agrobacterium tumifaciens* was used to transform poplar with a vector that places expression of the target gene under the control of the strong constitutive promoter, Cauliflower Mosaic Virus 35S (Pro35S) promoter. Both *PeRHD3a* transgenic lines and *PeRHD3b* transgenic lines showed very similar phenotypic characteristics. Overexpression of *PeRHD3a* or *PeRHD3b* in poplar plants resulted in the formation of only a single prominent adventitious root with well-developed lateral roots, characteristic abnormalities in the root tip, and longer and more plentiful root hairs.

We cloned and characterized the two *Populus WUSCHEL-related homeobox* (*WOX*) genes, *PeWOX11a* and *PeWOX11b*. Their full-length cDNAs were identified by RACE, and their promoter sequences were also obtained by Anchored-PCR, Inverse-PCR and TAIL-PCR. Transgenic vectors designed for over-expression, RNAi suppression and promoter GUS expression were constructed by Gateway system. Poplar ((*P. tremula*×*P. tremuloides.* clone T89) was transformed using *A. tumefaciens* strain EHA105 with these vector, respectively. Overexpression of *PeWOX11a* or *PeWOX11b* in poplar plants promoted more plentiful roots, and induced ectopic root formation in stem and leaf. The GUS staining showed that the fusion gene *PeWOX11a*::GUS was specially expressed in the root primordia and meristem of transgenic lines, while the fusion gene *PeWOX11b*::GUS was specially expressed in the hypocotyls of transgenic lines, which is related to adventitious root occurrence.

Keywords: adventitious rooting, ROOT HAIR DEFECTIVE 3 (RHD3), WUSCHEL-related homeobox (WOX), transgenic poplar.

[1] Jiangsu Key Laboratory for Poplar Germplasm Enhancement and Variety Improvement, Nanjing Forestry University, Nanjing 210037, China.
Key Laboratory of Genetics and Biotechnology, Ministry of Education, Nanjing Forestry University, Nanjing 201137, China.

TRANSCRIPTIONAL PROFILING ANALYSIS OF *POPULUS EUPHRATICA* IN RESPONSE TO SALT STRESS

Shutang Zhao[1], Jiafei Chen[1], Chunguang Du[2] and Mengzhu Lu[1]

Soil salinization is one of the major abiotic factors causing environmental problems and limiting the productivities of the main food crops worldwide. With the completely decoded genome sequence, *Populus* has been choosed as the model system for tree research, and among at least 35 species of this genus showing different stress tolerance, *Populus euphratica* seems to be a promising candidate for stress-tolerant study . With the availability of whole-genome poplar arrays, it is possible to conduct a genome-wide transcriptional profiling analysis of *P. euphratica* in response to salt stress, and to further identify salt-resistant genes and reveal underlying metabolic pathways involved in the process of salt response.

P. euphratica seedlings planted in soil-filled pots were subjected to 400 mM and 600 mM NaCl solution, respectively. Apical shoot stems with the top five young leaves were sampled at 6, 12, and 24 hours after exposure (HAE) to salt solutions, and plants with non-NaCl treatment were collected as controls. 11708 transcripts, approximately 19% of the all probesets on the Affy poplar genome microarray, were identified with significant changes. Result from microarray analysis was confirmed with a highly validated rate of 86.4% via quantitative real-time PCR. The result from time-course analysis demonstrated a similarly dynamic trend between 400 and 600 mM treatments. For direct comparison to control, 677 up- and 1001 down-regulated transcripts were consistently remarked from all three time points in both treatment. The metabolic function of congruously regulated genes mainly referred to cell wall, major and minor carbohydrates, starch and sucrose, amino acid, TCA-glycolysis and photosynthesis. Genes related to regulation, cellular response and transport were also concerned in the process of salt response, with special emphasis on transcription facors and miRNA targets. For the former, 939 putative transcription factors belonged to more than 30 families, which were primarily involved in AP2/ERF, bHLH, bZIP, HD-ZIP, MYB, WRKY, NAC *et al*., were identified with different profiling within 24 AE.

These data demonstrate that *P. euphratica* exhibits level-dependent transcriptional profilings in response to salinity stress. Function classification revealed that many of these genes were involved in metabolism, cellular response, transport, and specially regulation such as transcription, hormone *et al*.. Genes identified with different expression patterns between diverse salinization level are desired candidates for further function verification to understand more complicated molecular mechanisms of saline differences in plant salt response.

Keywords: *Populus euphratica*, salt tolerance, differentially expressed genes.

[1] State Key Laboratory of Tree Genetics and Breeding, Chinese Academy of Forestry, Beijing, PR. China. E-mail: lumz@caf.ac.cn

[2] Department of Biology and Molecular Biology, Montclair State University, Upper Montclair, NJ, U.S.A. E-mail: duc@mail.montclair.edu

ID-176

POPLAR - A MULTIFARIOUS TREE SPECIES FOR WOOD INDUSTRIES, RURAL LIVELIHOODS AND NATURE CONSERVATION

Gulshan Ahuja[1]

In India, the role of 'Trees Outside Forests' (TOFs) in supplying timber and other products, livelihood generation and carbon sequestration is well established. Amongst several tree species grown outside forests, poplars have made a significant contribution in this regard. They have proved to be a potential resource for socio-economic development in industrial and rural India and have also made a phenomenal contribution in carbon sequestration and hence combating the climate change. The farmers in poplar grown areas of the country have very conveniently adopted poplar agro-forestry on farmlands. Technology based innovative Poplar Agroforestry Plantation Models with genetically improved, high yielding clonal poplars on farmlands, have played an important role in India in meeting the growing needs of industrial timber on substantial basis, saving thereby precious forests. This has generated a multiplier effect on industrial and rural economy through raising of poplar woodlots, development of wood-based industries and generation of rural livelihoods. The improvement of soil fertility, conservation of bio-diversity, sequestration of carbon and generation of bioenergy have been other ecological and economic attributes of growing poplars on farmlands. Annually, about 50 million poplars are raised under agroforestry plantations in India, covering nearly 30,000 hectares and yielding 3.6 million cubic meters of wood every year. Thanks to India's 1988 National Forest Policy, the majority of the veneer, plywood and paper-pulp units are now largely dependent on farm-grown poplars and other fast-growing species raised under agroforestry. It has been well understood that expansion of poplar agroforestry plantations is critically important to ensure abundant supply of raw material to wood-based units, improvement in livelihood security, carbon sequestration, and overall socio-economic and environmental development.

This paper examines the development of poplar-based agroforestry in India and its impact on development of wood-based industry, creation of livelihoods for the stakeholders and conservation of nature and natural resources. It also suggests corrective policy and administrative measures to ensure the sustainability of poplar-based agro-forestry.

Keywords: agroforestry, Trees Outside Forests (TOFs), carbon sequestration, rural livelihoods, biodiversity conservation.

[1] Indian Forest Service, Department of AYUSH, Near Youth Hostel, Sector-3, Panchkula (Haryana), India. E-mail: gulshakumar@gmail.com, Fax: 91-172-2570919

ID-113

SEXUAL REPRODUCTION OF *POPULUS CASPICA* BORNM. FOR PRODUCTION OF SUITABLE SEEDLINGS

F. Asadi[1] and H. Mirzaie-Nodoushan[2]

Populus caspica Bornm is considered as an endangered species without proper sexual reproduction in natural conditions in the north region of Iran. In contrast to other poplar species, there is little knowledge on white poplar regeneration. The trees yearly disperse plentiful of short-lived tiny seeds that need the suitable conditions and substrates to germinate and grow. Usually, the required conditions are not available in its natural habitats.

The study was carried out to consider the problem. Therefore, for mass production of seed-born seedlings and broadening genetic basis of the species, matured capsules were collected on 25 single trees, distributed at different sites in Golestan, Mazandaran, and Gilan provinces in early April 2010. Sixteen of the 25 trees produced suitable and enough seeds. After well sifting, 30 seeds of each tree were sown per pot at three different soil treatments, including: (1) only nursery soil, (2) combination of nursery soil and fine sand (wind shifting sands), and (3) only fine sand, as well as three light direction treatments including: (1) Eastern side, (2) Southern side and (3) Western side of a large building for 16 provenances. The experiment design was factorial model-based on Completely Randomized Block Design with three replications. Pots were kept in large basins and irrigation was done daily in basin and pots. Weed control was done at different dates at growing season. Height of all seedlings was recorded at the end of THE growing season.

The results of analysis of variance showed significant differences between all sources of variance. Soil treatments caused 113, 57 and 0 cm in seedling height, respectively as mentioned above. Significant differences were observed between the mother trees based on their seedling height. The results indicated that the progenies of Zarringol2, Zarringol3, Kenesy and Golestan4 trees revealed 111.39, 98.94, 98.89 and 94.28 cm in height respectively as the longest one, so that 11 groups were specified among the16 mother trees. Significant differences between the direction treatments were observed so that the seedling height of 87.63, 87.33 and 81.43 cm were recorded for eastern, southern and western directions, respectively. As a main result the study showed significant differences for height in soil, mother trees and light direction treatments. Therefore, mass seed-born seedling production for the species would be possible by using the best treatments of the study.

Keywords: *Populus caspica*, sexual reproduction, seedling production, height growth.

[1] Research Center of Agriculture and Natural Resources of Mazandaran Province, Chamestan, Iran. E-mails: fasadi@rifr-ac.ir ; farhadasadi14@yahoo.com
[2] Research Institute of Forests and Rangelands (RIFR), Tehran, Iran.

ID-115

POPLAR GROWTH CHARACTERISTICS IN RIVERBANKS OF KERMANSHAH PROVINCE

F. Asadi[1] and F. Nouri[2]

More than one million cubic meters of black poplar wood is produced annually in different areas of Iran. Therefore, an estimation of poplar annual growth in artificial stands has been required to evaluate the potential of wood production at different areas. Due to harvesting operation in middle age trees in some poplar stands, an estimation of the wood volume which was harvested in previous years is necessary and would be added to final production.

In this research, we selected eight planted stands in marginal areas of different rivers of Kermanshah Province. Then, 7 to 18 sample plots were established according to the surface of each stand. In total, 2,040 black poplar trees of various sizes were sampled in 102 sample plots. In each plot, we measured DBH, height, wood volume per hectare under two conditions: (1) according to primary tree number per hectare, and (2) final tree number per hectare and volume growth. Meanwhile, statistical analyses have been done for the data.

Results showed that the annual growth for the 4th and 6th stands was between 32.8–105m^3 in primary tree number per hectare (1st condition) and 10.3-38m^3 for same stands in final tree number per hectare (2nd condition) so that the annual growth for the 6th stand was more three times that of the 4th stand. Differences in amount of volume growth, height and diameter between stands can be affected by tree spacing, genetic characteristics or site conditions. However, the matter requires more research. As a final result, due to low spacing in planted poplar stands, full callipering is not adequate and we have to use sampling methods. We suggest more than 5 percent in inventory to access the suitable number of sample plots and the best confident interval.

Keywords: poplar, volume per hectare, growth per hectare, Kermanshah.

[1] Research Center of Agriculture and Natural Resources of Mazandaran Province, Chamestan, Iran. E-mail: fasadi@rifr-ac.ir and farhadasadi14@yahoo.com

[2] Research Center of Agriculture and Natural Resources of Kermanshah Province , Kermanshah, Iran.

ID-153

VOLUME ESTIMATION OF *POPULUS DELTOIDES* BARTR. PLANTATIONS THROUGH ALLOMETRIC EQUATIONS UNDER RAINFED CONDITIONS OF NORTH WESTERN HIMALAYAS

R. Banyal[1], Sohail Ahmad Wagay and N.A. Masoodi

Poplar (*Populus deltoides*) has gained considerable importance under agroforestry plantations, especially Punjab, Haryana, Uttarakhand, Uttar Pradesh and Jammu & Kashmir States of India, mainly due to its deciduous nature, fast growing habit, adaptability to different environmental conditions and silvicultural systems and above all high industrial demand. This all enables the production of large quantities of wood in short period of time. Poplars make an appreciable and significant contribution in the landscape and economy of Kashmir province because it is the mean for livelihood to rural as well as urban habitation. During the last few decades, massive plantations of poplar were done to boost the economy of the region besides meeting out the demand of fruit boxes for apple and other fruits. The plantation of poplar was done on roadside avenues (green tunnel), available blank areas, and boundaries of agricultural fields, parks, orchards, home gardens and in the demarcated forests in the valley.

Individual forest stand owners and family farmers need to quantity the amount of wood (total biomass) they have for the sale in the market to satisfy their livelihood. So, the attention has been paid for the development of allometric techniques which estimate tree biomass from easily measured tree characteristics and to avoid the necessity of destructive sampling to great extent. Therefore, the study was conducted by the Faculty of Forestry in Shuhama campus of Sher-e-Kashmir University Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J&K by aiming at deriving the best fit model for *Populus deltoides* growing under rainfed condition in temperate region of North Western Himalayas of Jammu & Kashmir. Four regression models were tested *viz*. linear, non-linear, curvi-linear and logarithm for volume estimation and construction of local volume table. The model recommended for estimating volume is based on DBHd height because of the simplicity, easy to measure and the most common variables recorded in forest inventories. In general, the curvilinear equation with R^2 (0.94), RMSE (0.039) and χ^2 (0.043) gave the best results, followed by logarithmic with R^2 (0.9583), RMSE (0.105) and χ^2 (0.912). Therefore, the curvi-linear equation may be beneficial to get higher precision for predicting the volume of standing *Populus deltoides* trees under rainfed conditions. The best fit equation developed for volume estimation is curvi-linear ($V=0.039+0.011dbh+0.013H^2$) with DBH and height as independent variables. The non-linear model stands at bottom as compared to other models. The equation for logarithmic model is log V = 9.608 + 2.539 log (dbh) stands second in final rank order. The other developed equations are Volume = 0.541 + 0.038 (dbh) and Volume = 0.0016 x $(dbh)^{1.713}$. The equations derived may be used to develop volume tables or entered into a computer program to facilitate computer volume calculations for cruise data under temperate region of North Western Himalayas.

Keywords: poplar, volume, regression equation, model, rainfed, temperate, North Western Himalayas

[1] Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Camp Wadura, Sopore (J&K), 193 201, India. E- mail: drbanyal08@gmail.com ; rbanyal08@yahoo.co.in

ID-117

COMPARISON BETWEEN POPLAR AND WILLOW SRC WITH TWO DIFFERENT HARVESTING CYCLES FOR BIOENERGY PRODUCTION

Sara Bergante[1], Gianni Facciotto, Laura Rosso and Giuseppe Nervo

Poplar and willow are largely utilized in Europe for heating and power co-generation production in power plants but during the last year, in Italy, a new technology allows the bio-ethanol extraction from *Salicaceae* as second generation biofuels. Good extraction performances are reached in case of high cellulose and emi-cellulose and low lignin content in wood. During the 2005 spring, three Short-Rotation Coppice (SRC) experimental plantations with poplar (*Populus* ×*canadensis* '83.141.020'), and willow (*Salix matsudana* hybrid) have been established in Northern Italy, to compare and test the two most common cultural models utilized in Italy: 2-year rotation with very high density (8,333 trees·ha^{-1}) VHSRC, and 5-year rotation with high density (1,667 trees·ha^{-1}) HSRC. A Split-plot design with three replications was utilized in each site. The species was assigned to the plot and the density to the sub-plots. The fields were ploughed (30 cm of depth) and harrowed before planting. Machine planting was done in spring using 1-year-old nursery sets for HSRC and unrooted cutting, 20 cm of length, for VSRC. To control weeds, active residual herbicides were applied immediately after planting only in VSRC. Disk-harrowing was carried out twice only in the first year of growing; then only one mechanical weeding per year was done. After each harvest, a chemical weed control treatment was applied. Irrigation has been made each growing season in only two sites. For every year of growth, survival and growth have been measured. Above-ground biomass production (stem and branches) was estimated via non-destructive measurement methods during rotation and measured at the harvest time. A regression model was utilized for every species, to correlate diameter at breast height and dry weight. Data were statistically analysed, using power regression equations, analysis of variance (ANOVA) and range test.

Results show that, generally, the HSRC with poplar is the most productive model during the first six years after establishment. The differences between the two cultural models are not statistically significant for willow. In Casale Monferrato and Cavallermaggiore, the "5-year rotation model", at the end of five years, shows the best performances in survival and production values (average of dry biomass are respectively 13 and 17 t ha^{-1} year^{-1}). The growth curve shows that in HSRC poplar increase is continuous during the 5 years of rotation. Moisture content and specific gravity are variable depending on species and genotype: for willow, they are respectively 48.5% and 0.41 g cm^{-3}, while for poplar they are 57.6% and 0.35 g cm^{-3}.

The two models request different tending operations, particularly during establishment and harvest; beside the wood produced has different quality. With VSRC it is possible to produce chips for energy or particles boards, while with HSRC it is possible to produce logs for packaging or pulp and paper. The farmer can choose the model according to farm characteristics (machineries availability), planting material costs and wood market requests.

Keywords: poplar, willow, SRC.

[1] Consiglio per la Ricerca e la Sperimentazione in Agricoltura (CRA), Unità di Ricerca per le Produzioni Legnose fuori Foresta (PLF). St. Frassineto Po 35, 15033 Casale Monferrato (AL), Italy. E-mail: sara.bergante@entecra.it. Tel: +39 0142 330960 Fax: 0+39 0142 5558.

ID-069

THE POPLAR AND WILLOW SECTOR IN UZBEKISTAN

E.K. Botman[1]

Environment conditions and species composition of the forests in Uzbekistan do not cover the national needs in wood. While the requirements are about 10 million m^3, the annual volume of cutting does not exceed 50,000 m^3. Poplars and willows are the unique source of industrial wood.

In Uzbekistan, poplar stands on State lands occupy around 28,000 ha, of which willow stands cover around 1,300 ha and mixed stands of poplars and willows cover around 12,000 ha, the other areas under these species being artificially-created plantations. The most part of natural poplars forests (*P. euphratica*, *P. uzbekistanica* Kom, *P. bachofenii* Wierzb.) and willows (*S. songarica* Anders, *S. niedzwieckii* Gorz, *S. wilhelmsiana* M.) are riparian forests located along the rivers. As a rule there are protected territories in which cuttings are forbidden.

Imported wood is inaccessible to the majority of local population because of the high price. Therefore the only real possibility to satisfy, at least partially, the demand of the population and industry is to cultivate poplars and willows in the country.

In Uzbekistan it is possible to grow these species under artificial irrigation only. Now all irrigated arable land is given to farmers-tenants. The significant majority of them specialize on cultivation of cotton and grain and their lands are intended for producing these agricultural crops. As a rule farmers can grow up trees on strips along irrigation and road network only. At the same time many farmers would like to grow up poplars in greater scale. However both a legal basis and a programme of agroforestry development do not exist, in which poplars and willows are usually the main species.

The State Forest Fund occupies almost 20% of the country territory and has significant land areas suitable for afforestation. However forestry does not have quota on water for irrigation. Meanwhile there is an accrued demand for wood in the country, both for local population and for the industry. Though there is a Governmental decree about development of fast-growing tree species cultivation, this decision is not carried out in full scale in absence of intersectoral interaction.

Keywords: poplar, willow, natural stands, riparian forest, artificial stands, demand on wood, agroforestry, agricultural irrigated lands, State Forest Fund.

[1] Republican Scientific Production Centre for Decorative Gardening and Forestry, 111104, Darhan w., Zangiota district, Tashkent region, Uzbekistan. E-mail: darhanbek@yandex.com

ID-203

THE USE OF *POPULUS DELTOIDES* `HARVARD´ AS ENERGY SOURCE

J. Bustamante[1], D. Funes[1], M. Clausen[2], and M. Barbeito[2]

The cultivation of Salicaceae in high density and short cycles of cut, as source of biomass for the further transformation in energy, has been a fact in many countries for some years.

In Mendoza, Argentina, a trial was carried on with poplars planted with the above characteristics. The aim was to evaluate clones behavior, productivity and energy characteristics of the produced biomass. One of the two tested clones of poplar was *Populus deltoides* 'Harvard´. Woody cuttings of 30cm of length were used as planting material, at densities of 10,000 and 20,000 plants ha^{-1} and were harvested above-ground biomass in cut cycles of two years.

At the end of the first rotation cycle, it was determined on stems: superior caloric power, fixed carbon, volatile material and ashes in wood and bark separately.

The values determined for wood are: caloric power 4.605 $cal.g^{-1}$; volatile material 91,95%; ashes 0.51%; fixed carbon 5.12%; humidity 2.42%. For bark: caloric power 4.506 $cal.g^{-1}$; volatile material 81,47%; ashes 5,04%; fixed carbon 11,06%; humidity 2,43%. All percentages are weight to weight.
For this reason and estimating a dry biomass production according to average weight of harvested plants, for a density of 20,000 $plants.ha^{-1}$ of 30 $tons/ha^{-1}.year^{-1}$, we can reach an energy production of approximately 578 $GJ.ha^{-1}$ por $año^{-1}$.

Keywords: biomass, poplars, energy crops.

[1] Instituto Forestal, Facultad de Ciencias Agrarias, Facultad de Ingeniería, Universidad Nacional de Cuyo. Almirante Brown 500 Chacras de Coria. M5528AHB.Mendoza, República Argentina. E-mail: jbustamante@fca.uncu.edu.ar
[2] Dirección de Estudios Tecnológicos e Investigaciones (DETI), Facultad de Ingeniería, Universidad Nacional de Cuyo. Almirante Brown 500 Chacras de Coria. M5528AHB.Mendoza, República Argentina.

STEM DIAMETER AS AN ESTIMATION OF FRESH WEIGHT IN ENERGY CROPS OF *SALIX BABYLONICA X SALIX ALBA* `RAGONESE 131-27 INTA´

J. Bustamante[1], S. Pérez[1], J. Llera[1], and P. Zanetti[2]

In the development of energy crops with trees, having an indicator that allows us to estimate the biomass weight produced at a certain time of the crop cycle gives us a valuable information for the planning of the use of that biomass.

In Mendoza, Argentina, it was carried on a trial with trees planted at densities of 10,000 and 20,000 plants ha^{-1}, thinking of making its use in cut cycles of two years. The aim was to evaluate the behavior of the species, productivity and some characteristics as raw material for the use as energy source.

Salix babylonica × *Salix alba* ´Ragonese 131-27 INTA´ is one of species and clones tested. At the time of harvesting, at the end of the first rotation, the fresh weight of each stem was determined, as well as the diameter at cut height, 60cm and 100cm, in order to determine if the values of these variables had any relationship between them and therefore the diameters could be used as estimators of the fresh weight of the biomass contained in these stems.

The results determine the following models of estimation of fresh weight (FW) in grams of stems, according to: its diameter (in mm) at the base (BD): $FW = 0{,}049.\ BD^{2{,}78}$; its diameter (in mm) at 60cm (D60): $FW = 0{,}35.\ D60^{2{,}32}$ and its diameter (in mm) at 100cm (D100): $FW = 1{,}58.\ D100^{1{,}91}$. The first two models with a $R^2 = 0.96$ and the last with a $R^2 = 0.93$.

We can conclude that the diameters of the stem, at cut height 60cm and 100cm, are good estimators of the fresh weight of stems.

Keywords: energy crops, Salicaceae, biomass estimation.

[1] Docentes investigadores, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo. Almirante Brown 500 Chacras de Coria. M5528AHB Mendoza, República Argentina; E-mails: jbustamante@fca.uncu.edu.ar; sperez@fca.uncu.edu.ar; jllera@fca.uncu.edu.ar

[2] Personal de apoyo., Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo. Almirante Brown 500 Chacras de Coria. M5528AHB Mendoza, República Argentina

GROWTH COMPARISON OF *POPULUS EUPHRATICA* PROVENANCES IN THE SALINE SOILS OF THE GARMSAR DESERT STATION, IRAN

Mohsen Calagari[1]

Populus euphratica Oliv. is a native species in arid, semi-arid and desert lands of Iran. Also, it has high potential for afforestation in arid and desert lands. The purpose of this study is to evaluate the growth characteristics of *P. euphratica* provenances in order to introduce the most suitable species for plantation in saline and desert lands.

The cuttings of 16 *P. euphratica* provenances were planted, based on randomized complete block design (RCBD) with three replications under saline soil (Ec= 7.3 $ds.m^{-1}$ and pH=8.1) in the Garmsar desert station. Each provenance was planted in plots consisting of 15 cuttings (0.3 m spacing between rows and 2 m inter-row distances). Growth characteristics of the trees, including survival percentage, collar diameter, height and specific leaf area (SLA), were measured. Analysis of variance of growth characteristics showed that survival percentage, height, collar diameter en SLA variables had significant differences among Euphrates poplar provenances. Results of Duncan's test showed that provenances of Golestan, Khojir, Kerman, Kashan and Dezful had high collar diameter and height growth. Also salinity had negative effect on height variable. Finally, provenances mentioned had suitable potential for planting in soil salinity lands and desert climatic of Garmsar.

Keywords: Garmsar, growth characteristics, *Populus euphratica*, provenance, saline soil,

[1] Research Institute of Forests and Rangelands, P.O. Box 13185-116, Tehran, Islamic Republic of Iran. E-mail: calagari@rifr-ac.ir

ID-032

EVALUATION OF HYBRID POPLAR (*POPULUS EUPHRATICA* x *POPULUS ALBA*) FOR GROWTH CHARACTERS IN SALINE AND NON-SALINE SOILS OF IRAN

Mohsen Calagari[1]

P. euphratica and *P. alba* trees are native poplar species of Iran. *P. alba* for adaptibilty, wood production and straightness of stem form, and *P. euphratica* for resistance to drought and salinity, were chosen as parental species in poplar breeding. The purpose of this study was to evaluate the growth of two native species and their hybrid (*P. euphratica* x *P. alba 44/9*) under saline soils of the Garmsar desert station (Ec=7.3 $ds.m^{-1}$ and pH=8.1) and non-saline soils of the Alborz research station (Ec < 1 $ds.m^{-1}$ and pH=7.7).

One-year-old rooted cutting was planted with 3×3 m spacing based on randomized complete block design with three replications in March 2010. Growth characteristics of the trees, including survival percentage, diameter at 0.5 m above ground level, height (at the end of growth season), leaf area, specific leaf area (SLA) and leaf thickness (in the middle of growth season) were measured. Analysis of variance of growth characteristics showed that survival percentage, height, diameter, leaf area and SLA had significant differences between poplar clones and experimental fields. But leaf thickness was not significantly different. The hybrid clone had no significant differences between saline and non-saline soils for survival percentage, diameter and height variables. The hybrid clone had the highest survival percentage, diameter, height and leaf area values with 100, 3.5 cm, 2.7 m and 49 cm^2 respectively, in saline soils of Garmsar, while *P.alba* 44/9 had the lowest values with 70, 0.72 cm, 0.65 m and 12.1 cm^2 respectively. Finally the hybrid clone had suitable potential for wood production and resistance to salinity in the Garmsar region.

Keywords: growth characteristics, hybrid, *Populus euphratica*, saline soils.

[1] Research Institute of Forests and Rangelands, P.O.Box 13185-116 Tehran, Islamic Republic of Iran. E-mail: calagari@rifr-ac.ir

ID-033

SILVOPASTORAL SYSTEMS WITH *SALIX* IN THE LOWER DELTA OF THE PARANÁ RIVER (ARGENTINA)

Edgardo Casaubon[1]

The genus *Salix* is native to the Southern hemisphere. In Argentina, it can be found along the river and stream banks down to the 45th parallel. It is the most widely planted genus in the lower Delta of the Paraná River (60,000 hectares). The main use for *Salix* wood is for pulp and particle boards, as well as fruit, vegetable and meat boxes. However, it has a high potential for solid wood use. It is estimated that 5 to 10% of *Salix* wood is apt for this use. This option calls for a kind of silvicultural management other than traditional management. Also, beef cattle contribute to *Salix* cultivation by minimizing the large amount of grass growing spontaneously under the trees, thus reducing the possibility of forest fires, especially during long droughts. Currently, silvopastures under willow plantations, designed for wood production for several uses, not only provide shade, shelter and food for cattle, but also produce beef to meet the demand from both domestic and international markets. Silvopastures are thus a useful diversification option for small, medium and large farms.

The larger quantity of beef cattle over the past five-year period has led to the need to move from the traditional plantation system to a more intensive production system with the aim to achieve a comprehensive production of wood, grass and beef. With a focus on forest activity, the use of one-year-old and two-year-old pole cuttings without roots is suggested, especially for *Salix babylonica* x *Salix alba* *`131/25´* and for *Salix babylonica* x *Salix alba* `131/27´ grown in nurseries, at spacings larger than traditional ones (0,80x0,80 m) between mother strains, and larger spacings in stand (4x4 m and 5x5 m), controlling phreatic zone water depth by means of phreatic water level meters, keeping drainage networks clean in order to avoid stagnant water, and facilitating rainwater drainage during periods of heavy rain and the incoming of river water during droughts, thus improving the quality of water in drainage networks to be drunk by cattle, with an adequate availability for forage and tree growth.

This new silviculture accelerates silvopasture establishment with cattle introduction at the third year after planting, facilitating natural grass consumption as well as the simultaneous production of beef and wood for multiple uses. This also contributes to individual plant growth with a higher percentage of cylindrical shafts, lengthens the planting period (May-August), and boosts spontaneous forage and wood quality as dark stains caused by excess water are reduced, and the number of dead standing trees is also reduced for the same reason. There is less competition among plants, and fire risk is lower since there is less dry grass due to the wide availability of water in the drainage networks and for cattle to drink. It also increases the diversity of animals and plants associated with water availability.

Keywords: *Salix spp, Salicaceae*, silvopastoral systems, Lower Delta, Paraná River, Argentina.

[1] EEA Delta del Paraná (INTA). Paraná de las Palmas River and Comas Channel. E-mail: ecasaubon@correo.inta.gov.ar

AN OVERVIEW OF POPLAR CULTURE IN HARYANA STATE OF INDIA

Jagdish Chander[1]

With more than 80% of its geographical area under agriculture and only 3.52% area under notified forests, Haryana State of India is not bestowed with bounty of natural forests. To meet wood requirement of the state and to bring additional income to the farmers, poplar *(Poplus deltoides)* - a short-rotation woody crop, was systemically introduced by WIMCO in Yamunanagar district of the State in 1978 for growing as an agroforestry crop. Because of its ability to grow and mature quickly, it fitted very well into the commercial agroforestry system of Haryana. Cooperation extended by the government of Haryana through non-imposition of any restrictions on its harvesting, transport and sale has encouraged farmers to take up Poplar-Based Agroforestry (PBAF) on a large scale.

Poplar growers in the state have turned their fields into laboratory and are experimenting with various models of its farming combining poplar with horticulture, olericulture, poultry, fish farming and agriculture. They have now come out with various models of its farming and are adopting the ones that give them the highest economic returns. Some of the finally refined Poplar-Based Agroforestry (PBAF) models in practice in the state are: Poplar+ Wheat+ Sorghum, Poplar+ Sugarcane+ Wheat + Sorghum, Poplar+ Wheat+ Turmeric+ Sorghum and Poplar+ Sugarcane+ Turmeric.

Yamunanagar town has emerged as Asia's biggest timber market mainly due to post-harvest poplar activity in terms of wood sale, use and value addition mainly in the form of veneer and plywood manufacture. Harvested at a rotation of six to seven years, this species has become the backbone of a vibrant plywood and board industry in Haryana and poplar culture and poplar-based wood industries have become synonymous to each other. Forest Department is playing its role by introducing high yielding clones, conducting research related to insect and disease control, better agronomic practices, providing support to farmers in terms of fixing minimum prices for purchase of poplar wood and holding constant dialogues with poplar growers. During three and a half decades of its cultivation, poplar has become the part and parcel of farming system of the state and has emerged as the undisputed player of agroforestry in its zone of cultivation. It has brought prosperity not only to its growers but to the state as well. It has improved the environment of the state by saving the natural forests, wildlife and their biodiversity. It has contributed a lot in turning Haryana from a wood deficient state to a timber surplus state. As a result of successful agroforestry mainly due to poplar, the tree cover outside forests in the state has gone upto 3.8%, which is more than the forest area of the state. Damage by blue bull, monkeys, defoliators (mainly *Pygaeria fulgurita*), leaf blight *(Bipolaris maydis)* and mushrooming of poor quality nurseries in the absence of any policy to maintain purity of germplasm and fluctuating wood prices are some of the problems being faced in the state.

Keywords: PBAF, Haryana, Yamunanagar.

[1] Conservator of Forests (Research), Panchkula, Haryana, India. E-mail: jagdish.chander@hotmail.com

ID-111

MULTI-PURPOSE POPLAR PLANTATIONS IN ITALY

D. Coaloa [11], G. Nervo[1] and A. Scotti[1]

Poplar is a fast-growing species, economically important for wood production for several industrial purposes (plywood, sawlogs and pulpwood, fuelwood and biomass for energy) and other environmental roles such as protection of soil, regeneration of waste land, restoration of natural river-bank environments, phytoremediation, and to reduce the effects of climate change and air pollution.

The area planted with poplar in Italy has recently reached its historical minimum, due mainly to unfavourable market conditions and to competition with agricultural crops, confirming the negative trend already registered in the last two decades. So the poplar available fails to meet the demand of the timber industry that produces high-quality plywood; the deficit in domestic production is covered by massive imports of round wood from other European countries and Eastern Europe. Recently, beside this classical cultivation model, different high-density plantations, such as short-rotation coppice, have been adopted in order to meet in a short time the requirements of specific sectors such as biomass for energy or for particle boards. These systems, more efficient from the point of view of production, are more risky and less flexible for the supply. The recent increasing demand for renewable energy competes with the more traditional needs of the furniture and wood packaging industry.

Statistical data drawn from forest inventories (IFNC), agricultural censuses (CGA), investigations on the industrial wood sector along with the results of research projects concerning biomass for energy use (SuSCACE and FAESI) are the main information sources for our study. This study aims to analyze and describe the different cultivation systems of poplar plantations currently used in Italy, as the ten-year rotation model for the production of wood for the plywood industry, and short-rotation coppice for the production of small logs for panels or for biomass. The production costs of poplar wood for the various assortments and types of biomass resulting from different cultural models are calculated to assess profitability through net present value and cost benefits, taking into account the final destination, markets and support policies in force.

The growing request for lingo-cellulosic feedstock for the production of new wood panels (OSB) and biofuels (2nd generation ethanol) to be expected in the immediate future can be met with a program of strong expansion of the areas planted with the new high-density plantations. So the Italian poplar cultivation will be rapidly assuming multiple functions to meet new markets and strategic production requirements.

Keywords: poplar plantation models, economical aspects, poplar wood market, biomass for energy.

[1] CRA-PLF Research Unit for Intensive Wood Production of Agricultural Research Council, Strada Frassineto 35, 15033 Casale Monferrato (AL), Italy. E-mail: domenico.coaloa@entecra.it. Tel: (+39) 0142 330900; Fax: (+39) 0142 55580.

ID-071

SALIENT FEATURES OF POPLAR CULTURE IN INDIA

R.C. Dhiman[1]

Poplar is grown on forest land in hills of some Himalayan states, on farm land in Indogangetic plains, and along water channels and water courses in cold arid region of inner Himalayas. Farmers grow poplar for firewood, fodder and small timber in cold arid region, as a cash crop in Indogangetic plains and in some valley areas in hills. A major part of poplar culture is concentrated in the states of Punjab, Haryana, Uttrakhand, Uttar Pradesh and some parts of the adjoining states in Himachal Pradesh, Jammu & Kashmir, Rajasthan, Bihar, etc. and many of these locations collectively form the Region of Intensive Poplar Culture (RIPC). The main features of the RIPC are that it lies between 28^{o}N to 31^{o}N latitude; spread from the Pakistan border in northwest to around 1000 km to North Bihar and from Himalayan foothills in north to around 100 km towards south; rainfall varies from around 800 mm to 1800 mm, over 80% of which is concentrated in 2-3 months just after summers; temperature varies from nearly 0^{o}C to over 45^{o}C with extremely hot summers, and edaphic conditions vary from almost sandy soils near river beds to heavy clayey types. Major poplar culture is happening around three concentrated pockets *viz*., Beas-Sutlej river basin in Punjab state; Ganga-Yamuna river basin in parts of Haryana, Uttrakhand and Uttar Pradesh states; and in Tarai Region of Uttrakhand and Uttar Pradesh states. None of the poplar species, native or introduced, had ever thrived in the RIPC before the introduction of *Populus deltoides* four decades ago.

Populus deltoides is the main poplar species grown in the country; its culture is based on two dozen cultivars grown throughout the RIPC, some with wide and some others with endemic acceptability; culture is largely in private sector and well integrated with agriculture crop production; rotation varies from just below 4 years to over 12 years and purely based on economical considerations; harvesting throughout the year but concentrates during pre- and post- winter cropping season; wood trade in private hands of contractors and commission agents, though some poplar is directly harvested by some poplar-based industrial units; wood trading is based on fresh log basis and is traded daily in number of locations; wood prices change session to session and day to day based on log size, quality, location, season and demand and supply; wood is used for around three dozen products, the main use being for panel products; and all the tree parts are extensively marketed and used. Poplar culture is yielding numerous goods and services, is market driven and self sustaining. It is immensely helping and supporting agriculture crop production by improving organic matter of depleted soils and by diverting high water demanding paddy crop from being grown with poplar; produces 7.5 Mt fresh timber, 1 Mt pulpwood, 5 Mt firewood annually in addition to equally good yield of agriculture crops grown therewith; sequesters around 2.50 Mt C and generates employment of over 100 million man-days, largely in rural areas from around 20 m poplar trees, the annual planting of which has now increased since last IPC meeting. Poplar culture is now considered as a mean for employment generation, poverty alleviation, environment amelioration, sustaining agriculture, industrial growth and economical transformation.

Keywords: poplar culture, RIPC, *Populus deltoides.*

[1] Wimco Seedlings, Baghwala, Rudrapur (UK), India.

PRODUCTION OF POPLAR AND WILLOW CLONES FOR BIOMASS IN ITALY

Gianni Facciotto[1], Sara Bergante[1] and Stefano Lacaria[2]

To verify the actual production of poplar and willow clones grown in short-rotation coppice (SRC) in Italy, the Research Unit of Intensive Wood Production of the Agricultural Research Council (CRA-PLF), in collaboration with a private farm, Allasia Plant, established fields trials in three different sites in 2009 spring and 2010: two in the North of Italy, Cavallermaggiore (CN) and Pratosesia (NO), and one in the South of Italy, Decollatura (CS). Altogether twenty poplar and three willow clones are compared; nine poplar and three willow clones are present in all the sites. Cuttings of thirteen poplar clones and of three willow clones were planted in the spring of 2009 and 2010 in three replicate plots (complete randomized design) in each site. A semi-automatic transplanting machine was used for all clones. Planting density was 8,333 cuttings ha^{-1} and each plot consisted of three rows of 15 trees each. Weeds were controlled mechanically during the first year after plantation in all the sites. Only the trial of Cavallermaggiore was irrigated. Harvesting was done after two years in Cavallermaggiore, and after three years in the other sites.

Survival, diameter at breast height and number of shoots per stump were measured at the end of every year. At harvest time a sample of tree from the central rows of each plot were weighted (wet and dry) to evaluate biomass production (Odt ha^{-1}). Data were statistically analyzed; the significance of clone effect was tested through ANOVA and Duncan test (at $p<0.05$). Main climatic data and soil characteristic were collected in the three sites. No notable diseases problems were found both for poplars and willows. Poplar rooting was good (about 80%) with some differences among clones; willow rooting was excellent (over 90%) in the trials of Cavallermaggiore; in the other two sites poplar rooting was around 70% while willow rooting was 78% at Decollatura, and less than 60% at Pratosesia. The production was good for poplars (7-10 Odt $ha^{-1}year^{-1}$) and high for willows (14-16 Odt ha^{-1} $year^{-1}$) at the end of the first biennial cycle at Cavallermaggiore thanks to the irrigation, while it was lower in the other sites, around 6-10 Odt $ha^{-1}year^{-1}$ for both species. Some willow clones reached a very good production, better than poplar, not only in Northern Italy but also in the South, where annual rainfall is over 1000 mm.

Keywords: poplar, willow, biomass yields.

[1] Consiglio per la Ricerca e la Sperimentazione in Agricoltura (CRA), Unità di Ricerca per le Produzioni Legnose fuori Foresta (PLF). St. Frassineto Po 35, 15033 Casale Monferrato (AL), Italy. E-mail: sara.bergante@entecra.it. Tel: +39 0142 330960 Fax: 0+39 0142 5558 . E-mail:

[2] Allasia Plant s.s., Loc. S. Isidoro 97, 12030 Cavallermaggiore (CN), Italy. Tel. +39 (0)172 381087 Fax +39 (0)172 382206

PRUNING - AN ESSENTIAL OPERATION OF POPLAR CULTURE IN INDIA

J.N. Gandhi[1] and R.C. Dhiman

Pruning is an important management intervention for growing poplar nurseries and plantations in India. It starts with removal of young and tender lateral shoots, a couple of months of planting the cuttings/plantlets, and lasts around two years of final felling of trees. The objective of pruning in nurseries is to improve physical look, avoid intermingling and lodging of saplings during rains and winds, and facilitate cultural operations in dense populated nurseries. Pruning of saplings consists of around a dozen time removals of young shoots with hands or woody shoots with secateurs during the nursery production phase. Wide variation exists in lateral shoot formation with WSL 39 cultivar recording 17 shoots/saplings compared to almost no shoot in G3 and Bahar cultivars. Shoot formation also declines with delay in planting nurseries. February planted nurseries result in very high sprouting of stem buds compared to almost no sprouts in July planted nurseries, as recorded in G48 cultivar. Pruning of saplings in nurseries is therefore clone specific and production system specific.

Pruning is more judicious and cautious in poplar plantations. Pruning removes branches which support photosynthesizing foliage and therefore it affects poplar growth. It is, however, carried out during winters to improve timber quality, channelize growth to apical leader shoot by removing competing side branches and co-leaders and for saving trees from wind breakage and lodging by restricting lateral spread of crown. Two types of pruning viz., lateral pruning and vertical pruning are *in-vogue* depending upon the age and stage of tree growth. Lateral pruning starts soon after sprouting in same year planted saplings to restrict formation of thick foliage from multiple shoots which otherwise intensely compete with apical shoot growth. Lateral pruning in 1-2 years old poplar is also done by half cutting the branches for saving them from lodging and breakage by reducing the wind impact on tree crown. The concept of lateral pruning is fast developing in some poplar growing locations which are prone to wind storms. Experimental data proves that lateral pruning initially affects tree growth but trees grow normally thereafter. Vertical pruning improves timber quality by cutting thick branches and lifting the tree crown to 45-50 cm thickness (girth) tradable limit of logs. It also removes competing co-leaders to facilitate more growth on the main stem. The operation starts after the first year growth, carried out on alternate years till the final felling of trees. Many farmers have developed thump rules to prune tree stem to the height having transition zone between smooth and corky bark on main stem which normally coincides with tradable log thickness. Pruning in many plantations is carried out by untrained labour with wages paid in kind as pruned material for firewood. It normally leads to heavy pruning that checks the growth of the trees. The presentation includes data from field experiments and also photographs for highlighting this important operation.

Keywords: lateral pruning, vertical pruning, timber quality, lodging.

[1] R&D Centre, WIMCO Ltd. (Wimco Seedlings Division), Kashipur Road, Bagwala, Rudrapur, Uttrakhand, India-263153. E-mail: Gandhi.jn@wimco.in

ID-159

ADVANCING PLANTATION CULTURE OF BLACK WILLOW (*SALIX NIGRA* MARSH.) IN THE SOUTHERN UNITED STATES

Emile S. Gardiner[1], Randall J. Rousseau[2], Michael C. Tyree[3], Jennifer D. Knoepp[4], Theodor D. Leininger[1], Dana Mitchell[5], Robert B. Rummer[5] and Ray A. Souter[1]

Short-rotation eastern cottonwood (*Populus deltoides* Bartr. ex Marsh.) plantations have demonstrated great utility in restoring forests for biomass production and ecological co-benefits on formerly cropped alluvial soils in the southern United States. Experience has demonstrated, however, that sustainability of eastern cottonwood plantation culture is restricted on poorly drained, heavy clay soils characteristic of the most problematic agricultural sites in the Lower Mississippi River Alluvial Valley. Black willow (*Salix nigra* Marsh.) is analogous to eastern cottonwood from the perspective that it is a fast-growing pioneer of alluvial sites in river basins across the southern United States. But, black willow generally occupies sites characterized by relatively higher clay content and poorer drainage properties than eastern cottonwood. In addition to this favorable site plasticity, black willow possesses other silvical characteristics advantageous to plantation culture. It can be easily propagated from cuttings, produces adventitious roots prolifically, exhibits rapid early growth, and coppices readily following harvest. In 2008, the USDA Forest Service, Mississippi State University, and Louisiana Tech University entered into a collaborative venture to research black willow plantation culture on agricultural sites unprofitable for row crop production.

Our goal is to develop sustainable plantation systems suitable for attaining a variety of management objectives including biomass feedstock production and carbon sequestration on difficult agricultural sites. To achieve this goal, we implemented a comprehensive research program designed to address fundamental questions and issues relevant to black willow plantation culture. Our black willow improvement efforts are leading to the identification and selection of genetically superior clones from five geographic areas, and will produce the first genetically improved black willow clones for use in short-rotation plantations. We have completed experimentation to define optimal black willow planting stock, and are currently experimenting to refine plantation establishment practices. We are studying soil chemical pools to better understand the dynamics of nutrient availability and plantation productivity on degraded agricultural sites. Ongoing research on carbon cycling dynamics, plantation life-cycle inputs and outputs and bioenergy feedstock production will enable us to quantify energy budgets for assessment of economic and ecological sustainability of black willow plantations. This poster will provide an overview of our black willow research program, relay our research progress and present our most recent findings.

Keywords: biomass, short-rotation woody crop, tree improvement, clone testing.

[1] Center for Bottomland Hardwoods Research, Southern Research Station, USDA Forest Service, P.O. Box 227, Stoneville, MS 38776 USA. E-mail: tleininger@fs.fed.us; rasouter@fs.fed.us; egardiner@fs.fed.us

[2] College of Forest Resources, Mississippi State University, Box 9681, Mississippi State, MS 39762 USA. E-mail: rrousseau@cfr.msstate.edu

[3] School of Forestry, Louisiana Tech University, 1501 Reese Drive, Ruston, LA 71270 USA. E-mail: mtyree@latech.edu

[4] Southern Research Station, USDA Forest Service, 3160 Coweeta Lab Road, Otto, NC 28763 USA. E-mail: jknoepp@fs.fed.us

[5] Southern Research Station, USDA Forest Service, 521 Devall.

ID-131

POPLAR CULTURE FOR SPEEDY CARBON SEQUESTRATION IN INDIA: A CASE STUDY FROM TERAI REGION OF UTTARAKHAND

Mohit Gera[1]

Selected afforestation and reforestation interventions involving planting of poplar as a block as well as bund has been studied in the Terai region of Uttarakhand with the objective to assess their carbon sequestration potential, cost-effectiveness exclusive and inclusive of carbon benefits, and efficacy as a CDM forestry option. The excel spreadsheet model '*Project-Based Comprehensive Mitigation Assessment Process*' (PRO-COMAP) was used to estimate the annual incremental carbon sequestration, cost-effectiveness and likely benefits under different carbon price scenarios for two selected afforestation and reforestation interventions.

The results have shown a sequestration potential inclusive of wood products in case of poplar block and bund plantations to be 2.41 and 1.34 tC/ha/yr, respectively, calculated for the assessment period of 30 years, i.e., 2008-38. The study has demonstrated that the likely carbon sequestration benefits estimated with a carbon price of $\$5/tCO_2$ could be in the range of Rs 1000/- (US$18.2) to 2500/- (US$45.45) per ha per year which are very small compared to annual expected returns from such plantation in the range of Rs 75,000/- (US$1,364) to Rs 150,000 (US$2,727) per ha per yr. At the country level the existing poplar plantations under agroforestry have the potential to sequester up to 942,240 tC/yr. Other aspects such as eligibility of poplar plantations under CDM, as well as opportunities under REDD-plus are also discussed.

Keywords*:* poplar, carbon sequestration, cdm, REDD-plus.

[1] Additional Professor, Indira Gandhi National Forest Academy, PO-New Forest, Dehradun-248006, Uttarakhand, India.

ID-195

GROWTH AND VOLUME PRODUCTION OF SOME ELITE CLONES OF POPLAR (*POPULUS DELTOIDES* BARTR. EX MARSH) IN SUB-TROPICS OF JAMMU & KASHMIR

Sushil Kumar Gupta[1]

Poplar (*Populous deltoides* Barter. ex Marsh) is considered to be the ideal introduction in the north-Western Himalayan plains to meet the wood requirements and well relished under the concept of Short-Rotation Forestry.

In order to have specific genotype, different clones of poplar were evaluated in the nursery in the sub-tropical irrigated region of Jammu and Kashmir. After nursery evaluation, a trial on field performance using most promising clones viz. WSL-22, WSL-32, WSL-39, Karanti, Uday, S_7C_{15} and G_{48} was laid out in the year 2003. Field planting was done at 5x4 m spacing with 500 plants per ha. The experimental site comprised sandy loam, neutral to saline in reaction, with low to medium available nitrogen, low in available phosphorus and potassium. The soil organic carbon status of experimental site was comparable with that of the adjoining fallow.

On the basis of growth and yield data after 8 years of field study, it was revealed that plant height (m), diameter at breast height (cm) and volume production (m^3) were considerably variable among different clones. Highest mean plant height and DBH were recorded by clones WSL-22, WSL-32 and WSL-39 amongst the eight clones. So far as volume production is concerned, the clone WSL-22 produced maximum (4.126 m^3), followed by WSL-32 (3.449 m^3) and WSL-39 (3.446 m^3), whereas, 'Karanti' recorded minimum value of 1.932 m^3. For volume predictions, the two easily measurable attributes plant height and DBH were used to develop the simple regression models and it was found that DBH alone can be effectively for volume prediction and addition of plant height in the prediction model improved the volume estimates in *Populus deltoides*.

Keywords: north-Western Hymalayan plains, regression model.

[1] Division of Agroforestry, FoA, SKUAST- J, Chatha, P.O. Bhour Camp 180 009 (J&K), India. E-mail: sushilgupta67@rediffmail.com

ID-182

STUMP BIOMASS AND SPROUTING CAPACITY IN POPLAR STANDS IN SWEDEN

B. Hjelm and T. Johansson[1]

Interest in utilizing trees for bio-energy production has increased drastically in recent decades. In Sweden, hybrid poplar has been in focus as future biofuel supplier and has been planted on former farmland (on limited areas, ca 1000 ha^{-1}, mainly for research and demonstration). To improve the management of the first generation of poplar (*Populus* sp.) plantations in Sweden, equations for calculating aboveground biomass, stem taper, and stem volume have recently been published. After harvest, there are at least two alternatives for the site: (1) Extract the stumps with or without parts of the root system to allow subsequent re-planting of trees or cultivation of cereals; and (2) Utilize the sprouting capacity of the poplar stumps. The sprouts can be harvested in a 5–10-year rotation or thinned for later harvest of pulp wood.

A study of the biomass production was carried out for each alternative. The stump and root study was made in six poplar (*Populus* sp.) stands and the sprouting study in ten poplar stands, on former farmland in Sweden, situated between latitudes 55 and 60° N. At time for clear cut, the mean age of the poplar stands in the first study was 20 years (range 16-23), the mean stand density 1151 stems ha^{-1} (range 361-3279), and the mean DBH (diameter at breast height) 288 mm (range 81-574). For the second study the mean age of the poplar stand was 17 years (range 8-21), the mean stand density 1050 stems ha^{-1} (range 361-2143), and the mean DBH 244 mm (range 68-574). The mean dry mass weight for the 72 excavated stumps was 45±39 kg (1-185) and 14±16 kg (0.2-87) for roots ≥50 mm. Dry mean stump weight represented 21% by dry weight for the stem. The mean total dry weight per hectare for stumps was 34.9±21.8 (12.9-66.9) tons and 12.0±9.6 (4.7-10.9) tons for roots. The excavation of below-ground biomass can either focus on the stump or stump with parts of the root system. Depending on the soil type and moisture, the cleaning of stumps and roots might be more or less heavy. The studied sprouts were 1-7 years old. Stump sprouting was observed in all studied stands. The number of sprouts per living stump varied depending on sprout age and decreased as sprout age increased. The mean dry mass of all sprouts per $stump^{-1}$ was 16.1±14.0 (range 3.3-37.2) kg. The mean total sprout weight per hectare for sprouts amounted to 16.9±14.6 (range 1.2-41.3) tons ha^{-1} when calculated for the actual living stumps in the studied areas.

The aims of the present studies were to measure the biomass of poplar stumps (incl. root system) and the sprouting capacity from above clear cut poplar plantations. Thereafter present biomass estimation functions for stumps (and roots) and sprouting production as well as some practical implications.

Keywords: bio-energy, biomass equation, excavation, root, stump, sprouting.

[1] Swedish University of Agricultural Science, SLU, Department of Energy and Technology, Box 7032, 75007 Uppsala, Sweden. E-mail: birger.hjelm@slu.se

ID-039

COMPARISON OF BIOMASS PRODUCTION OF THIRTY POPLAR CLONES IN CHINA

Jianjun Hu[1] and Mengzhu Lu

Populus is one of the main forest tree species for afforestation in China. The use of willow and poplar short-rotation coppice (SRC) as a renewable energy source could help both to meet the energy demand and to reduce the CO_2 emissions. At present most popular cultivars and their hybrid clones used for wood production in fast-growing plantations are introduced from Europe. The aim of this work was to evaluate the capability of selected *Populus* clones for biomass production.

The poplar SRC plantation was set up in Jiaozuo, Henan Province in Central China in the spring of 2007. The site was situated at an altitude of 95 m where the average annual temperature was 15.2℃ and the average yearly rainfall was 625.4 mm. A total of thirty poplar clones, including 15 cultivars and 15 hybrids of *Aigeiros* section were grown at 1×1 m spacing. The results showed that the survival rate of different poplar clones ranges from 81% to 100% at the end of the first planting year, the average height of the poplar clone ranges from 82 to 251 cm, and the average diameter at the breast height extends from 0.8 to 2.3cm after one-year growth. In the spring of 2008, the aerial part was cut back at the height of 5cm.

In the spring of 2011, the above-ground biomass of the poplar SRC plantation was harvested after the first rotation of three-year growth. The results showed that the dry biomass yield was significantly different between poplar clones. The dry mass of the poplar clones was 7.51-16.33 $t \cdot hm^{-2} \cdot y^{-1}$. The dry mass of biomass of sixteen clones was more than 10 $t \cdot hm^{-2} \cdot y^{-1}$, and that of fourteen clones was less than 10 $t \cdot hm^{-2} \cdot y^{-1}$. The top five clones with the maximum dry mass were 03-332, 110, 910-95, 222 and N179 with 16.33, 15.22, 13.81, 13.43 and 13.09 $t \cdot hm^{-2} \cdot y^{-1}$, respectively.

Keywords: biomass, poplar, short-rotation coppice.

[1] State Key Laboratory of Tree Genetics and Breeding, Research Institute of Forestry, Chinese Academy of Forestry, Wan Shou Shan,Beijing 100091, P.R. of China. E-mail: hujj@caf.a.cn

DIFFERENCE IN GROWTH AND PHYSIOLOGICAL CHARACTERISTICS IN DIFFERENT GROWTH VIGOR CLONES OF *POPULUS DELTOIDES*

Qinjun Huang[1], Guowei Huang[1] and Xiaohua Su[1]

Aiming to know the difference of growing physiology characteristics and the physiological basis of high growth vigor in the first generation of *Populus deltoides*, which are from different growth vigor clones, here we set two groups of growth vigor - HIGH(A) and LOW (B) - for comparison. By the continuing indexes of phenotype and physiology, related research was carried out in the field of growth, photosynthesis and nutrient absorption.

The research results in: 1.There were significant or very significant differences in dry weight of root, stem, leaf and the total between A and B. The dry matter of root was assigned the minimum in different components, the largest proportion was stem in A, while it was the leaf in B. 2. Changes in growth and physiological characteristics showed a certain regularity during June to September. All clones grew most rapidly and physiological characteristics varied most significantly in July. 3. Correlation analysis showed that seedling height and ground diameter were both significant correlated to leaf area, night respiration rate, NH_4^+ uptake rate and the total photosynthetic rate($R>0.826$, $P<0.05$), suggesting that seedling growth was mainly affected by their own total photosynthetic capacity, nutrient absorption and night respiration consumption.

On the whole, A was superior to B in all these factors, which help construct the physiological basis of the high growth vigor.

Keywords: *Populus deltoides*, cross, dry matter, growth vigor, physiological basis.

[1] Research Institute of Forestry, Chinese Academy of Forestry, Qinglongqiao Street, Haidian District, Beijing, People's Republic of China. E-mail: huangqj123@126.com

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A NEW POPLAR AND WILLOW PUBLICATION FOR A GLOBAL AUDIENCE

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

In 1980 the Food and Agriculture Organization (FAO) of the United Nations published a comprehensive volume on poplars and willows. That book is now out-of-date and out of print. As a project of the International Poplar Commission (IPC), a new book entitled 'Poplars and Willows: Trees for society and the environment' is being produced. This is a co-publication of FAO, of which IPC is a part, and CAB International, a UK-based scientific book publisher specializing in agricultural and environmental topics.

The book, presently in press and expected to appear early in 2013, has more than 500 pages and is illustrated in black and white and in colour. The 13 chapters of the book, prepared by nearly 70 contributing authors from 15 countries worldwide, cover all aspects of poplar and willow taxonomy, ecosystems, physiology, genetics and breeding, operational production, environmental applications, abiotic stresses, diseases, insect pests, products and utilization, markets and trends, as well as their importance for rural livelihoods and sustainable development. An outstanding feature of the book is its nearly 2500 references. It also includes an up-to-date taxonomic treatment of the Salicaceae. Looking to the future, the book is offered in the belief that poplars and willows, as trees for society and the environment, can help us meet future environmental challenges sustainably and on a sound scientific base.

Keywords: poplar, willow, science, operations, environment, utilization, international.

[1] Environmental Forestry Consultants LLC, New London, Wisconsin, USA E-mail: efcllc@athenet.net
[2] Poplar Council of Canada, 1876 Saunderson Drive, Ottawa, Ontario, Canada K1G 2C5. E-mail: jrichardson@on.aibn.com

THE EFFECT OF HABITAT PROPERTIES AND MANAGEMENT TECHNOLOGY ON BLACK POPLAR BIOMASS PRODUCTION IN SERBIA

Petar Ivanišević[1], Zoran Galić[1], Saša Pekeč[1], Branislav Kovačević[1], Savo Rončević[1] and Siniša Andrašev[1]

Poplars in the section *Aigeiros* (black poplars) belong to the hydrologically conditioned species, which grow naturally in river inundations, forming a complex of alluvial hygrophilous forests in Serbia. So, natural habitats of black poplars are river inundations, on the soil formed on alluvial sediments, order of hydromorphic soils. Within this order, black poplars naturally occur only on two soil types: fluvisol in the class of undeveloped soils and humofluvisol in the class of semigley soils. However, they are cultivated also on other soil systematic units, but with considerably reduced yield. Regarding the black poplar growth, the most significant characteristic of the soil is the content of the fraction silt+clay in the physiologically active layer which determines the general growth model. All the indicators of the potential fertility of these soils depend on the content of this fraction.

The net wood volume production after twenty years significantly depends on the silt+clay fraction content: from 262.2 m^3ha^{-1} on sandy fluvisol to 629.5 m^3ha^{-1} on loamy fluvisol. The other component of fertility of these soils is the hydrological regime, which is in the functional relationship with the river water level. The study of the growth dynamics of the clone I-214 indicates that the positive deviation of the annual current increment from the general growth model occurs in the conditions of identical duration of soil flooding (78 days) and draining up to the depth of 120 cm (77 days). The negative deviation of the annual current increment from the general growth model occurs in the conditions of short duration of flooding (up to 20 days) and long soil waterlogging by ground water (more than 150 days) at the depth of 50 to 120 cm.

The analysis of the study results shows that, for the cultivation of black poplars, the most fertile soil systematic units are fluvisol and humofluvisol. Consequently, the study results indicate that the productivity of black poplars depends on two dominant conditions: edaphic (soil characteristics) and hydrological (flooding regime). The edaphic conditions determine the general growth model, while the hydrological conditions determine the annual dynamics of growth and increment.

Keywords: black poplars, inundation, edaphic and hydrological conditions.

[1] Institute for Lowland Forestry and Environment, University of Novi Sad, Antona Čehova 13, 21000 Novi Sad, Serbia. E-mail: perai@uns.ac.rs

ID-142

EFFECTS OF SOIL WATER POTENTIAL ON THE GROWTH AND PHYSIOLOGICAL CHARACTERISTICS OF *POPULUS TOMENTOSA* PULPWOOD PLANTATION UNDER SUBSURFACE DRIP IRRIGATION

Liming Jia[1]

Subsurface drip irrigation (SDI) is an intensive silvicultural practice which has the potential to increase productivity of triploid *Populus tomentosa* pulpwood plantations. In order to efficiently apply SDI in the cultivation of *P. tomentosa* pulpwood plantations, it is necessary to determine irrigation timing. A field experiment was conducted to investigate the effect of soil water potential (ψ_{soil}) on the growth and physiological characteristics of 6-7 year old trees under SDI in a *P. tomentosa* pulpwood plantation. The experiment included three ψ_{soil} treatments, which initiated irrigation when the ψ_{soil}at 20 cm soil depth and 10 cm distance from a drip emitter reached -25, -50, and -75 kPa, respectively. A control non-irrigation treatment (CK) was also included. Meteorological factors, ψ_{soil}, groundwater level, and tree growth were monitored hourly, daily, every 1-10 days, and monthly for two years, respectively. Soil water content at 20 and 50 cm depth, pre-dawn leaf water potential (ψ_{pd}), and trunk sap flow rate were measured in selected periods. Results showed that relative to CK, SDI could improve diameter, height, and individual volume increment of *P. tomentosa*. Irrespective of SDI treatment, SDI on average increased annual volume growth of the 6- and 7-year-old plantations by 24% and 28%, respectively over the CK treatment. Annual volume growth of the 6-year-old plantation following the -25 kPa treatment reached 39.90 $m^3\ hm^{-2}\ a^{-1}$, which was 43.5% higher than the CK treatment (P<0.01). Relative to the -50 and -75 kPa treatments, annual volume growth in the -25 kPa treatment was 20% and 31% higher (P<0.01) in the 6-year-old plantation, respectively, and 13% and 14% higher (P>0.05) in the 7-year-old plantation, respectively. Relative to CK during the fast growing period (April-July) of *P. tomentosa*, SDI increased the soil water content at 20 and 50 cm depth by 35% and 27%, respectively; increased average daily trunk sap flow rate (SF_{mean}) by 46%; and increased ψ_{pd} by 41%. The ψ_{soil} threshold for initiating irrigation had no significant effect (P>0.05) on the $SF_{mean}$and ψ_{pd} of *P. tomentosa*. However, among the three ψ_{soil} treatments, the average $SF_{mean}$and ψ_{pd}values were highest following the -25 kPa treatment. The increase of soil water availability in the 0-20 cm soil layer (i.e., active rooting zone) was also greatest in the -25 kPa treatment. These results may explain why the -25 kPa treatment had the highest tree growth rate among the three ψ_{soil} treatments. Overall, the observed increase in soil water content, SF_{mean}, and ψ_{pd} indicate that these are the mechanisms by which SDI significantly improves *P. tomentosa* tree growth.

In conclusion, our findings suggest that SDI should be promoted in the cultivation of *P. tomentosa* pulpwood plantations. To realize optimum tree growth, irrigation should be initiated when the ψ_{soil} at 20 cm depth and 10 cm distance from a drip emitter reaches -25 kPa. Furthermore, it is recommended that irrigation should be applied between April and July, and terminated between August and October when planting *P. tomentosa* in regions similar to our experimental plantation.

Keywords: subsurface drip irrigation, water management, sap flow, soil water potential, triploid *Populus tomentosa*, pulpwood plantation.

[1] Ministry of Education, Key Laboratory of Silviculture and Conservation, Beijing Forestry University, Beijing, China. E-mail: jlm@bjfu.edu.cn

BIOMASS PRODUCTION OF EURAMERICANA HYBRIDS PRELIMINARY RESULTS

Teoman Kahraman[1]

The aim of the study was to evaluate the growth of Euramericana hybrid clones at juvenile stage for woody biomass selection.

An experimental plantation was established beside the Filyos River at the forest nursery with 74 clones. The density was 13,363 (spaced 2.2x0.4 meter). Randomized block design used with four replications and 5 ramets used per pilot. Growth performances of clones were evaluated by using selection index values "SI=[$(D/2)^2$ x H x 3.1416]x N" (D: diameter, H: height, N : number of survival) at the end of the second vegetation period, and clone 'I-214' used as control clone. Analyses of variance were conducted on clone mean values and Duncan's Multiple Range test was applied to rank clones.

Analyses of variance for selection index value showed significant differences at 0,001 probability level. According to Duncan test, clones were separated into 11 groups and the first group consisted of 12 clones. Clone '149/85' was best performer with 13,56 index value, while control clone 'I-214' was ordered 49, with 3,56 index value. According to preliminary results, the best performer 12 clones was selected for the next stage in the long-term studies.

Keywords: Euramericana hybrids, breeding, biomass.

[1] Poplar and Fast Growing Forest Trees Research Institute, Izmit, Turkey. E-mail: teomankah@yahoo.com

INTER-CULTIVATION OF *POPULUS CILIATA* WALL. EX ROYLE AS THE NURSE CROP: ITS EFFECT ON SURVIVAL AND GROWTH PERFORMANCE OF *ABIES PINDROW* ROYLE AND *PICEA SMITHIANA* (WALL.) BOISS

K.S. Kapoor[1] and R.S. Rawat[2]

A field trial to assess and understand the effect of inter-cultivation of *Populus ciliata* Wall. *ex* Royle, commonly known as the Pahari Peepal, on the survival and growth performance of *Abies pindrow* Royle and *Picea smithiana* (Wall.) Boiss. - high level conifers of Western Himalayas and shade loving trees in the early years of their establishment - was laid in the forest area of Solang Valley, near Manali, District Kullu, Himachal Pradesh. The experimental area is situated at an elevation of about 2380 m above msl at $70^0 20^/$ E Longitude and 32^0 $25^/$N Latitude, having annual rainfall of approximately 180 cm, and supports the mature crop of silver and spruce around. The Entire Transplants (ETPs) of *Populus ciliata* were planted at different spacings as a nurse crop and the results revealed the significant effect of Inter-cultivation of *Populus ciliata* -The Himalayan Poplar- on the survival and growth performance of these high level conifers under trial. Maximum survival in case of both these conifers was recorded under shade of nurse crop with the spacing of 4m x 3m, whereas maximum values pertaining to the average height and collar diameter increment of both these species was registered under the shade of nurse crop with spacing of 6m x 3m, followed by the shade having nurse crop with spacing of 4m x 3m.

Therefore, from the outcome of this trial it can safely be concluded that these coniferous species should be planted in the field with *Populus ciliata* as the nurse crop - a species merging with the ecology of the area/habitat - for successful establishment of these conifers during their early stages of growth and development in the field, a concept merging with the ecology and conservation of the natural habitat besides aiming at raising the productivity of the natural/ manmade forests

Keywords: inter-cultivation, nurse crop, Entire Transplants (ETPs), *Populus ciliata*, *Abies pindrow* and *Picea smithiana.*

[1] Himalayan Forest Research Institute, Conifer Campus: Panthaghati, Shimla, 171 009 (HP), India. E-mail: kapoorks@icfre.org

[2] Present Address: BCC Division, Indian Council of Forestry Research & Education, PO New Forest, Dehradun 248006, India.

ID-085

THE SWEDISH POPLAR NETWORK INITIATIVE – TESTING CLONES AND DEVELOPING SHORT-ROTATION POPLAR CROPS THROUGH PARTICIPATORY RESEARCH

Almir Karacic, Theo Verwijst and Martin Weih[1]

During the recent years in Sweden, an increased interest for poplar-based short rotation forestry (SRF) resulted in a couple of thousands of new poplar plantations on both farm- and forestland. However, the further development of poplar-based SRF crops in Sweden is mainly hampered by the lack of climate-adapted clones and know-how among the potential growers. In this project, financed by the Swedish Energy Agency, we are trying to address these two obstacles by developing a network of farmers and land-owners who are interested to participate in research and development related to poplars and SRF.
The methodology of participatory research has frequently been used to improve management of natural resources in developing countries and is here adopted to increase the supply of biomass for bioenergy and other purposes in Sweden. The focus of four-year project is on building a network of farmers' own small poplar plots for testing the clones distributed by the Swedish University of Agricultural Sciences (SLU). The material distributed to the farmers belongs to several various collections, including old, poorly tested clones imported to Sweden between 1970 and 1990 and also more recent material released from the breeding programs at SLU and SweTree Technologies AB.

The first goal is to develop an efficient method of cooperation in which data on growth, phenology and disease status of poplars is gathered by the farmers on their own test plots. The data is administered and analyzed by the project coordinator and shared via the project website to other participants, various stakeholders or the general public. Such a network of test plots can be a valuable complement to the traditional clone testing in Sweden where additional efforts are needed to provide reliable data for an area laying between 54th and 64th degree northern latitude, i.e. outside the optimum ecological niche for the most of the material produced in European breeding programs. The second goal is to build up a region-specific knowledge about poplars and SRF among the project participants.

A certain spin-off effect is expected in the project as the information about various aspects of poplar-based SRF will be passed to the participants' own networks. The learning process is bidirectional as the participants' own experiences and competences become directly involved in the development of a new crop production system. An essential part of the project is developing the internet based tools for reporting data, communicating knowledge and sharing the experiences among all participants. In this project farmers have an opportunity to participate in the development of an alternative crop for set-aside farmland, which is developed on their own terms rather than imposed by authorities and short-term subsides.

Keywords: clone testing, participatory research, poplars, Sweden.

[1]Swedish University of Agricultural Sciences, Department of Crop Production Ecology, Box 7043, 75007 Uppsala, Sweden. E-mail: Almir.Karacic@slu.se

ID-093

PRODUCTION POTENTIAL OF DIFFERENT INTERCROPS UNDER POPLAR-BASED AGROFORESTRY SYSTEMS

Rajesh Kaushal and Salil Tewari[1]

To study the production potential of poplar- and shisham-based agroforestry systems, six intercrops viz., wheat, mustard, potato, gram, lentil and pea were evaluated for their growth and yield performance.

The experiment was conducted in randomized block design with four replications. The results were compared with open/sole crop treatment of different crops. The results revealed that average germination count and number of shoots/m^2 of wheat, emergence of potato and plant population of mustard, gram, lentil and pea were recorded higher in open as compared to poplar and shisham. Average plant height of different crops at 30 and 60 DAS was higher under agroforestry systems than open system. However, later on significantly higher plant height in all the crops was recorded in open as compared to under trees. Grain yield and straw yield were also more in open as compared to agroforestry systems. Nitrogen content in the different intercrops revealed higher values under trees as compared to open. However, nitrogen uptake was more in open than tree-based agroforestry systems. Among poplar and shisham, above all parameters were non-significant. However, generally, they were higher under poplar than shisham. Among the intercrops grown with poplar and shisham, potato gave the maximum gross and net income followed by wheat. Mustard, gram, lentil and pea did not perform better under poplar and shisham-based agroforestry systems during both the years.

Keywords: agroforestry, poplar, shisham.

[1] Agroforestry Research Centre, G.B. Pant University of Agriculture & Technology, Pantnagar-263 145, India. E-mail: saliltewari@gmail.com

ID-201

THE EFFECT OF INITIAL MEDIUM pH ON WHITE POPLAR GROWTH *IN VITRO*

Branislav Kovacevic[1], Dragana Miladinovic[2], Marina Katanic[1], Zoran Tomovic[3] and Sasa Pekec[1]

The effect of initial (pre-autoclaving) medium pH on shoot and root development of five white poplar (*Populus alba* L.) genotypes was tested. The shoot height, fresh mass of shoots per jar, dry mass of shoots per jar, number of roots, as well as the length of the longest root were measured and final pH of media determined, after 35 days of culture *in vitro*. Three initial pH of medium were tested: 3.0, 4.0 and 5.5 as control. Problems with agar solidification at low pH were overcome by microwave oven sterilization.

The obtained results indicate that tested genotypes have ability to grow on medium with low initial pH, and alter the media pH during culture. Majority of the clones had significantly better shoot and root growth and biomass accumulation when they were established on pH 3.0 medium. The obtained results could contribute to the improvement of *in vitro* propagation of white poplars, and in this way to wider growing of this species, as it is difficult to propagate by cuttings.

Keywords: *Populus alba*, micropropagation, rooting, microwave sterilization.

[1] Institute of Lowland Forestry and Environment, Antona Cehova 13, 21000 Novi Sad, Republic of Serbia. E-mail: branek@uns.ac.rs
[2] Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Republic of Serbia.
[3] Public enterprise "Vojvodinasume", Preradoviceva 2, 21131 Petrovaradin, Republic of Serbia.

ID-083

A MODEL FOR GOVERNING REGISTRATION OF NURSERIES FOR COMMERCIAL MULTIPLICATION OF QUALITY PLANTING STOCK

Dinesh Kumar[1]

Raising of nurseries and plantations of *Populus deltoides* (poplar) is a sizeable business activity in India. Poplar plantations in the country occupy an area of about 312,000 ha at a notional density of 500 trees per ha and they are managed at a 6-8 years rotation. The existing planting rate is about 30 million plants per annum. The planting stock (one-year-old transplant) is priced at Rs. 10 to 25 per plant (i.e. around US$0.18 to 0.45 per plant at current exchange rate). Only about 5 per cent of the planting by the growers is done from own nursery stock; the remaining requirement of planting stock is met from commercial nurseries. Planting material worth Rs. 285 to 712 million (US$5.19 to 12.96 million) is traded every year. Nurseries are mostly under private ownership and the nursery operators vary from very small-scale growers (farmers' nurseries) to large-scale (owned by a few corporate bodies). Most of the nurseries multiply the plant material of whatsoever clone(s) become available to them. Only a few nurseries (WIMCO Ltd., State Forest Department Haldwani, etc.) and research institutions (Forest Research Institute, Dehradun and few universities) have their own research programmes aimed at producing new clones. No mechanism exists in India to ensure physical and genetic quality of the planting stock and address IPR issues.

A model is proposed to govern the registration of *P. deltoides* nurseries. This model would entail mandatory registration of commercial nurseries and quality control mechanism – for physical as well genetic genetic quality. Morphological as well as DNA-based clonal identification descriptors would be used. The model would facilitate flow of superior clonal stock from breeder to grower and enable the breeder to get royalty from franchisees. The system can be easily extended to other clonally propagated trees too and it will create a competitive research-based system producing quality planting material which will ultimately benefit the growers and significantly contribute to the sustainable growth of plantation forestry in India. A similar system already exists in agriculture sector across the world and in forestry sector in numerous countries. Experiences from other countries, where such a system exists, and concerns of stakeholders in India need to be considered before such a model is put into0 use.

Keywords: nursery, certification, clone, registration, intellectual property rights.

[1] Silviculture Division, Forest Research Institute, Dehradun, India. E-mail: kumard@icfre.org

A NEW APPROACH FOR POPLAR PLANTATION

Kshitij Malhotra[1] and Dinesh Kumar

Poplar (*Populus deltoides*) is a fast-growing tree species, usually cultivated by farmers in their farmlands in northern region of India above 28^{o} N latitude. Wood of *P. deltoides* is the backbone of plywood industry in this region. It is cultivated on a large scale through entire transplants of superior cultivars, i.e. G48, S7C15, S7C8, WSL22, Udai, L34/82, etc. in the month of January. About 90-98% success is reported by this propagation method. Mortality occurs mainly during the first 3-5 months of planting.

India is an agricultural country and at time of poplar plantation farmlands are mainly occupied by wheat. For this reason, farmers tend to do monsoon plantation of poplar through use of plants in polythene bags or root trainers. But such plantations often result in sub-optimal performance. To overcome this problem a new approach is being tested in which plants are propagated through an unusual method of air layering.

In this approach, around 1 ft-long basal part of the shoot that had emerged from three to four years old stool bed during current season is air-layered during the fourth week of the month of June. "Rooter strand" is applied to aid in air layering. Rooting is found to occur in air-layered plants in two to four weeks period. "Rooter strand" has been found to help in rapid and uniform root development. Success rate of this approach in plantation in preliminary study is found to be 100 percent. But this approach requires special precautions during plantation and needs to be tested for full length of rotation before large scale adoption. This approach offers advantages such as need for less weeding, lower water requirement and reduced propagation cost in comparison with use of polythene bag and root trainer.

Keywords: propagation, mortality, monsoon plantation, air layering, rooter strand.

[1] Forest Research Institute, Dehradun, 248006, Uttarakhand, India. E-mail: rishipop@gmail.com

REGENERATION ABILITY OF POPLAR - A STUDY OF STUMP SPROUTING IN SOUTHERN SWEDEN

Rebecka Mc Carthy[1] and Lars Rytter

The interest in *Populus* spp. has increased in Sweden as a result of the current interest in biomass for energy purposes. Poplar species and hybrids are generally fast-growing and have been improved by breeding for productivity and vitality. So far, the knowledge about regeneration through sprouting is in generalpoorly known.

The objective of this study was to investigate the ability to develop satisfying sprouts in the second generation after harvest. A poplar clonal test of 0.7 ha on arable land in southern Sweden was harvested in the winter 2010/2011. The clonal test consisted of single tree parcels, which were completely randomized. Before flushing in the spring 2012 sprouts on 26 poplar clones were counted and assessed for survival, straightness, height and base diameter. Each clone was represented by three to five stumps randomly distributed on the site. Ten randomly selected sprouts were measured on each stump, including sprouts visibly attached to buttresses. Diameter and height were measured on the ten sprouts and additionally on the highest sprout. Height was measured up to the highest living bud, since some sprouts had been damaged in the top by frost or browsing. In the summer 2012 a re-inventory was done for survival the second year after harvest.

Four poplar clones had no living sprouts at the re-inventory and are not applicable for sprout regeneration. Several clones were crooked and hence also unsuitable for sprout regeneration. Some clones had vital and straight sprouts and from this study four clones could be recommended for use in a second regeneration based on sprouts. Of these four clones, two are already used commercially, one is a candidate to be included among the commercial clones and one is outside those categories. There were few significant differences in diameter and height growth of the average sprouts among surviving clones. One well-growing clone had bigger sprouts than some of the slower growing clones. At present it is difficult to evaluate whether it is better with clones that have many vital sprouts or if the clones with just a few sprouts would give a better start from a competing and water-nutrient availability perspective. This is a field in which further research is required.

If the objective, in contrast, is to remove the existing plantation after the first generation and replace it with new plant material, other clones with previously shown high biomass production, but low stump sprout survival after harvest, could be of interest.

This study shows that a new sprout-based generation of poplar cannot be taken for granted. Instead, different clones appear to have different survival and growth behavior, which must be taken into account when planning for the next tree generation. The study needs to be complemented with other studies to better assess the sprout characteristics, including root suckers, for different clones.

Key words: poplar clones, stump sprouts, survival, clonal differences.

[1] The Forestry Research Institute of Sweden, Skogforsk, Ekebo 2250, SE-268 90 Svalöv, Sweden. E-mail: Rebecka.McCarthy@Skogforsk.se

ID-124

CLONAL VARIATION IN GROWTH, BIOMASS AND NUTRIENT DISTRIBUTION IN *POPULUS DELTOIDES* UNDER AGRISILVICULTURE SYSTEM

Alka Mishra[1], Sushma and S. L. Swamy

Growth, above- and below-ground biomass and nutrient distribution were studied in five clones (G3, G48, 65/27, D121 and S7C1) of *Populus deltoides* grown under agrisilviculture system in sub-humid tropics of Central India.

The clones were planted at 4 x 5 m in a randomized block design with three replications. Diameter at breast height (dbh) and tree height were consistently higher in clone 65/27 and lowest in clone S7C1. Total biomass varied from 48.5 to 62.2 Mg ha^{-1} in 6-year-old clones. Total biomass in clones was in the order: 65/27 > D121 > G48 > G3 > S7C1. Stem wood accounted 60.4-68.9% to total biomass followed by coarse roots (12.2-18.9%), branches (12.3-15%), leaves (3.02-6.9%) and fine roots (1.5-2.7%). Root-shoot ratio ranged from 0.2 to 0.35. It was highest in clone G48 and lowest in clone S7C1. In 6-year-old clones, total N ranged from 184.3 to 266.3 kg ha^{-1}, P from 16.8 to 31.1 kg ha^{-1} and K from 81.9 to 128.7 kg ha^{-1}. Total N and P were highest in clone 65/27, while K in clone G48. Nutrients were lowest in clone S7C1. In general, maximum nutrients (N, P and K) were allocated to above-ground components (leaves > stem > branches) than below-ground components. Available N, P and K in the soil improved significantly after 6 years of planting. It was higher in 0-20 cm and decreased with soil depth. At 0-20 cm soil depth, N increased from 14.9 to 24.1%, P from 17.2 to 23.3% and K from 3.1 to 5.1% under different clones. The yield of both soybean and wheat reduced under poplar clones. Yield losses in soybean ranged from 10.1 to 33% and wheat from 15 to 30.3% under different clones.

The management strategies for reducing tree-crop competition and nutrient export from the site under *P. deltoids*-based agrisilviculture system for achieving sustainable production are discussed.

Keywords: competition, nutrient export, poplar, productivity, short-rotation plantation.

[1] E-mail: alkamishra142@gmail.com

ID-177

INFLUENCE OF POPLAR-BASED AGROFORESTRY SYSTEM ON WHEAT IN MOLLISOLS OF INDIA

H.S. Mishra, Ashutosh Singh and Salil Tewari[1]

Mollisols of Tarai region, Northern India, cover an area of 1.64 million ha below foot hills of Himalayas. The word Tarai means moist, indicating the wet moisture regime and high water table conditions for most part of the year. Soils of this area are highly productive, and were brought under cultivation since 1940 after removal of Jungle and grasslands. The area has a dry season from October to May and a wet season from June to September, when 85 to 90% of the rainfall (1,400 mm) is received, July and August are the wettest months (350-425 mm), June to October are lower (100-150 mm), September has 250 mm rainfall. May and June have very high mean temperatures (29 to 32^{o} C), December and January are the coolest months (13 to 15^{o}C). The soils have higher moisture regimes or greater average annual moisture contents than the precipitation received. Solar energy is in abundance in the area, however, moisture and nutrients are often limiting.

This investigation has been carried out to find out the potentiality of land and the wheat under poplar-based agroforestry system response to existing soil fertility. The experimental land received standard cultural practices for raising crop during season. Under agroforestry system and farming land use 20.1 x 1 m quadrates were laid out randomly and the crop was harvested on maturity from the base. Fresh weight of the sample was recorded in the field and representative sample was brought to the laboratory to record straw and grain weight. Moisture content was determined by gravimetric method and biomass yield was calculated on per ha basis. Under poplar-based agroforestry system, wheat variety HD 2338 was raised. The spacing of popular was 4 x4 m. As per soil test value N: P: K was supplied through urea, diammonium phosphate, single super phosphate and muirate of potash in two split doses. Existing density of popular trees was 716-tree ha^{-1} and age was six years. Under farming system, same variety of wheat crop was raised using same cultivation practices. The tree growth parameters (depth, height, crown area and tree density) were recorded.

Plant characteristics and production of wheat crop under farming system and agroforestry system were recorded as per standard procedure. In general, wheat performed better under farming system than under poplar-based agroforestry system. Under agroforestry system, pH was lower, organic carbon content was higher in 0-45 cm depth as compared to farming system due to addition from popular tress. Below 45 cm to 105 cm of profile depth, there was not much difference in nitrogen, phosphorus and potash content of the soil under both the land use system. Results demonstrated that tree species have potential to provide optimum micro-climatic conditions, which reflect in reduction of irrigation number during crop growing season as compared to farming system.

Keywords: Tarai region, soil fertility, farming system.

[1] Agroforestry Research CentreG. B. Pant University of Agriculture and Technology, Pantnagar-263145 Uttarakhand, India. E-mail: saliltewari@yahoo.com

ID-170

DETERMINATION OF SUITABLE POPLAR CLONES IN SHORT-ROTATION SYSTEM IN CHAMESTAN OF MAZANDARAN PROVINCE IRAN

Jamshid Mokhtari[1] and A.R. Modir-Rahmati[2]

For determining suitable poplar clones for being utilized in cellulose industries on the basis of maximum wood production in hectare, 15 clones of *Populus deltoides*, *P.euramericana* and *P. nigra* were studied in three exploitation periods (2, 3 and 4 years) in Chamestan of Mazandaran province in Iran. In order to homogenize the material, all the shoots were cut at the bottom after the first growth year. At the end of each exploitation period, all stems and shoots were cut and weighted twice: (1) wet wood product and (2) dry biomass after six months of drying in the open air.

Some parameters such as survival, number of total coppice stems per collar, number of shoots over 2 m height, mean diameter and mean height of shoots over 2 m height, diameter and height of the highest stems and resistance to pests and diseases were studied and compared at the end of the project. The results were analyzed on the basis of randomized complete block design.

Results showed that: (a) In 2-year short-rotation system, *P.deltoides 69/55, P.euramericana triplo and P.deltoides73/51* produced the highest amount of dry biomass of 20.05, 17.52 and 17.19 tons/ha/year, respectively; (b) In 3-year short-rotation system, *P.deltoides* 77/51, *P. euramericana* triplo and *P.deltoides* 69/55 produced the highest amount of dry biomass of 16.70, 15.75 and 14.73 tons/ha/year, respectively; (c) In 4-year short-rotation system, *P.deltoides* 69/55, *P.deltoides* 77/51 and *P.euramericana* triplo produced the highest amount of dry biomass of 19.00, 17.77, and 16.96 tons/ha/year, respectively.

The differences between dry biomass production of poplar clones in each rotation system were significant.

Keywords: poplar, short rotation, Chamestan.

[1] Member of Scientific Board, Forest and Rangeland Research Station of Chamestan in Iran. E-mail: mokhtari_snbr86@yahoo.com

[2] Member of Scientific Board, Research Institute of Forests and Rangelands, Iran. E-mail: modir-rahmati@rifr-ac.ir

ID-125

MEAN TEMPERATURE DIFFERENCES OF 3°C PRODUCE A 1-MONTH DELAY IN *POPULUS* CV CONTI 12 CAMBIAL WOOD FORMATION

Natalia Naves[1], Fidel Roig[2] and Paulo Zanetti[3]

Four plots of *Populus* cv Conti 12 planted under similar design in the pre-Andes alluvial plains of central Argentina were considered in this study. Sites are separated by 245 km each other and all affected by similar precipitation amounts (~150 mm yr^{-1}), the crops being irrigated with melting ice waters. However, differences in average temperature of 3.2°C yr^{-1} exist between the study sites.

We arbitrarily separated the plots in: A, those corresponding to the coldest places, and B: the warmer sites. In A, the period with average temperatures below 11°C is between April and September, while in B it occurs between May and August. The increment of trunk and timing of growth for ten trees at each site was recorded at DBH by using steel permanent dendrometer bands with a precision of 0.2 mm. Data were recorded weekly between 2010 and 2012. Each year, growth was re-activated a month earlier in the cooler sites and trees enter in dormancy one month earlier relative to the warmer sites. *Populus* species and cultivars have ecological amplitudes about their climatic requirements but generally have low heat requirements for growth. We discuss these results in terms of harvestable wood conditions and quality of plantation forests.

Keywords: temperatures, pre-Andes, *Populus*, growth.

[1] Dasonomía, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo, Mendoza, Argentina. E-mail: natinaves@gmail.com
[2] Laboratorio de Dendrocronología, IANIGLA, CCT-CONICET, Mendoza, Argentina.
[3] Técnico de apoyo académico Dasonomía, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo, Mendoza, Argentina.

ID-091

CONSERVATION AND DEVELOPMENT OF POTENTIALS OF *SALICACEAE* FOR IMPROVED LIVELIHOODS IN KENYA

P.O. Oballa[1]

A survey was conducted in the natural populations of endangered Salicaceae family endemic to Kenya, namely *Populus ilicifolia* (Engl.) Rouleau and *Salix subserrata* Wild with intention of domestication and conservation. Propagation potential was tested using various types of cuttings and seeds. Isoenzyme techniques were used as a quick method to determine the genetic diversity of *P. ilicifolia*, while wood analysis was determined by the standard methods in wood products laboratory at Kenya Forestry Research Institute (KEFRI).

It was found that there are small populations of the two species at various sites that should be used as sources of germplasm for conservation. All species propagate through vegetative means with a success rate of 60% for *P. ilicifolia* to 100% for *S. subserrata*. Fresh seeds of *P. ilicifolia* germinate well with a success rate of 75% within three days. Genetic diversity parameters considered for *P. ilicifolia* showed that percentage of polymorphic loci estimates was uniform at 50% for all populations. Mean number of alleles per locus was the same at 1.5. Mean observed and expected heterozygosity estimates over all loci and populations were 0.20 and 0.16, respectively. This confirmed that *P. ilicifolia* has inter- and intra-population genetic diversity that should be explored for conservation. Wood properties were within the range of other *Populus* species. No genetic diversity studies have been initiated for *Salix* species.

Successful trial planting along Nyando River, Asembo Bay and at Nyandera Dam in the Lake Victoria Basin, in addition to natural range, confirmed that the species can widely be domesticated in wetlands in hot ecological zones. It is recommended that the two species should be extensively sampled for conservation, domestication and sustainable use. The species can provide environmental services in protecting riparian and degraded wetlands around water sources while enhancing climate change mitigation role. Detailed studies on genetic diversity should be undertaken using more robust DNA techniques.

Keywords: Salicaceae, *Populus ilicifolia*, *Salix subserrata*, genetic diversity, vegetative propagation, isoenzyme, wood properties.

[1] Kenya Forestry Research Institute, P. O. Box 20412 - 00200, Nairobi, Kenya. E-mail: poballa@kefri.org

ID-035

ARE TREE MORPHOLOGICAL DETERMINANTS INDICATORS OF NITROGEN USE EFFICIENCY (NUE) IN HYBRID *POPULUS* CLONES FOR BIOENERGY PLANTATIONS?

Pierluigi Paris[1], Giuseppe Scarascia-Mugnozza[2] and Maurizio Sabatti[3]

Nitrogen (N) balance is a factor of dramatic importance for the sustainability of bioenergy crops, either herbaceous or woody ones, in terms of their energetic and CO_2 balances, greenhouse gases emission, environmental contamination and biofuel quality. Poplars are frequently used worldwide for bioenergy coppice plantations, with very high planting densities and extremely short rotation cycles (2-5 years). These factors strongly affect the N balance of bioenergy plantations, with very high N uptake, for the frequent harvests of large quantity of biomass constituted of thousands of small sized shoots, with a relative high bark:wood ratio.

We studied the relationships between tree morphological yield traits (stem diameter and height, dendromass yield, branchiness, and number of shoots on stool – N. shoots stool^{-1}) and N removal, in the harvested biomass, and N use efficiency (NUE). The research was conducted in two experimental plantations in Italy (sites of Vinovo and Bigarello), comparing Italian hybrids poplar clones: four new selections for bioenergy (AF2, AF6, Monviso, 83.140.138) and I214, as control clone.

After two biennial coppice rotations, N removal was found to be primarily influenced by the biomass production and a relationship between biomass yield and N removal was established. These data can be used for a first refinement of criteria of N fertilization of the woody crop, either in the case of the use of chemical fertilizers or as organic wastes for their disposal into bioenergy plantations (phytoremediation). Coppicing improved dramatically the amount of N removal, as a consequence of strong changes in morphological traits and density of shoot populations. Morphological stem/shoot traits, at clonal level, were found to be correlated to the N content in the woody tissues, as well as to the NUE of the clones. At the end of the first cycle, low branchiness was found to be correlated to low N content (N%), and indirectly to high NUE at clonal level. After coppicing, a low level of shoots on stool was found to be correlated with low N% and high NUE. Clone AF2 was the one presenting high NUE, low branchiness and low N. shoots stool^{-1}; combining these characteristics with high biomass production in the studied experiments. Clone AF2 was one of the most productive clones also in other experiments in Italy, as well as in preliminary tests in other European countries.

Cultivar selection of poplar for bioenergy production should be aimed at selecting genotypes with an high NUE, coupling high biomass yield with low branchiness and N. shoots stool^{-1}, as in the case of clone AF2. In the case of maximizing N uptake, as for phytoremediation, clone Monviso was the one matching high biomass yield with low NUE due to high branchiness and number of shoots on stool.

Keywords: branchiness, coppicing, fertilization, shoots on stool, SRWC.

[1] Correspondig Author: C.N.R.- Istituto di Biologia Agroambientale e Forestale, Via G. Marconi, 2, 05010 Porano, Italy. E-mail: piero.paris@ibaf.cnr.it

[2] C.R.A.-Dipartimento Agronomia, Foreste e Territorio, Via Nazionale, 82, 00184 Roma, Italy. E-mail: giuseppe.scarascia@entecra.it

[3] I.B.A.F.- Università degli Studi della Tuscia, Via S. Camillo de Lellis, 01100 Viterbo, Italy. E-mail: sabatti@unitus.it

ID-022

APPLICATION OF DIFFERENT DOSES AND METHODS OF IRRIGATION ON HIGH DENSITY CULTIVATION OF POPLARS 'CONTI 12' FOR BIOMASS PRODUCTION

S. Perez[1], J. Bustamante[1], M. Ferro Malecki[1], P. Zanetti[2]

In Mendoza and the world, the global energy crisis has promoted the research and development of another energy sources as alternative resource to fossil fuels. The biomass from high density and short rotation forests is a renewable resource that can be destined to energy production; the productivity is influenced by factors such as genetic characteristics of the species, edaphic and climatic conditions of the site, and the incidence of irrigation. Water is a limited resource so it will be necessary to know the requirements of irrigation in high density, in order to maximize the efficiency in the use of water and the productivity of these systems, promoting the sustainable use of the resource.

The general aim is to relate the biomass produced by poplar 'Conti 12' in high density and short rotation with different methods and strategies of irrigation.

For this purpose, a trial of cultivation of poplar *Populus x canadensis* 'Conti 12' was established, with a planting density of 14.512 plants.ha^{-1} in a rural property located in Perdriel, Luján de Cuyo. As planting material, woody cuttings of 30cm in length were used, which were placed leaving 1 or 2 buds on the surface of the soil.

A double row at a distance of 75cm was planted, then another double row at 150cm. This was repeated alternatively with a distance of 70cm between plants in the sense of the row.

The plants were cut back and the application of the irrigation treatments was carried out during a complete crop rotation (two years). The irrigation treatments include the application of three irrigation sheets. The ETC will be put back at 100%, 150% and 50%, using surface and trickle irrigation, with three repetitions, in a design of divided parcels.

The control of growth will be made at the end of the first growing season (1st year of rotation). It will consist in the measurement of buds number, diameters and height of buds, in order to estimate the production of biomass, in kg of dry matter by ha, and determine the differences that may exist as result of the application of treatments.

Keywords: poplar, high density plantation, irrigation, biomass.

[1] Docentes Investigadores, Cátedra de Dasonomía, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo. Alte. Brown 500. Chacras de Coria. Mendoza. C.P. M5528AHB Argentina. E-mail: dasonomia@fca.uncu.edu.ar
[2] Personal de Apoyo Académico, Cátedra de Dasonomía, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo. Alte. Brown 500. Chacras de Coria. Mendoza. C.P. M5528AHB Argentina. E-mail: dasonomia@fca.uncu.edu.ar

ID-014

NURSERY AND PLANTING TECHNIQUE FOR MONSOON PLANTATIONS OF *POPULUS DELTOIDES* BARTR.

Ulsheeda Rashid and Dinesh Kumar[1]

Poplar is a very prominent taxonomical group of tree species in plantation forestry in India. It occurs in natural forests also. However, its population in natural stands is small and is gradually declining. The bulk of the plantations is composed of *Populus deltoides*, an exotic species. *P. deltoides* is the only species of poplar that is planted on a significant scale in India. *P. deltoides* constitutes the backbone of agroforestry in irrigated plains of northern India. It has been estimated that more than 300,000 hectare equivalent plantations of poplar exist in India.

The selection of proper planting period or season is very important for the success of a plantation. Many plantations have suffered due to late or untimely planting. *Populus deltoides* is mostly planted in the winter season often in combination with wheat intercrop. While the poplar plants are in establishment stage, the wheat crop is progressing towards maturity and the farmers are reluctant to irrigate poplar trees. In certain cases poplar fails to survive if it is not irrigated well in its first season of growth during summers. So, there is a need to develop nursery technology for monsoon planting of poplar. This would provide a choice of planting season to the growers and would enable planting of this species in areas where it is not cultivated at present.The practice of monsoon planting will minimize the failure of the plantations. Moreover, costs of production, lifting, handling and field planting are also expected to be reduced with this approach. Experiments are being carried out in this direction at the Forest Research Institute, Dehradun, where nursery stocks of *Populus deltoides* were raised as containerized (polythene bags and root trainers), bareroot and entire transplants. The cuttings for this purpose were planted in the nursery during the normal time, i.e. January-February, and these stocks were outplanted during the monsoon season, i.e. July-August. The performance of these stocks is being evaluated in both nursery and field *vis-a-vis* winter planted entire transplants. Field survival and growth of monsoon planting in experiments and in farmer's fields are encouraging so far. The demand for such saplings is significantly increasing in some locations where farmers have been planting them in their fields for a couple of years now. The study is in an early stage and needs further investigation till rotation age.

Keywords: *Populus deltoides*, planting season, monsoon, containerized, planting stock.

[1] Silviculture Division Forest Research Institute, Dehradun 248006, Uttarakhand, India. E-mail: Ulshee27@gmail.com

ID-099

A STUDY ON *POPULUS DELTOIDES* FOR MASS PRODUCTION OF CUTTINGS

Neetu Rathor[1], Varinder Singh, Dinesh Kumar and Kshitij Malhotra

Populus deltoides (eastern cottonwood or poplar), an important tree species for commercial agroforestry, provides employment to thousands of farming families in the northern region of India. Farmers are earning money from poplar in two ways: (a) raising of nurseries for sale of plants, besides meeting own requirement of planting stock, and (b) raising of plantations for sale of wood to industry. Usually a poplar nursery grower wants to utilize undersized (<1.5 metre in height) one-year-old entire transplants to obtain maximum numbers of cuttings for propagation. The remaining entire transplants are sold by them to earn money. The present study was carried out to determine the optimum size of mother entire transplants for preparation of cuttings and to evaluate the performance of cuttings of different sizes (in terms of length and diameter).

The results of the investigation show that longer cuttings (7 inch and 9 inch length) and more than 2 cm diameter sprout faster and result in greater sprouting percentage, while those with less than 1 cm diameter and/or with length of 3 inch or 5 inch length do not perform well for utilization as propagation material. For practical purposes, cuttings of more than 1.5 cm diameter with cutting length more than 7 inch can be used for raising quality nursery stock. Use of 7 inch long cuttings should be preferred to 9 inch long cuttings so as to maximize the number of plants that can be produced per entire transplant, especially in case of cuttings with more than 2 cm diameter. The following regression equation can be used to estimate the number of good cuttings (>1.5 cm diameter) produced per entire transplant:

Number of cuttings (diameter >1.5 cm) per mother entire transplant = -11.51+ (1.57)*L+ (0.55)*D

where L and D refer to length and mid-diameter of the cutting. The equation is applicable only to collar diameter range 1.5 cm to 3.5 cm and entire transplant length of 3 m to 6 m. Cuttings taken from entire transplant with less than 1.5 cm collar diameter and less than 4 m length do not grow vigorously in the nursery, although their survival is more than 85%.

Keywords: poplar, ETP, cutting, diameter, collar diameter.

[1] Forest Research Institute, Dehradun, 248006, Uttarakhand, India. E-mail: nrathor430@gmail.com

ID-179

BIOMASS AND PRODUCTIVITY OF *POPULUS DELTOIDES* PLANTATIONS IN HOSHIARPUR DISTRICT OF PUNJAB

Laxmi Rawat[1]

Poplar plantations with agriculture crops along the bunds are quite common in Punjab. Generally, *Populus deltoides* varieties are grown on bunds. The present study was conducted in a *Populus deltoides* plantation at Bhagpur village of Hoshiarpur district, Punjab. Trees were 7-year-old. For biomass study complete harvesting of trees was done following stratified tree technique method of Art and Marks (1971).Ten trees were harvested. Although the plantation was even aged (7 years), there were wide variations in the DBH of all trees ranging from 5 cm to 30 cm and height varied from 5 m to 25 m in the study plot. The spacing between row-to-row and tree-to-tree was 3m x 4m, respectively. Biomass of all tree components viz. leaf, twig, branch, bole, root etc. was calculated along with productivity of all 10 trees felled. The biomass ranged from 24.99 t ha^{-1} to 291.66 t ha^{-1}. The average total biomass of the present study is 128.33 t ha^{-1} and average productivity is 18.33 t ha^{-1} yr-1. The peak productivity recorded as 41 t ha^{-1} yr-1. Since the trees were grown in farmer's fields along the bunds in a broad strip, the irrigation and fertilizers applied to the farm must have effects on the total biomass. Other biomass components varied as: leaf biomass (2.18 kg tree^{-1} to 13.94 kg tree^{-1}), twig biomass (1.32 to 10.70 kg tree^{-1}), branch biomass (5.07 to 29.37 kg tree^{-1}), bark (3.04 to 28.31 kg tree^{-1}), bole biomass (16.92 to 235.90 kg tree^{-1}) and root biomass/Below Ground Biomass (BGB) (4.17 to 34.04 kg tree^{-1}).

The contribution of individual tree components to total biomass varied as: leaf 5.21%; twig 3.69%, branch 8.66%, bark 8.6%, root 11.16% and bole 62.68%. The percent contributions of all these components in the site is as bole > root > branch > bark > leaf > twig. The percent contribution of bole in the present study is higher than in other studies reported, which can be attributed to addition of fertilizer by farmers in Punjab.

The relationship between different tree components and D2H has been established, which shows linear relationship with all tree components, including total biomass. Prediction Equations were also developed, which showed positive correlations as correlation coefficient (r2) values showed significant correlation between these parameters.

Keywords: *Populus deltoides*, Punjab, biomass, tree components, productivity, prediction equations.

[1] Forest ecology & Environment Division, Forest Research Institute, P. O. New Forest Dehradhun 248 006 U.K., India, E-mail: rawatl@icfre.org

ID-135

POPLAR IN HARYANA - PAST, PRESENT AND FUTURE

R.K. Sapra[1] and P.P. Bhojvaid[2]

The exotic poplars were introduced in India during late 1950s to increase the production of wood.Poplars had shown good performance in the States of Uttar Pradesh, Jammu & Kashmir, Punjab, Haryana, Himachal Pradesh.

Western India Matchwood Company launched a project for promoting poplar (*Populus deltoides*) farming in northern India during mid-eighties. Initially, large farmers adopted poplar farming, as its harvesting period was 8-10 years in Haryana State. To handle the shortage of raw material, plywood/veneer (PV) units modified their machinery to process small sized poplar wood, which led to its adoption by small farmers who harvest trees at 5-7 years. Due to higher profitability of poplar farming, over-supply of its wood took place,which caused crash in its prices in 2000. The Apex Court enforced the licensing of wood-based industries in 2002, which led to closure of 600 PV units in Haryana State. These developments forced many farmers to abandon poplar farming, which helped in stabilizing its prices by 2005.

Presently, PV units have started using substantial quantity of Eucalyptus wood due to reduced availability of poplar wood in Haryana State. This situation has provided an opportunity to the farmers to produce more poplar wood due to attractive prices and higher productivity of new clones. Presently, poplar farming is concentrated in Yamunanagar and adjoining districts, which should be extended all along Yamuna river till Palwal district in Haryana State. The establishment of Medium Density Fibre/Particle Board units, which use small sized timber or the roots, lops and tops of poplar, will further lead to reduction in its harvesting period to 2-3 years. The disease resistant clones of better productivity will be developed, which will further improve the economies of poplar farming. These developments will lead to exponential growth in availability of raw material leading to licensing of new PV units. Consequently, it will increase the forest/tree cover of the Haryana state.

Keywords: poplar farming, clones, PV units, harvesting period, licensing.

[1] APCCF, Van Bhawan, Sector 6, Panchkula, Haryana, India. E-mail: rk_sapraus@yahoo.com
[2] Director, FRI, Dehradun, Uttarakhand, India. E-mail: ppbhoj@icfre.org

ID-157

GROWING POPLAR AS A CASH CROP IN LOWER HIMACHAL PRADESH

Kamal Sharma[1] and R.C. Dhiman[2]

The state of Himachal Pradesh is largely a hilly terrain with some plain areas in low altitude districts of the state. These low altitude locations along with some valley areas are predominantly agriculture-based where growing of poplar (*Populus deltoides*) has been picked up as a cash crop by the farming community on an appreciable scale. Poplar farming in the state is becoming popular because of little care after planting, less labour oriented, increased monkey menace on agricultural and horticultural crops, weather vagaries mainly frost, flexibility in harvesting, readily available market with good price and ultimately high returns per unit area.

The main regions where poplar farming has been picked up as an economical proposition are parts of Una district (2-2.5 lakh saplings) followed by Mand belt of Kangra district (1 to 1.5 lakh saplings), Nalagarh area of Solan district (one lakh saplings) and Paonta valley in Sirmour district (one lakh saplings). On an average, 5-6 lakh poplar saplings are planted in these areas annually. Planting of poplar is also appreciable in Bahl valley of Sundarnagar, Mandi district and in Palampur valley of Kangra district. Some poplar is also grown in other districts. Demand of poplar saplings are met by the University, forest departments and private nurseries.

The main cultivars grown in the state are G 48, Udai, WSL 22, WSL 39, G 3, D 121 etc. Poplar is integrated with annual crops like sugarcane in Paonta, Mand, Una and Indora belt during the initial two years and with wheat, maize, flowers etc. in other years. Recently, some poplar plantations have also been made as a shade tree in tea gardens in Palampur valley. Most of wood grown in the state is traded in the adjoining states like Punjab and Haryana.

Keywords: *Populus deltoides*, farming, plantation demand.

[1] Institute of Biotechnology and Environmental Science, Neri-Hamirpur (HP) - India
[2] Wimco Seedlings, Baghwala, Rudrapur, (UK) – India

INTEGRATION OF TREE WILLOW (*SALIX* SPECIES) IN AGRICULTURE

N.B. Singh[1], J.P. Sharma[1], H.P. Sankhyan[1] and Sarvesh[2]

Willow (*Salix*) is well recognized short-rotation forestry crop throughout the world. It is considered as the life line in Lahaul and Spiti dry temperate region of Himachal Pradesh due to its multifarious uses. The sports industry, particularly cricket manufacturing units, is wholly dependent on the willow timber. Keeping in view its economic and social importance, a research programme was started in the department to develop more productive clones. Around 200 clones were introduced and screened in the nursery in the year 2002-2005. The 15 selected clones were planted in farmer field at Gandhigram, District Solan, H.P. in February 2007 to assess the performance of these clones under agroforestry (peas, tomatoes and oil seeds). The growth data was recorded in February 2012. Perusal of the data revealed that maximum plant height (18.31 m), diameter at breast height (24.62 cm) and volume index (0.861m^3) were obtained by clone J799. All the other clones were behind clone J-799. Lowest plant height (5.45 m), collar diameter (7.56 mm) and volume (0.036 $m^{3)}$ were found in clone SE-63-016. Kashmiri willow (*S. alba* cv *coerulea*) (control) did not perform well and gave plant height, diameter at breast height and volume index of 7.39 m, 10.21 cm and 0.071 m^3, respectively. Overall clone J-799 was found to be the best, followed by clone SI-64-017 and 084/03.

In an another experiment at KVK Lakhimpur Kheri under Chandra Sekhar Azad University of Agriculture and Technology, Kanpur U.P., rice and wheat yield under different *Salix* clones were evaluated during two consecutive years 2009-2010 and 2010-2011. The crop production varied significantly under various clones except wheat production in the year 2010. Rice production under *Salix* clones was at par with the control except under clone J799 in the year 2010. In the year 2011, rice and wheat production was significantly lower than the control.

Keywords: clone, diameter at breast height, phenotypic coefficient of variation, agroforestry.

[1] Department of Tree Improvement and Genetic Resources, Dr Y S Parmar University of Horticulture and Forestry, Solan (HP), India. E-mail: nbsuhf@rediffmail.com

[2] Assistant Professor, Department of Forestry, Chandra Sekhar Azad University of Agriculture and Technology, Kanpur Uttar Pradesh, India.

ID-169

FINE SCALE SITE VARIATION CORRELATED TO GROWTH IN A SALICACEAE PLANTATION (*SALIX* AND *POPULUS*) DURING THE FIRST VEGETATIVE PERIOD

H. Sixto[1], R. Calvo[1], M.M. Sánchez[1], J.A. Arrieta[2], J.M. Otero[2], J. Salvia[3] and I. Cañellas[1]

In a plantation established in 2011 in Valladolid (6.2 ha), a trial is in progress involving six genotypes belonging to different species or hybrid of *Salicaceae* family: 'SA04'(*Salix trianda* x *Salix viminalis*); 'Oudenberg', 'I-214', 'Dorskamp' and 'AF2' (*P .x euramericana*), 'Grimminge' (*P.deltoides* x *P.x interamericana*) for testing their suitability as high density short-rotation energy crops. The objective is to determine whether any interspecific variation exists to identify suitable genotypes for Mediterranean conditions, as well as to detect any intraspecific variation which highlights genotype response heterogeneity in a given area. We try also to identify the site factors which may be associated with this variability. Mechanized plantation was established with a density of 6,666 stems/ha. Both mechanical and chemical treatments were applied for weed control and drip irrigation was also employed. At the end of the first growth season, the height and diameter (10 cm above ground) were assessed in nine sub-plots per genotype, which covered the spatial variability present in the plantation. Basal area per plant was calculated. In the same sub-plots, fifty four soil samples were taken and thirteen variables relating to texture, fertility and chemistry were analyzed. Here we used the mean basal area in each sub-plots.

Based on the AIC, AICC and BIC statistics, the model which gave the best fit was a mixed model with a spatial variance-covariance structure which considers the position of the tree in accordance with the row-column layout, allowing for heteroscedastic variances within the genotypes. The analysis revealed significant differences in the fixed genotype effect ($P<0.0001$). 'AF2' and 'SA04' displayed significantly greater basal area (BA) than the rest in the year of establishment. Similarly, significant intra-specific variability is observed in 'Dorskamp' and 'AF2', as well as in 'SA04', revealing a level of internal variability of approximately seven times that of the rest of the genotypes. Based on a canonical discriminant analysis in which three growth categories were established: adequate (BA>500), discrete (BA 500-300) and poor (BA< 30), the fine scale factors identified as most strongly correlated with growth were low levels of clay, high levels of sand and fine gravel, and low level of carbonate. When the analysis is performed at genotype level, two *ad hoc* growth categories are established in each one, due to the amount of available data and the growth variability within the genotype. The discriminatory factors in the global analysis were, as might be expected, highly influential, but other variables such as pH, silt o fine soil also had an effect on certain genotypes.

The presence of G*E interaction is one of the factors which makes more difficult clonal recommendation. Furthermore, the existence of fine scale soil variability can make production forecasts difficult at local level. It is therefore important to determine the response of the plant material to these soil variations and identify the most influential factors at clonal level in order to achieve a more homogeneous production.

Keywords: poplar, biomass, spatial heterogeneity.

[1] INIA-CIFOR. Crta. de la Coruña km 7,5, 28040 Madrid. E-mail: sixto@inia.es
[2] Iberdrola Renovables, Vía de los Poblados 3, Madrid.
[3] Biopoplar Ibérica. c/Güel 58, 17001Girona. Spain.

ID-127

STATUS OF *POPULUS* PLANTATION SPECIES IN JAMMU AND KASHMIR, INDIA

Syed Tariq, Deepak Khanna and Neelu Gera[1]

The Social Forestry Project was started in Jammu & Kashmir in 1980s with the aim of making the people in rural areas self-sufficient in daily needs of forest products and for overall upliftment of the rural community. Under the farm forestry activities, plantations have been raised on available lands such as grassland, river banks, canal banks, road sides, etc. by the Social Forestry Department. People consider poplar as their most preferred tree species for quick economic returns and took initiatives in planting the trees.

The district-wise data on poplar plantation indicates the preference of the species planted by the people of the valley. Species like *P. alba* (white poplar), *P. tremula* (aspen); *P. nigra* (Italica-black poplar); *P. deltoides* (rousee fras); *P. ciliata* (jungli fras); *P. caspica* (dudh fras) are present in the valley. Of the total trees resource outside the forest, poplar stems constitute the largest in number and volume. In order to give boost to the growing of poplars in the state, a large number of clones were tried. Intensive trials of various clones like *P.* x *eumericana* Robusta 'H'; *P.* x *eumericana* Casale '48'; *P.* x *eumericana* Casale '30'; *P.* x *eumericana* Eugenii 'B'; *P.* x *eumericana* Regenerata; *P.* x *eumericana* Gelerica; *P.* x *eumericana* Renibek 'LJ116' were started in Kashmir valley in 1963 in Chitternar Research Station. A report on recent study done by the Forest Survey of India, Dehradun has been published in March 2011 on various trees including *Populus* trees but information is not available on the species wise number and volume of the different species.

Keywords: poplar, Kashmir valley, clones.

[1] Assistant Director General, Indian Council of Forestry Research and Education (Headquarters), Dehradun, 248006 India. State Forest Research Institute, Near Wood Land School, Sonwar, Srinagar, Kashmir, Jammu and Kashmir, 190001, India

POPLAR PLANTATIONS – A CANADIAN OPPORTUNITY

B.R. Thomas[1]

This paper will highlight the mandate of the Poplar Council of Canada, and focus on a review of opportunity and challenges facing Canadians for plantation forestry. The species and hybrid available are presented, silvicultural options, and regional considerations including climate change, and differing provincial policy.

A range of issues are also discussed that would assist in promoting and incenting the use of poplars across the country and why these opportunities should not be dismissed. The potential use of poplars is much greater than simply fibre for pulp and paper or other traditional forestry end products. Breeding programmes can meet a wide range of objectives through proper selection and testing. Genetic resources, however, must be preserved and a national strategy developed.

Keywords: plantation, breeding programmes, selection, testing.

[1] Chair, Poplar Council of Canada, 5320 – 122nd Street, Edmonton, Alberta, Canada, T6H 3S5. Website: www.poplar.ca, E-mail: poplar@poplar.ca, Genstat@shaw.ca

ID-144

LARGE-SCALE PLANTATIONS OF *POPULUS DELTOIDES* BARTR. IN VAISHALI DISTRICT, BIHAR

Sandeep Tripathi[1], Rameshwar Das[2] and Kumar Mishra[3]

Poplar based agroforestry is being promoted and popularized in India by the Government and wood-based industries to meet the increasing demand of raw material for wood-based industry and fuel-wood, poplar (*Populus deltoides*) was introduced to India in 1950s. Among tested and introduced poplar clones, a few of them are widely grown in northern India The net income from poplar plantations is three times greater than agricultural crops alone. Presently, the adaptation of large-scale poplar-based agroforestry is confined to North-West of India. An attempt has been made to expand poplar culture in the Vaishali District Bihar which is situated between 25^0N-30^0N latitude. The present poplar growing region in Northern India is from 28^0N-48^0N latitude with better ecological conditions for growth. But, the Institute of Forest Productivity, Ranchi under the aegis of the Indian Council of Forestry Research and Education has been successful in establishing large-scale poplar-based agroforestry in the Vaishali District. Farmers are motivated through multi-pronged extension strategies viz. villages meetings, involvement of NGOs, Extension workers, on-farm and off-arm training, kissan nurseries, demonstration centres at farmers' field and buyers-sellers meet.

Around 7.60 million saplings (ETP) of poplar are produced and introduced on farmlands spread over 1,250 villages covering 35,000 farmers in all the 16 administrative blocks of Vaishali District and adjacent blocks of nearby districts. The effort also developed forest nursery-based entrepreneurs among farmers for raising kissan nurseries. Capacity building, development of farmers' skills in forest nurseries, plantation techniques apart from exposure study tours to poplar growing regions were other highlights of the programme. Establishment of model nursery, demonstration centres, clonal garden and hedge garden were also some of the key support activities of this novel initiative. The growth data of plantation forecasts yield of 4-5 quintals per tree at a rotation of 8 years. Even by lower estimate of average survival it is expected to provide a yield of 1,879,300 MT of timber, this will further lead to employment generation. Based on the prevailing market rate of timber and firewood, a yield of more than US$ 200 million is expected from these poplar plantations.

The paper deals in detail with the technical methodology adopted for introduction of *Populus deltoides* along with mass awareness to support these activities and expected socio-economic, and related ecological gains. Further, carbon sequestration of 150,900 MT from project plantation is expected. Individual successes certainly are an indication but the acceptability of farming community to allow tree crop along with agriculture crop is most important breakthrough. Year after year, the message of adoption of agroforestry is going deeper and deeper in mind of farmers and spreading like wild fire. Farmers are interested in taking this calculated risk for getting 3-4 fold increased revenue return from the same piece of land. Poplar is replacing semal, the traditional industrial wood raw material of the area. The initial strategy of "push" the poplar has gradually turned into "pull" (demand) driven stage. The paper deals in detail about the technical methodology adopted for introduction of *Populus deltoides* backed up with mass awareness to support these activities and expected socio-economic, carbon sequestration and related ecological gains.

Keywords: agroforestry, poplar, Kissan nursery, Entire Transplant (ETP).

[1] Deputy Director-General (Research), ICFRE, Dehradun, India. E-mail: sandeeptrip.ifs@gmail.com
[2] Director, Institute of Forest Productivity, Ranchi, India.
[3] Deputy Conservator of Forest, Forest Research Centre, Patna, India.

ID-161

STATUS OF SHORT-ROTATION COPPICES (SRC) WITH POPLAR AND WILLOW IN GERMANY

Georg von Wuehlisch[1]

Increased prices for heat and power as well as subsidization of bio-energy have provoked an area increase of Short-Rotation Coppices (SRC) to 5,000 ha on arable land in Germany. Farmers receive subsidies equaling those for producing foodstuffs while users of wood biomass receive subsidies for combined production of heat and power per unit of energy delivered into grids. Environmental agencies have recognized woody biomass production as the most sustainable form of energy, creating at the same time the lowest CO_2 sequestration costs.

The ability of *Salicaceae* to fix atmospheric Nitrogen is an important criterion in this respect. "Greening" as the new instrument of European Common Agriculture Policies to raise biodiversity may give further stimulus to SRC if recognized to fulfill Greening requirements. Civic heat grids are common in East German communities and it is also there that marginal arable land is available for SRC. Most plantations are located around Berlin. Poplar and willow are grown on about equal area. Poplar hybrid clones of the Tacamahaca Section, mainly Max 1, NE 42 and willow hybrid clones, mainly Tordis, Inger, Tora of Swedish breed are preferred. However, additional clones are required. Usual planting densities around 10,000 cuttings per ha result in high establishment expenses of USD3,000 per ha. In some federal lands farmers may receive grants for plantation establishment. Willows are coppiced every 2-3 years and poplars every 3-4 years because in the fourth year biomass increase in poplars is still substantial but not in willow. Harvesting costs with combined harvester chippers are lower than conventional forest equipment; however the chips need to be dried for storage. Better, but equally inexpensive, harvesting systems should be developed. Utility companies are taking farmers under contract to produce wood biomass. This may be preferable on marginal sites, non-competitive for foodstuffs production, because with respect to the high investment, a farmer has to commit his land for a period of at least 20 years.

Keywords: short-rotation coppice, renewable energy, production models, sustainability.

[1] Johann Heinrich von Thuenen-Institute, Institute for Forest Genetics, Sieker Landstrasse 2, 22927 Grosshansdorf, Germany. E-mail: georg.vonwuehlisch@vti.bund.de

ID-158

POPLAR AND WILLOW BIOMASS FROM MARGINAL LAND? PRODUCTION, ECOLOGICAL AND ENVIRONMENTAL IMPLICATIONS

Martin Weih[1]

With the advent of the biofuels craze, all land is being scrutinized for its ability to produce biomass for bio-energy and bio-based materials, even degraded and marginal land. As a consequence, the increasing demand for biomass is generating land-use conflicts. Land-use conflicts could be solved through spatial segregation of food/feed and biomass producing areas by continuing producing food on established and productive agricultural land and growing dedicated energy crops on "surplus" or "marginal" land. Marginal land is frequently characterized by poor soil quality, i.e., poor soil performance (low nutrient availability, low organic matter, high degree of degradation) and poor soil resilience (ability to recover after disturbance). The biomass crops to be grown on marginal land must be able to cope with poor soil quality and produce relatively large amounts of biomass with low resource input.

Ideally, the biomass crops to be grown on marginal land need to be high-yielding, resource efficient, stress tolerant, readily adopted (not requiring novel cultural practices), well adapted to local conditions (short transport distances), possess desirable feedstock qualities, and have some breeding history. Many of these properties can be combined by poplars (*Populus* spp.) and willows (*Salix* spp.). Possibilities for crop improvements include the selection of new crops, breeding of new varieties and improved management. Ultimately, the improvements should result in higher yields and/or better resource utilization, e.g., high energy output per unit of invested energy (or resource). Major focus for improvements (e.g. crop selection, breeding) should not be on yields under optimum conditions, but also low-resource conditions and stress tolerance (e.g. nutrient use efficiency, water use efficiency). The utilization of natural processes (e.g. mycorrhizas and other beneficial soil organisms) should be increasingly considered in the development of sustainable biomass production systems on marginal land.

As the use of land is a key link between human activities and the environment, land use change is also one of the major drivers of environmental and biodiversity change. Conflicts emerging from the demand for land will require land-use decisions that involve trade-offs among and between those demands and objectives for environment and sustainable development. Without mastering the sustainability challenge, the ultimate objectives of mitigating climate change, obtaining independence from fossil fuels, feeding and fuelling a growing human world population and maintaining biodiversity and ecosystem services will not be met. We need to determine which biomass production systems are most adequate for the respective types of land, including marginal land, by taking into account issues such as yields that realistically could be achieved on those lands; inputs and costs, as well as potential environmental and socio-economic impacts.

Keywords: biodiversity, biomass production, decision making, land-use change, *Populus*, resource-use efficiency, *Salix,* trade-offs.

[1] Swedish University of Agricultural Sciences (SLU), Dept. of Crop Production Ecology, Ulls väg 16, SE-75007 Uppsala, Sweden. E-mail: martin.weih@slu.se

ID-001

GRAFTING ON STUMPS OF AGING AND INEFFICIENT POPLARS FOR REGENERATION OF SHELTERBELTS

Li-Juan Wu[1]

As an important forest species in afforestation in China, *Populus* is wildly planted for industrious timber and shelters in northern China. In 1970s, poplar-based shelters were built as main shelterbelt for the farmland in Daxing district of Beijing. To the late 1990s, the poplar shelters started aging, as evidenced by the slow growth and even death. There were 7,785.2 ha pure poplar plantations accounting for 79.90% of the total 9,744.1 ha of shelterbelts. In addition, approximately 4,749.4 ha of such poplar shelterbelts were established by using two clones, *P. canadensis* and *P. simonii* × (*P. pyramidalis* + *Salix matsudana*). Obviously, regeneration of poplar shelterbelt was needed urgently. Conventional reforestation needs a large amount of excellent seedlings leading to a high cost. Therefore, a reforestation technology should be in place to achieve full ecological functions and increasingly economic benefit.

Since 2003, we have started to use grafting techniques on poplar stumps and management of grafted seedlings on poplar stumps. The main results were obtained as followings: (1) The optimal ages of *P. canadensis* and *P. simonii* × (*P. pyramidalis*+*Salix matsudana*) for efficient regeneration by grafting were respectively defined as 26a and 20a; (2) *P. canadensis* cv. 'Neva', 'Guariento' and other five clones were screened as appropriate clones for grafting seedlings, due to their fine stump affinity, fast growth and strong resistance; (3) A set of measures in management of stump grafted seedlings and young trees were developed; (4) Regenerated stands (RS) through stump-grafting had more density, distribution breadth, absorption studs of root, comparing to the normal plantation (NP) in the same year established with seedlings; (5) RS had more average DBH per year, total biomass and the carbon sink capacity when compared to NP; (6) RS had many additional advantages, such as saving irrigation water with 75%, omitting the site preparation, fixing dust by the remained stumps, and significantly improving the survival and growth; (7) RS saved nearly 50% of the cost for NP. These results provide an excellent example for practical application of grafting techniques on poplar stumps.

Keywords: *Populus*, aging shelterbelt, regeneration, stump-grafting, low cost.

[1] Forestry Workstation of Daxing District, Beijing 102600, People's Republic of China. Tel: +86 13811712757, E-mail: 2543520739@qq.com

BIOLOGY AND CONTROL OF *PHALANTHA PHALANTHA* DRURY – A SERIOUS PEST OF *POPULUS DELTOIDES* BARTR. IN UTTARAKHAND, INDIA

Shamila Kalia[1], Rajani Walia[1] and D.P. Semwal[2]

Phalantha phalantha Drury is a serious pest of *Populus deltoides* Bartr., especially during monsoons. Its larvea is a voracious feeder of both young and mature leaves leaving behind the midrib. The biology of *Phalantha phalantha* Drury was studied in the laboratory, outdoor wire meshed cages of insectary as well as in the field conditions on poplar. Adult butterfly lays 1-3 eggs at the apical end on the same or different shoot. Life-history studies reveal that under normal biotic conditions, the pest undergoes 4-5 generations and all the generations overlap considerably.

Further control of the pest was also worked upon so that the pest could be controlled during the attack in monsoons on poplars. Keeping in view the harmful and hazardous after-effects of chemicals, experiments were carried out with plant-extract based formulations for its control. Extracts of two plants viz. powder of *Eucalyptus* leaf and powder of *Jatropha curcas* seeds were evaluated for the efficacy against this pest. A significant reduction in mean larval weight (88%) was observed with these test formulations. The larval populations could not reach the crucial late instar stage, actually responsible for damage. Second instar larvae were found to be more sensitive than the third and fifth instar larvea of *Phalantha phalantha.* This suggests that the pest should be targeted at an earlier stage of growth. These compounds have the potential to restrict the pest population in the early instar stage, resulting in the death of the larvae thereby helping prevent damage.

The experiments revealed that the formulations prepared were effective at disrupting the behaviour and physiology of this pest and could be used as alternatives for the control of *Phalantha phalantha* once efficacy is proven at the field level.

Keywords*: Populus deltoides,* nymphalidae, life cycle, *Phalantha phalantha.*

[1] Forest Research Institute, P.O. New Forest, Dehradun, India, 248006. E-mail: shamila@icfre.org
[2] IT Commissioner, Income Tax Office, Dehradun, India, 248001.

LARGE-SCALE WILLOW MORTALITY IN LAHAUL VALLEY, HIMACHAL PRADESH: SOME ISSUES OF IMMEDIATE CONCERN

K.S. Kapoor[1], V.R.R. Singh and Sunil Marpa[2]

Lahaul, forming a part of the district Lahaul and Spiti, the largest district of the state of Himachal Pradesh, and having most fragile ecology with special reference to North-west Himalayas, is situated in between $70^0 46' 29''$ to $78^0 41' 34''$ E Longitude and $31^0 41' 57''$ to $32^0 59' 57''$ N Latitude. The district, with a population density of two persons/sq.km, forms the remotest frontiers of the state. As far as the physiographic and climatic parameters of the area are concerned, it mainly falls in the cold desert region with some part of it dotting the dry temperate zone of the state. Precipitation is mainly in the form of snow and water deficiency exists primarily because of the absence of monsoon rains. Mainstay of the people here is agriculture , which as per the landuse statistics is possible only in 0.40 per cent of its geographical area, and animal husbandry (cattle population approximately being 2.1% higher than the human population). Proportion of the cultivated land is also quite low (0.38%), whereas the forest lands constitutes 15% of the geographical area of this district. Summers (June to September), the major growth period for the botanical elements, is quite short and accordingly, woody elements require more time to grow, develop and establish themselves.

Salix Linn, belonging to the Salicaceae family, is a deciduous tree or a shrub and is commonly known as willow. Speaking regionally, it is called as Valley in Lahaul and Changma in Spiti and is certainly a Gift Tree of the area because of its multifarious uses providing fuel-wood, fodder, house building and construction material for the local people. Because of its high relevance and socio-economic significance to the people of this remote and rugged area, every individual family in the region has its own patch of willow trees growing either on the corners or at the boundaries of their fields. People had also been found growing the *Saliix* species in the village common lands. Data revealed that about 3,000 ha of forest land had been covered with willow plantation which constitutes 20% of the total forest cover of Lahaul Forest Division. Out of this total coverage, 200 ha are in the farmer's fields, 1,500 ha in the forest land but grown by the local farmers and the remaining 1,300 ha are the plantations established by the State Forest Department, mostly monocultures, except for few mixed plantations of willows and poplars.

Recent large-scale mortality in Lahaul Valley, however, is a matter of serious concern and accordingly, studied in detail. In-depth analysis revealed that repeated propagation of the old planting stock, establishment of monocultures, changes in the climatic conditions, inconsistent snowfall, reduced supply of water etc., made the species prone to all these natural vagaries, including aphid attacks, thereby leading to this heavy toll. Accordingly, all this has been attempted in the present paper and discussed keeping in mind the limited land resource, large-scale dependence of the local people, limited choice of the tree species for this harsh terrain which will help us to think, plan and work for the long term sustainability of this unique eco-system and that too in a unique way, ultimately striving to conserve and manage the unique resource on sustainable basis.

Keywords: willow mortality, Lahaul, cold deserts, monocultures, landuse and precipitation.

[1] Himalayan Forest Research Institute, Conifer Campus: Panthaghati, Shimla, 171 009 (HP), India. E-mail: kapoorks@icfre.org
[2] Present Address: Senior Research Fellow GBPIHED, Kullu Unit MOHAL Distt. Kullu (HP).

MASS PRODUCTION OF POPLAR CATERPILLAR, *CONDYLORRHIZA VESTIGIALIS* GUENEE, 1854 ON ARTIFICIAL DIET, IN LABORATORY CONDITIONS

E.B. Machado[1], B. Santos[2] and M. Steenackers[3]

The caterpillar *Condylorrhiza vestigialis* Guenée, 1854 (Lepidoptera: Crambidae) is one of the major problems encountered by poplar culture in Brazil. The caterpillar causes intense defoliation. Studies indicate the possibility of biological control of the caterpillar using one of its natural enemies, namely the *Condylorrhiza vestigialis* multiple nucleopolyhedrovirus (CoveMNPV). This virus proved to be harmless for humans as well as for the environment. The present study aims to develop an artificial diet for mass production of *C. vestigialis* in laboratory conditions, in order to reproduce the virus as it only develops into living insects.

The caterpillars were kept in an acclimatized room at 27°C ± 2°C, 60 ± 10% RH and a photoperiod of 12h.The artificial virus-free diet (GREENE, 1976) consisted of white beans, wheat germ, soy protein, casein, yeast, agar, V8 vegetable juice, a vitamin complex specific to the species, sorbic and ascorbic acid, tetracycline and dried poplar leafs. Caterpillars developed to moths which in their turn produced eggs. The eggs of *C. vestigialis* obtained daily were placed per 200 in paraffin cardboard cups containing about 50 ml of artificial diet and kept in an acclimatized room for 10 days. Subsequently, about 200 caterpillars, in the beginning of the fourth instar, were transferred to plastic boxes containing 240 grams of artificial diet now inoculated with CoveMNPV. The boxes were kept in an acclimatized room for-seven to eight days. In these conditions, about six grams of virus contaminated material can be produced. The caterpillars killed by the virus were collected and stored at a temperature of -5 ºC awaiting the production of a wettable powder for field application. The established system allowed the production of a virus-based bio-insecticide, enabling the yearly treatment of 3,000 hectares of poplar forests. In these controlled conditions, high quality raw material is continuously produced, allowing the most appropriate environmental planning.

Keywords: poplar, caterpillar, *Condylorrhiza vestigialis*, nucleopolyhedrovirus (CoveMNPV), biological control.

[1] Swedish Match do Brasil S.A. Travessa Pinheiro, 194 Curitiba, Paraná, Brazil. E-mail: edilene.machado@swedishmatch.com.br

[2] Universidade Federal do Paraná (UFPR), Caixa Postal 19031, CEP 81531-980, Curitiba, Paraná, Brazil. E-mail: Bsantos@ufpr.br

[3] Research Institute for Nature and Forest (INBO), Gaverstraat 4, 9500 Geraardsbergen, Belgium. E-mail: marijke.steenackers@inbo.be

ID-190

ADVANCES IN THE STUDY OF SUSCEPTIBILITY OF *POPULUS NIGRA* CLONES TO THE ATTACKS OF *RHYTIDODUS DECIMUSQUARTUS* (SCHRANK) IN MENDOZA, ARGENTINA

D.A. Rabinovich[1], M.G. Holgado[1], N. Riu[2], M.J. Battaglia [1] and M. Molina [1]

Rhytidodus decimusquartus is a Cicadellidae that affects the forest curtains of *P. nigra* 'Italic' and *P. nigra* 'Chile', with a very high population density. While nymphs produce big amounts of honeydew, adults disturb nearby residents, invading their homes. These problems are serious in certain places of the province. For this reason, it is essential to study the behavior of the "leafhopper".

The objective of this work is to establish the degree of intensity and severity of *Rhytidodus* attacks on clones of *P. nigra*. Monitoring was carried out in the collection of the Department of Forestry, Faculty of Agricultural Sciences, UNCuyo. The observations started in autumn 2012, before leaf fall. We analyzed the variable "number of oviposition scars on petioles per plant" in 14 two-year old poplar clones. Attacks on leaves from four branches oriented toward the cardinal points in five plants of each clone were counted. Statistical analysis was performed using the program estatgraphics. A comparison of the proportion of plants affected in each clone used chi-square test. We also assessed the severity of the attacks by setting an arbitrary scale.

About intensity, all the clones were ovipositions. With regard to the severity, the clone *P. nigra* 'Blanc de Garonne' presented the highest scars number, indicating a preference of *R. decimusquartus* to oviposit, while clone *P. nigra* 'Chile' had significantly less severe manifestations. However, the observations should continue to determine the further development of this species in the clones under study, its population growth and to detect those clones which are less susceptible to this pest to be used in commercial forest plantations.

Keywords: Cicadellidae, incidence, severity, oviposition preference.

[1] Cátedra de Zoología Agrícola – Departamento de Ciencias Biológicas, Facultad de Ciencias Agrarias, UNCuyo. Alte. Brown 500. Chacras de Coria. Mendoza. Argentina

[2]Cátedra de Dasonomía – Departamento de Producción Agropecuaria - Facultad de Ciencias Agrarias – UNCuyo. Alte. Brown 500. Chacras de Coria. Mendoza. Argentina. E-mail: mholgado@fca.uncu.edu.ar

ID-040

SOME INSECT SPECIES ON POPLAR PLANTATIONS IN MARMARA REGION OF TURKEY

Fazıl Selek[1]

Poplar plantations are very important for the supply of timber in Turkey. Insect attacks decrease the wood increment. Regular observation of poplar plantations gives an effective opportunity to control insect epidemic.

In this study, poplar plantations of Marmara Region were deeply observed from January 2012 until today. Damaged leaves, branches and stem samples of poplar trees were collected and observed in laboratory. Eggs, larvae, pupae and adults were calculated and recorded. Some parasites and predators of different insects were obtained.

As a result, these insects were identified: *Lymantria dispar, Melanophila picta, Paranthrene tabaniformis, Melasoma populi, Pristiphora conjugata, Cripthorrynchus lapathi, Pheosia tremula, Lithocolletis populifoliella, Capnodis miliaris, Malacosoma neustria, Gypsonoma dealbana, Nycteola asiatica.*

L. dispar show epidemic periodically every five years in Turkey. *M. picta* could be effective especially in drought periods, *P. tabaniformis* and *C. lapathi* can attack at any moment and they are very dangerous insect species.

Keywords: poplar plantations, observation, insect epidemic.

[1] Poplar Research Institute, 41001 Ovacik Mahallesi, Hasat Sokak, Basiskele, Kocaeli, Turkey. E-mail: kavakxx@gmail.com

INTEGRATED PEST MANAGEMENT OF POPLARS UNDER AGROFORESTRY IN NORTHERN INDIA

Arun P. Singh[1]

Over 125 species of insects have been recorded infesting poplars, both native and exotic, in India. The posters highlights most important pests under agroforestry in northern India, namely plantation pests defoliators, *Clostera cupreata* and *C.furgurita*; poplar stem borer, *Apriona cinerea*; nursery pests; poplar shoot borer, *Eucosma glaciata*; Leopard butterfly, *Phalantha phalantha*; poplar leaf beetle, *Nodostoma waterhousie*, white grubs, *Holotrichia* sp., *Granida* spp., *Brhamina* spp. and Termites, *Copototermes heimi* and *Odontotermis distans*.

Distribution, nature of damage, infestation period, symptoms of attack, potential impact and control measures including, cultural, natural enemies, tolerant clones and chemical are highlighted for each of these pests.

Keywords: IPM, biological control, poplar clones, cultural methods, lepidoptera, coleoptera, isoptera, hemiptera, NPV.

[1] Rain Forest Research Institute, P.O.Box #136, Sotai, Jorhat, Assam, India-785001. E-mail: singhap@icfre.org

ID-185

PLANTS EFFICACY AGAINST POPLAR DEFOLIATOR *CLOSTERA CUPREATA*

K.P. Singh and Rashmi[1]

Integrated pest management (IPM) has been the most recent method of pest control. IPM is a combination of various methods being utilized in management of insect pests without disruption of the environment. Nowadays, chemists and entomologists together are trying different new tools compatible with IPM concepts without disturbing the ecosystem. These tools include the use of plant extracts, biopesticides, microbial control, pheromones and by genetic manipulation. Keeping these facts in view, the present study was undertaken to investigate the larvicidal activities of *Calotropis procera* and *Plumbago zeylinica* leaves against Poplar defoliator, *Clostera cupreata* under laboratory conditions as well to assess the chemical nature of the active components present in the extracts.

The 3rd instar larvae of *C. cupreata* were exposed to a wide range of concentrations (0.0625 to 2.00%) of LC50 value of each sample along with their control. The data indicate that *C. procera* and *P. zeylinica* leaf may be utilized as the probable candidates for the development of biopesticide to control the population of Poplar defoliators as safer and economic alternatives to the synthetic insecticides. The phytochemical analysis of these extracts suggested the presence of alkaloids, glycosides, saponins, proteins, terpenoids, sterols and flavonoids. The larvicidal property of the *C. procera* and *P. zeylinica* leaves may be due to the presence of possessing different bioactivities which exhibit potential to cause interference into the normal metabolism of the insects. The alkaloids reported to be present in the latex of *C. procera* have been shown to contain insecticidal properties.

Keywords: *Calotropis procera*, *Plumbago zeylinica*, larvicidal property, poplar, *Clostera cupreata*

[1] Chemistry Division, Forest Research Institute, P. O. New Forest- 248006, Dehradun, Uttarakhand, India. E-mail: rashmi@icfre.org

ID-152

THREATS TO WILLOW PLANTATIONS FROM INSECT-PESTS UNDER CHANGING CLIMATIC CONDITIONS

Ranjeet Singh and V.R.R. Singh[1]

Willow is one of the most versatile, fast growing and useful woody plant suited to temperate climate. It not only occupies the important place in the landscape of Kashmir Valley, Ladakh region and higher altitudes of Himachal Pradesh but also in the economy of these states and its people too. It is cultivated along the river beds, nallas, irrigation channels, around agriculture fields as block plantation and also as ornamentals in the gardens and lawns. Willows also form the major source of firewood (82.43%), raw material for industries like cricket bats. Beside these uses, willow is also used as fodder both fresh and dried form. Willow of economic importance has been introduced in Kashmir between 1918-1927 and the most important introduction is *Salix alba*, *S.caprea*, *S.fragalis*, *S.matsudana* and *S.viminalis*.

The cold arid zone of Jammu and Kashmir includes Leh and Kargil districts, and Lahual & Spiti Valley of Himachal Pradesh, which lies at an altitude of 8,000-25000 ft. above the sea level. The zone is characterized by extreme aridity coupled with prolonged winters, sub-zero temperature and scanty precipitation. In spite of harsh winters, the summers appear to be very conductive for insect pest development. Several crop losses due to insects in the zone have previously been reported.Willows act as hosts to a large number of insects. Some are especially dependent on willow while others are polyphagous, also attack many other additional tree species. The insect attacking the willow can be divided into four group's viz. borers, defoliators, sapsuckers and gall formers. Insect which make galleries in the bark and wood of willow are most serious when the bole is affected and the wood is made unfit for profitable use. Among them, there are about two hundred species of defoliators which caused injury to the plant. Insects which feed by the sucking the sap of willows caused damage by injecting their saliva into the plant which has a toxic effect on the tissues or infected the plant by transmission of diseases especially virus infection. The gall forming insects resulted in gall formation.

Keeping in view the importance of willow in this region, studies were concentrated on important insect pests associated with and have been explained in this paper. Major insect pests associated with willow plantation are *Yponomeuta rorellus*, *Tuberolachnus salignus*, *Chionospis salicis*, *Cossus cossus* and gall-forming insects.

Keywords: Kashmir Valley, virus infection, gall-forming insects.

[1] Himalayan Forest Research Institute, (Indian Council of Forestry Research and Education), Conifer Campus, Shimla (Himachal Pradesh), India. E-mail: ranjeet662@yahoo.co.in

ID-147

FAUNISTIC SURVEY OF TERMITES CAUSING DAMAGE ON POPLAR AND THEIR MANAGEMENT

Vivek Tyagi[1] and Shamila Kalia[2]

Numerous insect fauna have been recorded to infest poplars in India and elsewhere. Termites, being one of them, have been found causing damage in forest nurseries, plantations as well as in storage conditions in poplars. The present paper is the work on faunistic surveys, status and damage of termites carried out for the first time in nine districts of Western Uttar Pradesh in India.

The termite species identified and recorded damaging *Populus* sp. were *Microcerotermes fletcheri, Odontotermes distans, O. feae, O. obesus* and *Microtermes mycophagus*. During observations, it was noted that certain woods appear to have greater immunity to termite attack than others. It was also observed that these termites strongly preferred the poplar wood in comparison to others.

The damage occurred below the ground level. Termites begin their attack below ground-level in the upper 20 cm of the soil layer, the tap-root ring-barked and the attack extending a short distance above the ground as well. This often resulted in the death of seedlings and young trees.

In addition to the above a review of different control measures has also been included to make available poplar less susceptible to termites.

Keywords: insects, damages, poplar wood, Western Uttar Pradesh.

[1] Project Assistant, Division of Entomology, Forest Research Institute, Dehradun-248006, Uttarakhand, India. E-mail: vivektyagi.fri@gmail.com

[2] Additional Director, Panchayat & Human Dimensions, ICFRE, Dehradun-248006, Uttarakhand, India. E-mail: shamila@icfre.org

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RELATIONSHIP OF TANNIN AND AMINO ACID CONTENTS OF MAIN POPLAR STRAINS WITH THE DAMAGE OF *XYLOTRECHUS RUSTICUS* (L.) IN HEILONGJIANG PROVINCE

Shan-Chun Yan, Hong Cheng, Jian Zhang and De-Fu Chi[1]

The food selection, growth, and fecundity of insect herbivores are largely dictated by the chemical composition and nutritive values of plant. Gray tiger longicorn beetle, *Xylotrechus rusticus* (L.) is a typical oligophagous pest insect, mainly boring in trunks of *Populus* spp.. Tannin is known as an important secondary metabolite which plays an essential role in plant defense to insect. The amino acids are essential nutrient and play a potential role in insect host selection. The purpose of our study was to examine whether tannin contents and amino acid compositions in xylem and phloem from different poplar strains affect the host plant selection of gray tiger longicorn beetle; the relationships of tannin contents and amino acid compositions in xylem and phloem with damaged ratio of poplar and larvae density of *X. rusticus* in poplar stems.

The phloem and xylem samples from different poplar strains were collected, including 35-year old *Populus pseudo-simonii*, 24-year old *P. pseudo-simonii*×*P. nigra*, 24-year old *P. simonii*×*P. nigra*, 16-year old *P. koreana*, 27-year old *P. simonii* and 40-year old *P. simonii*. Most of the samples were collected at 2.5m height of the trunks from all the strains. In addition, samples were also collected at 1.0m and 4.0m heights from 27-year old *P. simonii*. The tannin contents, amino acid compositions and relative contents in the phloem and xylem samples were analyzed. A significant difference in tannin content was found in phloem among different poplar strains, while the difference in xylem was not obvious. The damaged ratio of poplar was not correlated with tannin content. Negative correlation between tannin content and larvae density of *X. rusticus* was obvious. *P. pseudo-simonii* had high tannin content, but also had high damaged ratio and low average larvae density, while *P. simonii*×*P. nigra* had low tannin content, but was not damaged by *X. rusticus;* its resistance mechanism to *X. rusticus* needs to be further researched. Applying tannin to poplar stems has a repellent effect on the adults of *X. rusticus*, which has a positive relation with tannin dosage.

Fifteen amino acids including Ala, Arg, Asp, Cys, Cyss, Glu, Gly, Ile, Leu, Lys, Phe, Pro, Ser, Thr and His were detected in the phloem at 2.5 m height of stem of tested poplar strains; the kinds of amino acids in the xylem were similar to that in the phloem, except that Val instead of His was present in the xylem. In the phloem, the relative contents of the same amino acids in different poplar strains were remarkably different, but there was no significant correlation between amino acid relative contents and the ratio of damaged trees. In xylem, the relative contents of the same amino acids in different poplar strains were also remarkably different, but there was significant positive correlation between amino acid relative contents and the ratio of damaged trees. The results suggested that the higher the amino acid relative contents in xylem, the better for the growth and development of *X. rusticus* larvae. In *P. pseudo-simonii*, the 15 kinds of amino acids were all present with their contents in rather balanced level in the xylem, and the rate of damaged trees was as high as 84%. In *P. simonii* × *P. nigra*, only 4 kinds of amino acids were present with their contents in relatively lower level, and in *P. koreana*, 13 kinds of amino acids were present with their relative contents not balanced; the both strains showed high resistance to

[1] Northeast Forestry University, Harbin 150040, China.

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X. rusticus. The rate of damaged trees showed no correlation with the relative contents of amino acids in different heights of trees.

Keywords: *Xylotrechus rusticus*, popular strains, tannin, amino acid, phloem, xylem, resistance to insects.

PHYTOPATHOLOGICAL PROBLEMS IN SHORT-ROTATION PLANTATIONS OF POPLAR AND WILLOW FOR BIOENERGY PRODUCTION

Naldo Anselmi[1] and Achille Giorcelli[2]

Short-rotation forestry (SRF) plantations of poplar and willow is a very good opportunity for production of bioenergy. However, several diseases could strongly reduce the wood production and therefore these plantations must be very carefully monitored. The SRF stands present several characteristics that may induce parasite attacks: (1) high density of plants, which implies high competition for water and nutrient supply; high moisture and prolonged periods of wetness in connection with limited gas exchanges and lack of light; frequent anastomoses among roots of different stumps; (2) constant sprouting of green tissue during the most part of the growing season; and (3) presence of large wounds and cut surfaces due to repeated coppicing

The strong water stress connected with increasingly frequent droughts may heavily reduce stump survival due to intensified competition for water and nutrients. Limited air exchange and weak light may increase the attacks by sooty mould fungi, associated with attacks of leaf sucker insects. The high moisture level under the close canopy is conducive to attacks by *Marssonina* spp. *and Melampsora* spp. on poplar and willow, and by *Gloeosporium salicis* on willow. In the recent years, *Melampsora* rusts, in particular, have been typical limiting factors to stump survival in SRF, rather than in terms of quantitative losses of dry matter, and they represent a constraint in genetic renewal. The weakening of plants due to high competition is a triggering factor for bark necrosis by *Discosporium populeum* on poplar, *Discella carbonacea* on willow and by *Citospora* spp. and by *Phomopsis* spp. on both *taxa*.

Fluctuations of the water table are putative factors for root rots by *Rosellinia necatrix* which, especially after repeated coppicing, may extend throughout all stumps and remarkably increase their mortality. Besides, wood rots by *Auricularia*, *Chondrostereum purpureum*, *Stereum* spp. and others fungi may occur inside stumps and progressively induce early mortality.

Keywords: *Populus*, *Salix*, SRF, diseases, water stress.

[1] Department for Innovation in Biological, Agro-food and Forest systems (DIBAF), University of Tuscia, Via S. Camillo De Lellis snc, 01100 Viterbo, Italy. E-mail: anselmi@unitus.it

[2] CRA (Agricultural Research Council), PLF (Research Unit for Intensive Wood Production), Strada per Frassineto 35, 15033 Casale Monferrato (AL), Italy. E-mail: achille.giorcelli@entecra.it

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IMPACT OF APPLE RHIZOSPHERIC BACTERIA AS CROSS INOCULANTS IN WILLOW FOR DISEASE REDUCTION AND GROWTH PROMOTING ACTIVITY

Sunita Chandel[1], Durga Prasad Bhandari[1] and Manoj Kumar Singh[2]

Willow (*Salix* sp.) is considered as a deciduous, perennial biomass crop belonging to family *Salicaceae*. It has multifarious uses and especially grown for energy production with additional potential for the bio-filtration of waste water and sewage sludge, besides being used in making sport articles, artificial limb and paper industry.

Willow has a limited genetic variation, raising fears of large populations being affected in the event of a disease outbreak. Diseases that appear to affect willow plantations are many but damping-off and bacterial blight often appeared in nurseries that interfere with the growth of the plant and on severe infections resulted into mortality of the plants. The pathogens *Fusarium oxysporum*, *Rhizoctonia solani*, *Pythium irregulare* and *Pseudomonas* spp. were recorded for the first time in seedlings grown in research nurseries at Dr.Y. S. Parmar University of Horticulture and Forestry, Solan (H.P.). Looking into high mortality rate, it was proposed to study the role of different naturally occurring plant growth promoting bacteria (PGPRs), i.e. *Bacillus* sp. (BS_1 & BS_2) and *Pseudomonas* sp. (P_1 & P_2), as cross inoculants collected from the apple rhizosphere zones. The PGPR bacteria were characterized based on morphological, biochemical and molecular studies. Both the species of *Bacillus* sp. and *Pseudomonas* sp. were found to decrease the damping-off and wilt infection. Maximum seedling growth such as root, shoot length and increased number of leaves were recorded after two months of inoculations. While untreated (control), plants resulted more than 20 per cent disease severity which was maximum as per 0-5 rating scale. No sign of disease symptom was recorded in PGPR treated plants. Hence application of such plant growth promoting rhizobacteria may be an important substitute for producing healthy and sustainable agroforestry system.

Keywords: willow, PGPR, cross inoculation, apple rhizosphere, damoping-off, wilt.

[1] Department of Mycology and Plant Pathology, Dr.Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) 173230, India. E-mail: schandelmpp@rediffmail.com

[2] Department of Tree Improvement and Genetic Resources, Dr.Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) 173230, India.

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VARIATION IN NATURAL DECAY RESISTANCE IN *POPULUS DELTOIDES* CLONES

N.S.K. Harsh, Suresh Chandra, Vishal Kumar and R.C. Dhiman[1]

Due to their fast growth and productivity, poplars are ideal for agroforestry and farm forestry. Generally it is believed that poplar wood is not durable but the present study showed that poplar wood exhibited natural decay resistance.

Natural decay resistance of wood is the inherent quality of wood to resist the attack by fungi. Accelerated laboratory tests for determining natural decay resistance in poplar wood revealed that there is definite variation among *P. deltoides* clones G-48 and G-3 from different locations for decay resistance. While the G-48 clone from Pind Khakli, Hoshiyarpur (Punjab) showed Class I (Highly resistant) resistance, G-48 clone from Hariana Bungha, Hoshiyarpur and Tajowal Mand, Kathgarh, Hoshiyarpur were in Class IV (non-resistant). Similarly G-3 clone from Brahman Majra, Jagadhri Tehsil, Yamunanagar (Haryana) showed Class II resistance against decay but G-3 from Hariana Bungha, Hoshiyarpur and Pind Khakli, Hoshiyarpur were non-resistant (Class IV).

Clone G-48 from Pind Khakli, Hoshiyarpur was found to be highly resistant clone against decay. This material can be used for making decay resistant plywood as well as for doors, windows, panel and furniture making.

Decay resistance was found to vary within a tree from base to top, maximum resistance observed at 2.5 m height, above and below it decreased considerably. Resistance was more at the base than at the top of the tree. This quality can be used for selecting logs one meter above and below 2.5 meters from the base for selecting material for manufacturing decay resistant plywood and panels.

The materials assessed for natural decay resistance were obtained from trees of different age groups starting from 4-5 years to 16 years, however, age of trees was not found to show any relation to decay resistance as the wood from 4-5 years of tree was found in the same resistant Class as from the tree of 16 years of age. Similarly wood samples from the trees of 5-7 years of age showed wide variation in decay resistance from Class I to Class IV.

Poplar wood showing resistance against decay will have potential for other uses, such as furniture making, construction, paneling, and will fetch good price to the growers.

Keywords: natural decay resistance, *Populus deltoides*.

[1] Forest Pathology Division, Forest Research Institute, P.O. New Forest, Dehradun, 248006, Uttarakhand. India. WIMCO Seedlings Ltd., Rudrapur

FIRST REPORT OF *BIPOLARIS SPICIFERA* AND *B. SETARIAE* ON *POPULUS DELTOIDES* IN INDIA

Sajala Mishra, Y.P. Singh, U.S. Singh[1], R.C. Dhiman[2], K. Uniyal and J.N. Gandhi[2]

The genus *Populus* represents a significant component of the world's potential renewable resources for the 21st century. *P. deltoides* is the main introduced poplar, which is widely grown in the Indo-Gangetic plains of North West India. Poplar suffers from a number of abiotic and biotic agents. Among potential diseases, *Bipolaris* blight caused by *Bipolaris maydis* of *P. deltoides* was first reported by Chauhan and Pandey in 1992 from India. Bipolaris leaf blight, a major foliage disease of the recent past, was revisited to gather information about its status in field and pathogen. Nine full sib populations (having G-3 as one of the parents) were assessed during 2008-2009 for the disease status over time. r-DNA sequence analysis was used for the identification of the pathogen besides morphological characters.

The average range of blight was 34.2 (S7C8xG-3) to 58.9 (IN 163xG-3) per cent in 2008, while it was 4.8 (W-A/49xG-3) to 87.5 per cent (CC-4xG-3) in 2009. Parent, Wimco 39xG-3, was affected at maximum (77.3%) and S7C8xG-3 at minimum (37.9%) with blight during 2008. Next year, highest disease was recorded on the parent, CC-4xG-3 (100.0%) and least on W-80xG-3 (9.5%). The per cent blight was almost same (52.1% in 2008 and 52.5% in 2009) in G-48 x G-3 parent over the entire period of observation. The disease increment over time was more conspicuous during first year of observation i.e. 2008, probably due to substantially more rains.

The initial pathogen *B. maydis* has been completely replaced with *B. setariae* and *B. spicifera*. One more issue is of significance that these new species have wheat and grasses respectively, as hosts which, otherwise are also a part of poplar agroforestry systems. This line of observation reaffirms the old belief that *B. maydis* was transferred from maize to poplar as explained by Leonard (1987) that both *P. deltoides* and *Zea mays* have got the same gene centre-North America, regardless of their different botanical descriptions. This suggests that there is a co-evolution of host parasite interaction which is undetectable state under the natural ecosystems. In the present case, genetically susceptible male poplar cultivar G-3 (Texas provenance) was vegetatively multiplied (uniform cytoplasm) in agroforestry systems in India which imposed strong pressure on the pathogen populations -*B. maydis* race T- which led to the development of devastative epidemics in the country initially and its decline in the later stages in absence of the host, G-3 clone.

Keywords: agroforestry, blight, host, poplar.

[1] Forest Pathology Division, Forest Research Institute, Dehradun-248 006, South Asia Regional Project Co-ordinator, IRRI, Delhi office, NASC Complex, Pusa, New Delhi-110 012, India. E-mail: singh_yp@rediffmail.com

[2] Wimco Seedlings Ltd., Baghwala, Rudrapur- 263 153, Uttarakhand, India

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EVALUATION OF TRUNK SUSCEPTIBILITY OF SEVEN *POPULUS SPP.* CLONES TO *SEPTORIA MUSIVA* IN TUNUYÁN-MENDOZA, ARGENTINA

N. Riu[1], G. Lucero[2], S. Robledo[1], P. Pizzuolo[2], [4], V. Hapon[2], [3],[4] and J. Boiteux[2],[4]

In the province of Mendoza, Argentina, forestry is based mainly on poplar cultivation. Only a few clones are cultivated and have been chosen on the basis of their behavior and productivity. Until now, nobody has considered their susceptibility to *Septoria musiva*, causal agent of the poplar canker, the main disease of poplar in Mendoza. These clones are: *P. deltoides* 'Harvard', 'Calfish 2', *P.* x *canadensis* 'Guardi' and 'Conti 12'. In poplar orchards Conti 12 as well as in those of deltoides clones have shown a reduced susceptibility to *S. musiva* attacks.

The aim of the present study was to evaluate the trunk susceptibility of different poplar clones to *S. musiva* in the field under natural infections. During 2010, we evaluated seven poplar clones of a 9-year old Populetum, located in Tunuyán (33° 64 '51" south latitude and 69° 06' 73" West Longitude). Susceptibility was determined by the presence of trunk cankers produced by *S. musiva*. Statistical analysis of data showed that there is an association between clones and presence of cankers and they could be clustered in four susceptibility levels. The most susceptible clone (level 3) *Populus* x *canadensis* 'Neva', an intermediate susceptibility (level 2) was *Populus* x *canadensis* clones 'NNDV' and *P* x *canescens* 'Hybrid Spanish', and level 1 clones *P.* x *canadensis* `Conti 12 'and` Boccalari' and less susceptible (level 0) were *Populus deltoides* 'INTA 67/67' and *P. deltoides* '562-11'.

These results are in agreement with previous studies of our group, except for clone 'Boccalari' that had previously shown high disease susceptibility. It should be noted that clone *P. deltoides* '562-11', that shows a low susceptibility to poplar canker according to this study, have presented a very good performance in wooden production in studies carried out by the Forestry Institute of the Faculty of Agricultural Sciences, UNCuyo. Less promissory was the clone 'NEVA' which in the Forest Institute studies presented a low wooden production, and in our study shows high susceptibility to poplar canker.

Keywords: *Populus* clones, susceptibility, *Septoria*.

[1] Cátedra de Dasonomía, Facultad de Ciencias Agrarias- UNCuyo, Argentina. E-mail: dasonomia@fca.uncu.edu.ar
[2] Cátedra de Fitopatología, Facultad de Ciencias Agrarias, UNCuyo, Argentina.
[3] Instituto de Ciencias Básicas, UNCuyo, Argentina.
[4] Instituto de Biología Agrícola, Mendoza, CONICET. Mendoza, Argentina

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POPLAR DEFENCE MECHANISMS AGAINST *MELAMPSORA LARICI-POPULINA*

Marijke Steenackers[1], Bart De Cuyper[1], Arnaud Dowkiw and Catherine Bastien[2]

Resistance, tolerance and avoidance are considered to be different plant strategies against disease. There is an important conceptional distinction between these three defence mechanisms. While resistance traits prevent hosts to become infected or reduce the level of infection, tolerance traits reduce the fitness-impact of parasiteson infected hosts. Avoidance on its hand operates before parasite contacts and decreases the frequency of incidence by adapting growth phenology to epidemics. Genetic improvement to minimize yield loss under disease is an attractive goal as it exerts no selection pressure on pathogen populations, and could form a useful component of durable disease management programs. However, progress towards this end requires a thorough understanding of the phenotypic traits that influence the final plant response (yield) in presence of significant disease infection and their genetic control and relationships.

We examined the candidate traits that may confer resistance, tolerance and avoidance in a fullsib *Populus deltoides x Populus nigra* progeny infected by *Melampsora larici populina* and analyzed evidence of genetic variation in their expression. Different methods for quantifying those defence mechanisms are suggested and association between them examined.

Keywords: *Melampsora larici populina*, *Populus deltoides x Populus nigra*, durable disease management, resistance, tolerance, avoidance.

[1] Research Institute for Nature and Forest (INBO), Gaverstraat 4, 9500 Geraardsbergen, Belgium. E-mail: Marijke.Steenackers@inbo.be ; Bart.DeCuyper@inbo.be

[2] UR0588, INRA, 2163 avenue de la Pomme de Pin, CS40001 Ardon, 45075 Orléans, cedex2, France. E-mail : Arnaud.Dowkiw@orleans.inra.fr ; Catherine.Bastien@orleans.inra.fr.

STUDIES ON VARIABILITY AMONG ISOLATES OF *RHIZOCTONIA* SP. OF POPLAR

S. Upadhayay, A. Bagwari, K. Uniyal, Kavita, Y.P. Singh, R.C. Dhiman[1] and J.N. Gandhi[1]

Poplar is considered to be the best tree species for intercropping with agriculture crops having high growth rate, short rotation, good economic returns and less effect on companion crops under agroforestry. Poplar is attacked by a large number of pathogens in nurseries and plantations, the result of which is the reduction of biomass. *R. solani* is one of the most important plant pathogenic fungi. The pathogen has worldwide distribution and infects a very wide range of plant species.

Twenty isolates of *Rhizoctonia* species that causes leaf web blight in poplar were collected from WSL-22 clone raised in nursery of WIMCO Research and Development Centre, Bagwala, Rudrapur (Uttarakhand). The *Rhizoctonia* sp. isolates were grown on two media viz. PDA and WA to capture their variability in relation to colony type, pigmentation, rate of growth and mycelium and sclerotium characters, etc. Fungicidal sensitivity to Benomyl (systemic) and biogenic interaction with *Trichoderma harzianum*, a potent antagonist, were carried out. Toxin bioassay was also done.

Leaves of the clone WSL-22 of *P. deltoides* showed burning symptoms in the nursery. Initially, the disease began as brown, irregular spots of varying size then, these spot coalesce to form bigger spots that were relatively darker. Cottony colony was dominant on both the media, pale olive buff and shades of yellow were dominant in colony colour and pigmentation, respectively. PDA, in general, supported the maximum growth of all the isolates. Mycelium was hyaline, it first became yellowish and then turned brown; monilioid cells were also observed. Leaf bioassay of toxin showed the symptoms developed on the leaves *in vitro* resembled to the spots seen in the nursery. Benomyl at 15 ppm, was effective in completely inhibiting the growth of maximum number of *Rhizoctonia* sp. isolates. *T. harzianum* reduced the growth of fungal isolates from 25.3-48%. The variability study may be helpful in elucidating the structure of field population of the pathogen that in turn, may be used for resistance screening of genotypes.

Keywords: agroforestry, Web blight, *P. deltoides*, pathogenic population.

[1] Forest Pathology Division, Forest Research Institute, Dehradun, 248 006, Wimco Seedlings Ltd., Baghwala, Rudrapur, 263153, Uttarakhand, India. E-mail: singh_yp@rediffmail.com

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WORKING PARTY ON HARVESTING AND UTILIZATION OF POPLAR AND WILLOW WOOD

EVALUATION OF ROOTING SUCCESS IN POPLAR CLONE CUTTINGS USING DIFFERENT TREATMENTS

F. Asadi[1] and R. Ghasemi[2]

Rooting and early growth of four poplar clones belonging to separate species planted in plastic vases were examined after applying pre-rooting treatments combinations to dormant cuttings. Treatments included three cutting lengths (15, 20 and 25 cm) and soaking times (0,2 and 4 days) that carried out in a randomized complete block design layout with three replications. Significant differences in both rooting percentages and growth attributes were shown between clones after 12 weeks of growth.

After the period, we have measured height, leaf number, leaf weight, root length, root number, root weight, stem weight, total weight and percentage of root weight/total weight as rooting success. The results indicated that cuttings planted without soaking had the lowest rooting success, less than 12% on 4 days soaking. Cuttings planted with 15, 20 and 25 cm length have revealed respectively 29, 42 and 35 % of rooting success. Cuttings planted with 0,2 and 4 days soaking have shown respectively 31, 32 and 43% rooting.

For optimal rooting about *P. caspica*, we recommend using 25 cm cuttings, soaked for 4 days in water, but for *P. euphratica*, we suggest using 20 cm cuttings without soaking. Regarding the *P. alba* 58/57, we recommend using 25 cm cuttings and soaked for 4 days in water.

Keywords: poplar clones, rooting, cutting length, soaking time.

[1] Research Center of Agriculture and Natural Resources of Mazandaran Province, Chamestan, Iran. E-mails: fasadi@rifr-ac.ir ; farhadasadi14@yahoo.com
[2] Research Institute of Forests and Rangelands (RIFR), Tehran, Iran.

ID-114

THE IMPORTANCE OF THE BASKET WILLOW (*SALIX* X 'AMERICANA' HORT.) FOR THE INHABITANTS OF THE SAVA VALLEY CANTON

Dalibor Ballian[1] and K. Baotić[2]

Bosnia and Herzegovina is a south-east European country in transition, with high levels of unemployment in rural areas. Though there are many opportunities for rural development, these opportunities remain unused. One of them is the production of articles of basketry from the basket willow, of which there is a tradition in some areas of Bosnia and Herzegovina. The Sava Valley Canton, in the northern Bosnia and Herzegovina, has an area of 324.6 km² and a population of 44,648, largely rural. About 90% of the population is agricultural, but incomes are low from their smallholdings, which cannot compete in the open market. The local residents are therefore trying to grow the production of basket willow and sell basketry products as an additional source of income.

The region has 13,060 ha of cultivable land, or slightly less than 50% of the total area of the canton. Willow plantations occupy about 500 ha, or 3.8% of this cultivable land, a percentage that is slowly increasing: financial assistance from the canton increased the area by 33.47 ha between 2007 and 2011. Most of these willow plantations, old and new, are on soils that are unsuited to other crops, but are ideally suited for the basket willow. This use of unproductive areas is planned to continue in the coming period.

The cultivation and processing of the basket willow (*Salix viminalis* L.) has a long tradition, but yields are relatively low. For this reason, steps were taken 50 years ago to introduce the American basket willow (*Salix* x 'Americana' Hort.). In recent years attempts have been made to revive the craft of basket weaving, to restore old willow plantations, and to plant new ones. Basket willow plantations of various sizes are now to be found in more than 1,000 households, and about 3,000 people are involved in basket weaving, producing 250,000 articles of more than 100 different kinds. This generates additional income; the export of basket willow products alone yields about €1 million per annum.

Keywords: basket willow, *Salix* x 'Americana' Hort., Bosnia and Herzegovina.

[1] Faculty of Forestry, University of Sarajevo. Bosnia and Herzegovina. E-mail: balliand@bih.net.ba
[2] Sava Valley Canton – Orašje, Bosnia and Herzegovina.

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WOOD MARKET FLUCTUATIONS AND ITS IMPACT ON PLANTATION TREND OF *POPULUS DELTOIDES* IN INDIA

Kulvir S. Bangarwa[1]

Agroforestry is being promoted and popularized in India by the Government and wood-based industries so that the requirement of fuel wood, fodder and timber wood for industries are met from the farmers themselves and the pressure on forests is reduced. Poplar (*Populus deltoides*), a native tree of the USA introduced in India during the 1950s, is widely grown in northern India as an agroforestry tree because of its fast growth with high production potential, straight growing stem, short rotation, quality wood production and less adverse effect on associated agricultural crops being of deciduous nature.

Commercial-scale plantations of poplars have been expanding since the WIMCO-sponsored Farm Forestry Project was launched in 1984. This Project promoted the poplar-based agroforestry plantations by providing technical know-how for planting and care of poplar trees and buy-back guarantee with a minimum support price. Market prices for poplar wood reached their maximum level in 1994-95 and, as a result, farmers sold their wood in open market deviating from minimum buy-back support price of the promoting company. The poplar-based agroforestry plantations had been increasing at a very faster rate all over northern India up to year 2000. Ten million trees used to be planted annually in 0.02 million ha with an average density of 400-500. But poplar was no more popular among farmers during 2001-2004 because the prices of their products were at a minimum level. Farmers were forced to sell their products at throwaway prices anywhere between Rs.700 (US$14.00) and Rs.1,550 (US$31.00) as compared to Rs.3,500-5,500 (US$70.00-110.00) per ton. Farmers were compelled for pre-mature felling of poplar. Sale price of 6 to 8 year-old poplar trees with a girth of 1 m was lower down to about Rs.500-600 (US$10.00-12.00) per tree in 2004. The low market price of poplar wood discouraged the farmers with the result that the farmers were compelled to deviate from poplar-based agroforestry plantations. Accordingly, nursery growers also reduced the production of poplar saplings in their nursery. Rates and demand of poplar wood started to increase by the end of 2004 and the farmers were again attracted towards poplar-based agroforestry plantations.

Presently, the sale price of poplar wood is up Rs 10,000 (US$200.00) per ton, depending upon girth and quality of wood. Timely pruning is very important for the production of excellent quality knot free wood. The tree attains a girth of 1 m at breast height (1.37 m) after an average age of 7 years and such a tree fetches an average of Rs.3,500 (US$70.00). The net income from poplar plantation would be about Rs.200,000 (US$4,000.00) per hectare per year (three times in comparison to crops alone).

Keywords: agroforestry, poplar, *Populus deltoides*, market prices, quality of wood.

[1] CCS Haryana Agricultural University, Department of Forestry, Hisar 125004, India. E-mail: kulvirsb@yahoo.com

ID-023

ATTITUDE TO PLYWOOD PRODUCTION OF SIX NEW POPLAR CLONES ('BRENTA', 'MELLA', 'SESIA', 'SOLIGO', 'TARO' AND 'TIMAVO')

G. Castro[1], R. Alga[1], G. Fragnelli[1], S. Vigolungo[2] and R. Zanuttini[3]

In the present paper, we analyze the dendrometric and physical characteristics, and the quality and suitability to rotary cutting of the wood of six new poplar clones ('Brenta', 'Mella', 'Sesia', 'Soligo', 'Taro' and 'Timavo'), and compare them with those of 'I-214', the most widely spread clone in the Italian panorama.

In one polyclonal plantation, three trees per clone were felled. After their dendrometric characteristics were assessed, from every plant we cut some logs for the rotary cutting test, carried out in a plywood industry, and two disks (5 cm thick), from which we obtained samples for the physical analyses (basic density, fresh weight and total shrinkage).

The basic density of the new poplar clones examined was definitely higher when compared to that of 'I-214' and so were the quantity and quality of the veneers obtained. In particular 'Taro' and 'Soligo' turned out to be extremely interesting: the first one for producing the highest number of sheets of excellent quality, the second for both the good quality of the veneers obtained and for its growth rate, much higher than that of 'I-214'.

The mechanical characteristics of the plywood obtained from these clones, according to the results of preliminary tests, proved to be significantly better than those of 'I-214'; this, together with the highest amount of raw material obtainable, makes the new clones particularly suitable for all those innovative uses beyond the production of packaging (for instance in the building sector, with or without structural functions) in which the performance aspects are determining.

Keywords: poplar, *Populus*, peeling trials, rotary cutting, wood quality, plywood.

[1] CRA - Unità di Ricerca per le Produzioni Legnose Fuori Foresta, strada per Frassineto 35, 15033 Casale Monferrato (AL), Italy. E-mail: gaetano.castro@entecra.it
[2] Dipartimento di "Scienze e tecnologie ambientali forestali", Università di Firenze, Via San Bonaventura, 13, 50145 Firenze, Italy.
[3] Università di Torino, Dipartimento AgroSelviTer, via Leonardo da Vinci 44, 10095 Grugliasco, Italy. E-mail: roberto.zanuttini@unito.it

ID-156

POPLAR CULTURE ON FARMLAND – FARMER'S EXPERIENCE FROM UTTAR PRADESH, INDIA

Nikki Pilania Chaudhary[1]

This paper summarizes our over two-decade experience of Poplar culture as farmers and its comparison with the dominant agriculture land use practice in the region. We have compared financial returns from poplar-based agroforestry with that of traditional intensive paddy-wheat rotation farming, dominant practice in the region. The study is based on the data recorded at our farm during the period 2004 to 2011. We have found that poplar-based agroforestry has generated financial returns four times higher as compared to intensive paddy-wheat rotation-based farming during the given period.

The NPV of returns from poplar-based agroforestry on one acre of land with seven years rotation turned out to be Rs 7, 09,330 at a discount rate of 12%, while NPV of returns from paddy-wheat rotation-based farming stood at Rs 1, 71,428. The Benefit-Cost Ratio for poplar-based agroforestry was 4.10 as compared to just 1.92 of paddy-wheat crop rotation.

We were introduced to poplar in 1987 under the Public Private Partnership scheme which was initiated by the local match company WIMCO. We were given poplar saplings and technical know-how for raising them; nationalized banks provided finance to meet the cultivation expenses and the company entered in a buy-back agreement for the purchase of wood grown therefrom. Since its start in 1987, we have planted poplar saplings 20 times during 1987, 1993-2006, 2008-2012 and harvested the same 13 times during the years 1992 and 1999-2011). Starting with clone *D-121,* we have planted other clones like *G-3, L-49, S7C15, S7C8 and G-48* successfully on our farm. Presently we are planting new clones introduced by WIMCO seedlings like *WIMCO-39, WIMCO-81* and *WIMCO-110*. Our poplar-based agroforestry system involves planting 200 trees per acre on a seven-year rotation, intercropped with sugarcane for the first two years and wheat thereafter till the harvest of poplar. Now we are also growing fodder oats and barseem needed as green fodder for dairy cows.

Poplar-based agroforestry has undoubtedly improved the lives of farmers with its high returns. Over the last three decades, poplar generated remunerative tax free and consolidated returns much higher than the normal crop rotations; provided security against crop failures due to extreme weather and climatic conditions; reduced regular engagement and attendance on high input intensive culture of other crops; and provided financial stability to our farming.

Keywords: BCR, NPV, poplar-based agroforestry, paddy-wheat rotation.

[1] Gaurav Chaudhary, Chaudhary Farms, Village Tanda Vijasi, P.O. Neoria, District Pilibhit, Uttar Pradesh, India. E-mail: chaudharyfarms@gmail.com

ID-054

IMPROVED BIOLOGICAL DELIGNIFICATION OF POPLAR WOOD BY MECHANICAL OPERATION PRIOR TO PRE-TREATMENT

Shãrdesh Kumar Chaurasia[1]

Pulp and paper industry uses different chemicals to separate cellulose fibres from lignin to free the fibres for papermaking. This chemical treatment results in releasing malodorous air emissions and pollutants to water. To surmount these problems, biological processing offers potential opportunities for changing the industry towards more environmental friendly industry. Biological pulping has the potential to improve the quality of pulp, properties of paper and to reduce energy costs and environmental impact relative to traditional pulping operations. It has been suggested that energy savings alone could make the process economically viable. Other benefits include improved burst strength and tear indices of the product and reduced pitch deposition during the production process.

The technology has focused on the white rot fungi prior to pulping, which have complex extracellular ligninolytic enzyme systems that can selectively remove or alter lignin and allow cellulose fibers to be obtained. When white rot fungi colonize on wood, their extracellular enzymes are not able to diffuse into the intact wood cell walls because the enzymes are too large to penetrate the pores of the wood cell walls and only the surface phenomenon occurs on the wood chips. In order to make it more feasible a new aspect of biopulping is being studied, in which the fungal treatment will be given to mechanically separated wood fibres thereby increasing the surface area for the fungal hyphae to penetrate easily in the wood sample.

The present research work has been focused mainly on the target to reduce the pressure of environmental pollution caused by the use of chemicals in pulp and paper industries. The process is aimed to solve some critical problems with biopulping such as long treatment time and penetration of fungus in dense wood. Thus the study will provide an insight to find out economically feasible conditions to commercialize biopulping on large scale.

Keywords: biopulping, cellulose fibres, lignin, papermaking, pulp and paper, White rot fungi.

[1] Forest Research Institute, Forest Biotechnology/Pulp & Paper Technology, Cellulose & Paper Division, Indian Council of Forestry Research & Education, Dehradun (UK), India. E-mail: shardesh84@gmail.com

QUANTITATIVE PROTEOMIC ANALYSIS OF REGENERATED SECONDARY VASCULAR SYSTEM IN *POPULUS TOMENTOSA* USING ISOBARIC TAGS FOR RELATIVE AND ABSOLUTE QUANTITATION

Jun Chen[1], Shulei Jiang[1], Jiafei Chen[1] and Mengzhu Lu[1]

Wood formation is a complex process involving many enzymes and proteins regulated coordinately in different developmental stages of SVS (secondary vascular system). Both protein species and quantities are tightly regulated during this process. Using iTRAQ (isobaric tags for relative and absolute quantitation) and the regeneration system of SVS previously established in our laboratory, we performed a series of quantitative proteome profilings of SVS at different stages during wood formation. In total, 2019 distinct proteins were identified with 95% confidence, among which 401 were identified with peptides (95%) $\geq$ 1, and 225 were identified with peptides (95%) $\geq$ 2. Eighty-six, sixty-five and thirty-nine differentially expressed proteins have been identified and associated with the biological process of callus cell division, cambium formation and differentiation, cell wall synthesis respectively. Fifteen are assigned to signal transduction and twelve are categorized into transcriptional factors.

In addition to the identification of nemerious well characterized proteins known to function at corresponding developmental stages, seventeen unknown proteins have been found to be differentially expressed at different stages during wood formation and are associated with cambium formation, xylem pattern formation, xylem formation, and programmed cell death respectively. These proteins can be used as candidates for understanding the regulation of wood formation and as potential resources for genetic modification of trees.

Keywords: poplar, secondary vascular regeneration, iTRAQ, quantitative proteome, multidimensional chromatography.

[1] State Key Laboratory of Tree Genetics and Breeding, Research Institute of Forestry, The Chinese Academy of Forestry, Xiang Shan Road, Beijing, P.R.China, 100 091. E-mail: chenjun@caf.ac.cn and lumz@caf.ac.cn

POTENTIAL OF THERMAL MODIFIED POPLAR WOOD FOR CONSTRUCTION PRODUCTS

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

Thermal modification is a proofed technological transformation to adopt the biological durability and/or the dimensional stability of wood. It has been demonstrated in literature that several modification treatments can be accurately controlled to increase the natural durability of popl ar wood (originally attributed to durability class V or D5) to a durability class of preference. As such, the modification can be adapted to the end use of the intended product.

However, most treatments alter the mechanical properties of the wood. The recorded lower strength values are not critical as such; however, the induced variability of the mechanical parameters (elasticity and strength) is high and mostly unpredictable. The high levels of uncertainty limit the use of thermal treated poplar beams for timber constructions.

This research reports on two thermal treatment schemes for six different poplar clones. The treatment process itself is based on modification by contact heat applied under elevated pressure. To explore the potential of the treated material for construction purposes it is essential to evaluate the potential of grading (strength control in reference to CE marking), and gluing (potential of larger constituted beams).

It could be demonstrated that mechanical grading of the treated material is possible according to EN 14081series. The beams were graded using density and dynamic modulus of elasticity. Grading was shown to be clone-dependent. However, groups of clones could be detected which can be graded with the same settings. Moreover, the particular treatment process is so precise that a prediction of the strength class of the treated material can be made, based on the grade of the initial poplar beams. In fact, as a function of the treatment severity (temperature and time), the initial grade dropped one to two classes after treatment. Further research is needed before industrial implementation as the number of repetitions (100 beams per clone) is insufficient when looking at the European standard and for this research only one dimension was used (cross section of 95 by 50 mm).

The potential of laminated beams for load-bearing (EN 14080) and non load-bearing (EN 13307) applications was evaluated as well using six different glue types. Two component poly-urethane and emulsion glues show the highest potential for a qualitative bonding. As such, this study demonstrated that thermal treated poplar wood can be used for laminated timber constructions and window joinery. The only drawback is the dependency of the necessary underlying grading system on the clone or clonal group.

Keywords: thermal modification, grading, bonding, window joinery.

[1] Ghent University, Laboratory of Wood Technology, Coupure Links 653, 9000 Ghent, Belgium. E-mail: Lieven.DeBoever@UGent.be

[2] Ghent University, Laboratory of Wood Technology, Coupure Links 653, 9000 Ghent, Belgium. E-mail: Joris.VanAcker@UGent.be.

CONTRIBUTION OF *POPULUS DELTOIDES* IN ECONOMY OF FARMERS IN PUNJAB

A.S. Dogra[1], S. Nautiyal[2] and D.P. Nautiyal[2]

The Punjab state, with a total geographical area of 5,038,000 ha, is predominantly an agricultural state where 83% of the total land is under agriculture and 6.6% under forest. The land under agriculture cannot be diverted to forest without forsaking the production of good – grains, pulses, cotton, sugar-cane, vegetables etc. The only way, therefore, to minimize the gap between production and consumption of wood in Punjab is by raising trees in conjunction with agricultural crops on field boundaries approach roads and as inter-culture with crops.

Agroforestry is one of the land husbandry gaining importance as an approach for diversifying traditional agriculture. Progressive farmers of Punjab and adjoining states have adopted agroforestry intensively keeping in view of its good economic return to the farmers.

Poplar-based agroforestry in Punjab is economically viable and more profitable to the farmers than many other crop rotations. The present paper deals with the contribution of *P. deltoides* in economic gain to farmers of Punjab. The total area under poplar plantation in Punjab, including agroforestry, is estimated to be 75,000 hac. The total productivity is estimated based on the data of 8 years old poplar plantation. The estimated minimum bole wood is 6.5 t. / ha^{-1} /$year^{-1}$ and @ Rs. 10,000/- per t/yr the total income will be Rs. 65,000/ha/yr. Therefore, total bole wood income from 75,000 hac amounts to Rs. 4,875 million. The income from bole + bark+ branches + twigs estimated of about 3.1 t./ha/yr and @ of Rs. 3,000/t/ha/yr for 75,000 hac. comes to Rs. 677 million. The income from stump and root is estimated about 2 t/ha/yr and @ Rs. 3,000/t/ha/yr, the amounts 60,000/ha/yr and for total 75,000 ha. It comes to Rs. 450 million. Hence, the overall income to the farmers of Punjab from poplar plantations is minimum Rs. 6,000 million, besides the foliage which improves the soil fertility by decomposition of leaf litter.

Keywords: agroforestry, crop rotations, bole wood, stump.

[1] Ex PCCF State Forest Department, Punjab, House No. 256, Sector 37-A, Chandigarh-160036, India.
[2] Plant Physiology, Forest Research Institute, Dehradun, Uttarakhand, India.

STUDY OF POPLAR-BASED AGROFORESTRY IN EASTERN UTTAR PRADESH

Kumud Dubey[1] and M. K. Shukla

Agriculture is the major source of the livelihood for the majority of the population in Uttar Pradesh state of India. Due to increasing pressure of population on land, most of the farmers of Uttar Pradesh - about 82% - are marginal, having uneconomical land holding of less than 3 ha. The income generated from such small land holding is not adequate to keep the farmers above the level of poverty. It has been observed that the sole agricultural practices is not economically sustainable and there is an emergent need to utilize the available resources optimally for increasing the productivity so that the ever increasing demand for food, fodder, vegetables, fuel wood, timber, medicines etc. may be achieved. Poplar is considered to be one of the preferred tree species for agroforestry due to its deciduous nature, fast growth, short rotation and high commercial value. Farmers of western Uttar Pradesh are successfully practising poplar-based agroforestry. However, in eastern Uttar Pradesh, poplar has not been incorporated in agroforestry, only few farmers have planted poplar on their farmlands. This may be due to the lack of information and awareness regarding productivity and economic viability of poplar-based agroforestry in the agroclimatic conditions of eastern Uttar Pradesh. To promote poplar-based agroforestry in eastern Uttar Pradesh, the effect of poplar on the agricultural crop production and on soil fertility has to be studied as prerequisite step.

Therefore, the present study was aimed to study the effect of poplar plantations on the agricultural crop production and soil fertility. For this, an existing poplar-based agroforestry was selected for the study. The selected existing poplar plantation was of 3-year old and planted on the bund of agricultural field with a spacing of 3 to 4 feet. Crop production data for wheat and paddy was recorded at different distances (1m, 5m and 10m) from the poplar plantation row. Similarly, the soil samples collected from different distances (1m, 5m and 10m) from the poplar plantation row were also studied for its physico-chemical characteristics. Crop production and soil sample from the field of nearby area, without tree plantation, was taken as control. From the results, it was observed that agricultural crop production was reduced in both wheat and paddy under poplar plantation in comparison to control. However reduction is more in case of paddy in comparison to wheat. In case of wheat, production was drastically reduced at the distance of 1m from the tree row, however at the distance of 10m the production is at par with the production of control plot. In case of paddy, production was significantly reduced in comparison to control. However, overall, 10 to 20% reduction was observed in crop production. As far as its soil characteristics were concerned, organic carbon and Nitrogen were increased under poplar agroforestry. Farmers were getting around 2000/- to 3000/- per tree (as per present rate) after 7 to 8 years of plantation. In addition to this, wood obtained after pruning was also being utilized as fuelwood. From the present study, it was concluded that though there is reduction in agricultural crop production under Poplar agroforestry, by considering overall gain, it may be opted as viable option for the appropriate land use system that increases production in ecologically sustainable manner, and supports sustainable development of the farmers of eastern Uttar Pradesh.

Keywords: poplar agroforestry, crop production, soil characteristics, eastern Uttar Pradesh.

[1] Centre for Social Forestry and Eco-Rehabilitation, 3/1 lajpat Rai Road, New katra, Allahabad, Uttar Pradesh, India. E-mail: dkumud@yahoo.com

DEVELOPMENT OF A SHORT-ROTATION COPPICE SIMULATION MODEL AND CALIBRATION FOR POPLAR

Gianni Facciotto[1], Alvaro Rocca[2], Sara Bergante[1], Romano Giovanardi[2], Mario Baldini[2] and Francesco Danuso[2]

In the last decade, short-rotation coppice (SRC) crops in Italy showed a rapid increase up to about 7,000 ha (90% poplar). In Italy, SRC poplar represents 10% as compared with the traditional poplar stands and its production is mainly used in energy plants for heating and power cogeneration. Many experiments have been already carried out and the data obtained showed a continuous yield increasing, due to genetic and cultural practices. On the other hand, the commercial stands showed a strong yield variability, to be related to the environmental interaction between soil and climate. As a consequence, the understanding of these interactions and the possibility of forecasting yield or optimizing the combination genotype × environment are important and could be made by simulation models. Many simulation models for annual crops have been already developed (CropSyst, Epic, Stics, CSS, etc.) but less common are models for perennial crops; moreover, the few models available for SRC are generally with an annual step, not able to represent the system with sufficient detail. In this work, a new SRC simulation model is presented and calibrated with data coming from multiannual experiments performed in North Italy.

Different poplar clones have been cultivated in two North Italy sites (Casale Monferrato, AL; and Osoppo, UD) from 2002 to 2011, with biennial and 5-year harvesting cycles. Measurements performed on each plot have been: planting time, sprouting dates, leaf dropping time, above-ground biomass for stems+branches and leaves. Non-destructive growth analysis has also been performed on some plots of 2-year and 5-year harvesting cycle, estimating the above-ground biomass every 15 days during the growing season via Dbh. In order to calibrate the model, soil parameters (texture, hydrological parameters, soil organic matter, soil depth) and daily meteorological variables (maximum and minimum temperatures, rainfall, global radiation and evapotranspiration) have also been obtained; management techniques (planting, irrigation, nitrogen fertilization and harvest) are also considered.

A model for SRC crop has been developed (*SRCsim*) with the aim to represent multiannual woody crops under different management systems and environmental conditions, with a daily time step. The simulation results generated by the model are the above-ground (leaf and stems+branches) and root biomass (coarse and fine), soil water and nitrogen dynamics, carbon and energy balance. The model has been developed using the SEMoLa simulation language and is based on the previously developed crop model *MiniCSS*. The model is sensitive to water and temperature stresses and also to the soil nitrogen availability.

[1] Consiglio per la Ricerca e Sperimentazione in Agricoltura, Unità di Ricerca per le Produzioni Legnose fuori Foresta (CRA-PLF). Strada Frassineto Po, 35, 15033 Casale Monferrato (AL), Italy. E-mail: gianni.facciotto@entecra.it. Tel. +39 0142 330900. Fax +39 0142 55580

[2] Dipartimento di Scienze Agrarie e Ambientali, Università di Udine, Via delle Scienze 208, 33100 Udine, Italy. E-mail: francesco.danuso@uniud.it. Tel. +39 0432 558614. Fax +39 0432 558603

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Model *SRCsim* has been improved and calibrated using the crop data from the experiments performed in Casale Monferrato. The most sensitive parameters, used to improve the model performance, have been phenological parameters, radiation use efficiency and crop coefficients for water consumption. A validation with independent data from the other site (Osoppo) and other trials from Casale Monferrato have been performed. Also in this case, the models proved to be able to predict biomass yield of poplar SRC, when parametrized for the specific environment.

The model *SRCsim* can be used for management and planning purposes, e.g., to preliminarily estimating the biomass production of the territory and its variability. In fact, the model can be used to perform Monte Carlo simulation to evaluate the statistical properties of the yields. Other planning tasks can be the optimal location of the processing plants or the identification of the collecting district and the optimization of the crop management techniques. The model is freely available from the authors. SRC*sim* will be included in a multilingual software application

Keywords: poplar, biomass, SRC simulation model.

VOLUME AND YIELD ASSESSMENT OF *POPULUS DELTOIDES* BARTR EX. MARSH FOR AGROCLIMATIC ZONE-I BIHAR

Ramesh Kumar Jha[1] and Priya Saloni[2]

Intensive farm forestry requires that foresters/farm tree growers are able to estimate tree volume accurately for such phases of timber management as timber sales, advance planning growth and yield studies. The poplar (*P. deltoides*) is being raised in Bihar as a fast-growing tree species, yielding high timber volume at a relatively short rotation. Its wood is well suited to industries such as match, splints, pulp and paper, plywood, fiber board, etc. The farmers in the state are following a short rotation of 6-7 years, as the trees attain marketable size at that age and thus reduce the gestation period of final return from poplar trees. As the farmers of Bihar have taken up poplar cultivation in a big way, particularly in Vaishali district, they are curious to know the quality and quantity of their produce and want to have an estimate of their standing tree crop of return from its sale before final decision about its marketing. But they have no tools available to make such an estimate through Standard timber volume (ob).

Poplars are usually sold in the local markets and at mill gate as round timber over bark. Using co-efficient of determination (r^2) as the indicator of best fit, the linear model was chosen for constructing and assessing the standard timber volume (ob) table. Following regression equations provided be best estimates for over bark volume of individual trees for up to 6 years.

Plant Poplar – P5
V = - 0.475 + 0.04108. DBH R^2 = 84.6
G-48
V = -0.29 + 0.03033 DBH R^2 = 97.8
L- 188
V = 0.038 + 0.01342 DBH R^2 = 90.0
Uday
V = -0.474 + 0.0426. DBH R^2 = 87.5
L-49
V = -0.398 + 0.04063 DBH R^2 = 86.3
L-52
V = -0.450 + 0.04096 DBH R^2 = 93.2

The R^2 value is 84.6 to 93.0. It clearly indicates that the timber volume (ob) table may be used for estimation of volume of poplar tree at the age of six. It is also applicable for use in the field without correction. As per collected data, the height, gbh, diameter of L-52, L- 49 and Uday clone are better than other clones.

Keywords: timber volume, Bihar, *P. deltoides*.

[1] Senior Scientist, Forestry, Department of Forestry, Rajendra Agricultural University, Pusa, Samastipur, 848125. Bihar.
[2] M.Sc (Wood Science & Technology) Student, Forest Research Institute (D.U.), Dehra Dun, Uttarakhand.

ID-075

PROTOMIC CHANGES DURING REGENERATION OF THE SECONDARY VASCULAR SYSTEM IN *POPULUS TOMENTOSA* CARR. REVEALED BY QUANTITATIVE PROTEOMICS

Shu-Lei Jiang, Jia-Fei Chen, Shu-Tang Zhao, Jun Chen and Meng-Zhu Lu[1]

Wood is the end-product of the secondary vascular system (SVS) development, wich begins from the cell division in cambium, and then goes cell expansion, secondary wall biosynthesis, lignification, and programmed cell death. This complex process involves many regulators to act coordinately. Thus, quantitative proteome profiling of SVS development may reveal important insights into the regulatory mechanisms of wood formation.

The regeneration system of SVS in *Populus tomentosa* in our laboratory was previously established and samples were collected by scraping regenerating tissues from the whole surfaces of the trunks at the 6, 8, 10, 12, 14, 16, 18 and 20 days, covering the process of regeneration of SVS. Proteims were extracted, trypsin digested and labeled with an 8-plex isobaric tags for relative and absolute quantitation (iTRAQ) of proteins. Strong-cation-exchange(SCX) and reverse phase (RP) chromatography was performed and analyzed in conjunction with 4800 MALDI-TOF/TOF MS. 2019 distinct proteins were identified and 225 of which quantitative proteins were identified. The function of these proteins was determined by classifying with gene ontology and most of the proteins were related to from cell division and deferientiation, secondary wall formation and final cell death. In detail, 86 quantitative distinct proteins related to cambium formation, 65 to xylem defferentiation, 39 to cell wall synthesis, 15 related to signal transduction and 12 related to transcriptive regulation. We also identified 17 proteins with unclear functions in wood formation using quantitative proteomics, PtGN, PtTCTP and PtSLP may relate to cambium formation, PtADL, PtMYB158 and PtVEP to xylem formation, PtCYP75B1, PtP78RF and PtMIPS to auxin response, and PtCHIA to ethylene signaling, etc..

Based on the result, we proposed a model for SVS regeneration in *Populus tomentosa*, describing the molecular features of SVS regeneration after bark girdling in *Populus tomentosa*. Pre-programed expressions of these diverse groups of proteins are consistent with the developing process of SVS. These proteins can also be used as candidates for studying the regulation of wood formation.

Keywords: *Populus tomentosa*, secondary vascular system, regeneration, gene regulation, quantitative proteome

[1] State Key Laboratory of Tree Genetics and Breeding, Research Institute of Forestry, Chinese Academy of Forestry, Beijing 100091, China. E-mail: lumz@caf.ac.cn)

ID-188

CHEMICAL UTILIZATION OF *POPULUS DELTOIDES* FOR DEVELOPING LEAF PROTEIN CONCENTRATE

Lutful Haque Khan[1], V.K.Varshney[1] and Sanjay Naithani[2]

Shortage of supply of good quality protein for meeting the requirements of increasing animal and human population has necessitated search for additional sources. Leaf protein concentrate (LPC) is a concentrated form of protein which is derived from the foliage of plants. LPC constitutes the most abundant and inexpensive source of available protein and thus has been recognized as a non conventional source of protein. In this context, trees acquire immense importance as a potential source of LPC where the production of protein from tree leaves is advantageous over crops as they do not involve the recurring cost of cultivation.

Poplar *(Populus deltoides)* is fast growing, easy to propagate, and highly adaptable to different climate and soil conditions. Due to these characteristics, combined with the wide range of goods and services it provides, poplar is planted at large scale in north India. The poplar leaves are important byproducts from plantations. These are simply burnt or underutilized and thus may have serious environmental impact from their disposal. Their value added utilization may provide another income stream from plantations to the farmers. The potential of the poplar leaves as protein source has not been examined. A chemical utilization approach for production of LPC from poplar is described in the present paper. A method for isolation of LPC was standardized through investigating the influence of various process parameters such as ratio of fresh leaves to water, coagulation temperature, duration and pH, acetic acid coagulation, and drying temperature on the yield and protein content of the LPC. The optimized process was applied for isolation of LPC from lower, middle and upper canopy of the tree. The optimized LPCs were evaluated for their nutritional profile such as biochemical attributes including amino acid composition, in vitro digestibility and anti-nutritional factors. The data were statistically analyzed and the results are discussed.

Keywords: leaf protein concentrate, *Populus deltoides*, nutritional profile.

[1] Chemistry Division, Forest Research Institute, DehraDun-248006, India. E-mails: khanlh.fri@gmail.com; varshney2000@yahoo.com
[2] Cellulose & Paper Division, Forest Research Institute, Dehradun-248006, India.

ID-031

BIOMASS OF POPLAR AND WILLOW AS BIOENERGY RAW MATERIAL

Bojana Klasnja[1], Sasa Orlovic, Zoran Galic

Poplars and willows, as the most represented species grown very successfully in short-rotation plantations, can be a significant source of thermal energy, being a relatively quickly renewable energy raw material. Thermal energy potential of wood was researched on the poplar clones *P. x euramericana* (cl. I-214), *P. deltoides* (cl. PE 19/66), and white willow *Salix alba* (cl. 398), aged one and two years. One-year and two-year old rooted cuttings were grown in plantations with small planting spaces (38,461 plants/ha), in order to produce a high biomass yield per hectare. As the share of bark depends on the age of wood, calorific values were determined separately for bark and for wood. Based on the share of bark, calorific value was assessed for individual trees of the analyzed clones. Previously, bark and wood density in oven dry state, as well as the contents of ash and moisture, were determined for the selected trees.

The share of bark (per mass) in one- and two-year old rooted cuttings ranged between 18 and 19%, except for wood of one-year old willow (26.7%). The calorific values of oven dry wood (higher heating value) of one-year old poplars (calculated for the whole tree, based on the share of bark) were 15,787 MJ/kg (I-214) and 17.070 MJ/kg (PE 19/66), of two-year old poplars 24,275 MJ/kg (I-214) and 20,817 MJ/kg (PE 19/66), respectively. Higher heating values of oven dry one-year old willow wood were 18,460 MJ/kg, and two-year old 22,572 MJ/kg.

The weight of the harvested biomass per unit area was calculated based on the data on bulk density of the study clones. Maximal yield of biomass after first year was shown clone PE 19/66 (23,846 t/ha), clone I-214 reached 11,923t/ha, which is about 50% lower, and minimal value of the yield 4,231t/ha (about only 17.7% max yield) was estimated for willow wood. The values of average biomass weight after the second year behaved similarly. Maximal yield was 97,306 t/ha (cl. PE 19/66), about 58% of this value for cl. I-214 (48,461 t/ha), and minimal value for willow wood – 28,846 t/ha (about 32% max yield).

Estimated values of energy yield that could be obtained by combustion of biomass after the first year of vegetation ranged from 407,048 GJ/ha, for clone PE 19/66, to 188,227 GJ/ha for clone I-214, and 78,099 GJ/ha for willow wood, that reaches only 19% of the maximum value. After the second year, estimated energy values had the similar relations: maximum for clone PE 19/66 – 2025,626 GJ/ha, clone I-214 reaches about 58% of the maximum (1176,387 GJ/ha), and for willow wood 651,106 GJ/ha (about 32% of maximal yield). Obtained differences of biomass and energy yields between poplar and willow clones were due to the more vigorous growth of poplar clones. This was more expressed during the second growing season where average height of plants of both poplar clones was 5.6 m (DBH 3.8-4.4 cm), and for willow clone only 3.9 m (DBH 2.4 cm only).

Keywords: poplars, willows, biomass, energy.

[1] University of Novi Sad, Institute of Lowland Forestry and Environment, Antona Cehova 13, 21000 Novi Sad, Republic of Serbia. E-mail: bklasnja@uns.ac.rs

ID-080

EXTRACTION AND UTILIZATION OF DYE FROM POPLAR BARK ON PILOT SCALE

Rakesh Kumar[1], Rameshwar Dayal, Sanjay Naithani, O.P. Bhatt[2]* (Retd.),
Praveen Onial and Raj Dev Rawat

The exuberant amount of pollution caused due to synthetic colours in textiles leads to environmental degradation. So the right choice for the people who care and are considerate about themselves and the environment is natural dyes. Nature produces many natural dyes from various resources, including plants, animals and microorganisms, which are possible alternatives to synthetic dyes and pigments currently employed. Increased awareness for eco-friendly products in the developed countries has opened up a new channel for the export of hand printed fabrics printed with natural dyes. In the near future, the product with natural colours may have an increased demand, not only for the safety of health and environment but also for their beauty and novelty. It is estimated that worldwide upto 70% of all plants have not been investigated fully and that only 0.5% has been exhaustively studied for value added applications. Therefore, with the endeavour to produce natural dyes, a significant number of plants of India have been investigated for isolation and characterization of colourants and to explore their applications in dyeing different types of fabrics.

The paper discusses about the production of natural dyes from poplar bark on pilot plant scale and highlights their use in textile industry. The batch trials were carried out to optimize the process parameters for the isolation of natural dyes on a pilot plant scale. The dyes imparted a number of fascinating shades on silk, wool and cotton with good colour fastness properties. The CIEL*a*b* K/S and hue values of the dyed fabrics were also determined. The pilot plant studies indicate that there is a scope for the up scaling of the process for the isolation of natural dyes from the poplar bark.

Keywords: *Populus deltoides*, natural dyes, pilot plant, textile.

[1] Chemistry Division, Forest Research Institute, Dehradun. India. E-mail: rakesh@icfre.org
[2] Cellulose & Paper Division, Forest Research Institute, Dehradun, India.

POPULUS CHEMISTRY: AN OUTLOOK FOR IMPROVED UTILIZATION

Vineet Kumar[1]

Increasing scarcity of the timber-based trees have prompted an interest in plantation forestry, especially species like *Populus* which has been planted on large scale for applications particularly for wood, wood composites, pulp and paper-based industries, etc. throughout the world. Interestingly, apart from the wood utilization for composites and paper, *Populus* spp. are a good source of saw dust, bark, leaves, etc. which have potential applications for a variety of increasing applications in development of fragrance and flavours, natural dyes, compost, incense sticks, antioxidants, etc. A number of interesting phytochemicals have been isolated from different species of *Populus*.

Studies on methanol extract of the stem bark of *Populus davidiana* led to the isolation of ten flavonoids; sakuranetin, rhamnocitrin, 7-*O*-methylaromadendrin, naringenin, eriodictyol, aromadendrin, kaempferol, neosakuranin, sakuranin and sakurenetin-5,4′-di-*β*-D-glucopyranoside. The twigs of hybrid poplar Neva, *Populus nigra* L., *Populus deltoides* Marsh have been found to contain 5-hydroxy-7-methoxy-flavone, 5,7-dihydoxy-flavone and 5,7-dihydroxy-flavonol. Analysis of volatile components of leaf-buds of *Populus nigra* L. resulted in isolation of sesquiterpene alcohols, β-eudesmol, α-eudesmo,l γ-selinene, δ-cadinene, γ-cadinene and α-elemene alongwith other major sesquiterpene components. The fresh and dried buds contained 0.27% 0.12% essential oil respectively. Two new phenolic glucosides [isograndidentatin A and isograndidentatin B], phenolic glucosides [grandidentatin, salireposide, populoside, populoside A, and salicortin], and phenolic acids namely *p*-coumaric acid and caffeic acid were isolated from the leaves of *Populus ussuriensis*. The compounds showed significant antioxidant activities. Similarly a number of phytochemicals have been reported from different species of *Populus*. In our laboratory hitherto unutilized and abundantly available biomass (saw dust, bark, twigs, and leaves) from *Populus deltoides* have been utilized for development of natural dyes, compost, incense sticks etc.

The paper discusses the potential applications of yet unutilized biomass from *Populus spp.* for a variety of useful applications for the benefit of mankind.

Keywords: *Populus*, chemistry, utilization, plantation forestry, wood, phytochemicals, biomass

[1] Chemistry Division, Forest Research Institute, Dehradun, 248006, India. E-mail: drvineet@gmail.com

ID-137

IMPACT OF EXTENSION STRATEGIES ON MAKING A POPLAR TREE AS A POPULAR AMONG THE FARMERS IN NORTHERN INDIA

B.S. Mandal[1], Y.P. Singh[2] and N. Mandal

In the post- independence era, nation has witnessed spectacular progress in agriculture sector. However, in the quest of enhancing supply of food, fiber and fuel to satisfy the needs of burgeoning population, the land and water, which are two most important natural resources, have been put to tremendous stress. Their faster depletion and degradation is our greatest concern today in view of sustainable agricultural and socio-economic security of the nation. Concerted and dedicated efforts are needed to save the health of our land, water and the environment. Arresting soil health decline with falling soil organic content and total factor productivity constitute high priorities of research in the areas of soil and water management. A paradigm shift in research priority is, therefore, warrants to meet present challenges. Forestry is the second-largest land use in India after agriculture with a forest and tree cover of 76.88 million ha or 23.4% of the geographical area. Trees and tree based products have a significant potential for providing jobs as well as a rage of forest products such as fuel wood, edibles, fodder, pulpwood, building materials and medicines. Tree plays an important role in contributing towards sustainable livelihoods of rural poor. Forest in the Haryana state is far below the national goal of one third area under forest and tree cover. To fulfill this goal and to meet out the ever increasing demand of industrial wood led to unprecedented expansion of tree plantations on the farmer's field. Successful implementation of the agroforestry programme will help in improving of agricultural productivity and production through soil and water conservation and restore soil fertility.

Poplar has proved as the most promising species under agroforestry system for the plains of Haryana. Punjab and Uttar Pradesh under irrigated conditions. Farmers, particularly small and medium categories, give prime importance to the continuous flow of income before adopting and practicing any new technology. In general, pursuit of providing food as well as environmental security, agroforestry is one of the indispensable options for land management in future. Agroforestry is not only helping in diversification in land management system but also an economically potential alternative with tremendous contribution to environmental improvement and judicious use of resources. Agroforestry is said to be a sustainable land use for the well-known ameliorating effects of trees on physiochemical properties of soil. The agricultural fields in the tropical North India State of Haryana have become a rich reservoir not only for the food grains but also for the industrial timber. It could be possible due to adoption of the agroforestry system as the farmer get more return in terms of grain, fodder and wood. On the other hand, the forestry system provides only wood to the farmers that too after a span of 6-7 years. In Haryana, a large number of farmers are adopting the agroforestry system and poplars have played a tremendous role in boosting the economy of farmers. In this paper the trainings, demonstrations, field days, farmer`s-stakeholder relationship, impact of the training, success stories of farmers were given in detailed.

Keywords: sustainability, agriculture, agroforestry, poplar, training, success stories, profit.

[1] Krishi Vigyan Kendra, Kaul (Haryana), India. E-mail: mandal.balwan@rediffmail.com
[2] Forest Research Institute, Dehradun, India.

ID-183

BIO-CONVERSION OF POPLAR (*POPULUS DELTOIDES* BARTR.) BIOMASS INTO FERMENTABLE SUGARS FOR BIO-ETHANOL PRODUCTION

Rekha Rawat and Lakshmi Tewari[1]

The growing global energy demand and concerns about the fuel economy and negative environmental impact created by growing green house gase (GHG) emissions from fossil fuels call for alternative low cost, renewable and non-polluting energy sources. One such renewable energy source is ligno-cellulosic biomass. Poplars are one of the most promising species for energy generation because of its minimum fertilizer demand and ability to grow on marginal lands, which make it a potential feed stock for bio-ethanol production. Wood and lignocellulosic biomass are comprised of three main polymeric constituents – cellulose, lignin and hemicellulose. The lignin content makes the biomass more recalcitrant towards hydrolysis and hence it needs proper pre-treatment. Therefore, the present investigation was conducted for bio-process optimization for saccharification of poplar wood powder.

The fine wood oven dried (80 C) powder (particle size <2mm) was chemically treated with alkali (NaOH) prior to subjecting it to enzymatic saccharification. Response Surface Methodology (RSM) was adopted for experimental design during alkali treatment and enzymatic saccharification of alkali treated substrate. The reducing sugar yield in the hydrolysate of alkali treated samples ranged from 7 to 41 per cent (w/w). The untreated as well as alkali treated poplar was saccharified using 15 FPU per gds of cellulase enzyme at 50 C for 48 h. For untreated wood very low saccharification ratio (9.2%) was recorded while much higher saccharification ratio (41%) was achieved with alkali treated substrate. The saccharification ratio was further enhanced to 57.1 per cent using enzyme cellulase concentration of 24.95 FPU/gds. The changes in chemical composition of poplar wood during NaOH treatment were also studied and lignin content was reduced from 26.8 to 14.1 per cent while accessibility of cellulose for cellulase enzyme increased. The physico-chemical changes in the substrate after alkali treatment and enzymatic hydrolysis were further confirmed by FTIR (Fourier Transmission Infra-red) spectroscopic analysis and scanning electron microscopy. Thin layer chromatography study revealed the presence of glucose as a pre-dominating sugar in the hydrolysate after enzymatic scarification of untreated as well as alkali treated substrates. The cellulase enzyme complex used during the investigation was isolated from cellulolytic bacterial culture which was identified as *Bacillus amyloliquifaciens* ARC3.

Keywords: polymeric constituents, saccharification, cellulose enzyme.

[1] Department of Microbiology, College of Basic Sciences and Humanities, G.B.Pant Univeristy of Agriculture and Technology, Pantnagar, 263145, India. E-mail: Lakshmi_Tewari@Yahoo.Co.In

ID-139

CULTIVATION OF WILLOWS IN MOUNTAIN COLD DESERT OF INDIA: THE LAHAUL VALLEY CASE STUDY

Yashwant S. Rawat[1] and Colin S. Everson

In the cold desert of the Lahaul Valley, lack of resources, extremely low temperature and xeric climatic conditions of the region concerned (Khoksar: 3200 m; Jahlma: 3000 m; Hinsa: 2700 m; and Kuthar: 2600 m), two willow species (*Salix fragilis* and *S. alba*) are cultivated through the traditional shoot-cutting plantations method in the indigenous agroforestry with traditional (wheat, barley, buckwheat, kidney bean, *kuth* and *manu*) and cash crops (pea, potato and hops), as well as forestry systems (plantation on private land surrounding settlements) for fuelwood, fodder and minor timber. Both willows are well adapted to the cold desert environment and much suitable for land restoration. However, *Salix fragilis* is cultivated extensively.

These species in cold deserts may combat desertification and can thrive well in these areas as compared to any other species. In the present article, the historical, current and potential agroforestry uses of willows are also described. Currently, about 74.59% of the total households are deficient in fuelwood and fodder requirements. On account of a change in introducing solar power, the socio-economic status of the farmers have been improved but the area under willow plantations have drastically declined from past to recent years. In addition, eradication of planted willows has increased recently because of natural calamities like avalanches, floods, uprooting due to road construction and settlements, as well as diseases.

As a result, utilization pattern, traditional knowledge on willows, conservation and management were also affected. On an average, nearly 44.71% trees of the total plantations were planted under agroforestry and 55.29% under forestry with monoculture patches in and around the settlements. Willows fulfil about 18.5% to 69.5% of the total fuelwood requirements of the people living in this valley. To help sustain people of such a high elevation and cold desert conditions, plantations of wild and cultivated willows as well as the introduction of new varieties have been justified especially in the context of fulfilling basic requirements and ecological perspectives.

Keywords: willows, shoot-cuttings, agroforestry, diversity and distribution, management and conservation, cold desert, Lahaul Valley, Himalaya.

[1] School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa. E-mail: yas_rawat@yahoo.com; yasrawat@gmail.com

LIGNOCELLULOSIC BIOMASS AS FEEDSTOCK FOR BIOFUELS PRODUCTION

Laura Rosso[1], Lorenzo Vietto, Gianni Facciotto, Sara Bergante and Giuseppe Nervo

According to European directives, Italy has the objective of achieving 17% share of energy from renewable sources. At present, the energy from lignocellulosic material (about 40% of the renewable energy consumption) comes from residues of wood processing and agro-waste, and only in part from agricultural crops and forest. In order to ensure a sustainable supply of biomass in the long-term, it is necessary to increase the use of dedicated crops to the production of renewable energy without negative repercussions on food security, particularly growing these crops on marginal agricultural lands. Among *Salicaceae* species, *Populus alba* and *Salix* spp. are able to tolerate difficult growing conditions and can thrive where traditional agricultural crops do not guarantee high returns (coarse textured soils, alluvial flood-prone areas).

The aim of this study is the identification of clones of two genus, white poplar (*Populus alba* L.*)* and willow *(Salix* spp.), with good performances and wood characteristics suitable for the production of biofuels. Another characteristic making these species interesting as biofuel feedstock is the high percentage of cellulose present in their wood. The clones have different contents of cellulose that can vary between 42 and 49% of dry matter. In addition to genetic features, there are other factors that influence the cellulose content in the plant, including technological and crop management. Among the technological characteristics of lignocellulosic materials, the increase of the specific gravity on the volume of biomass produced has a significant impact on the efficiency of conversion. High growth influences positively the increase in supply of raw materials by reducing costs; high specific gravity means high cellulose content because a positive correlation exists between specific gravity and cellulose. About crop management, confirming previous studies, we have observed that nitrogen fertilization in poplar increases the cellulose and decreases the lignin content.

In order to select highly productive white poplar and willow clones suitable for this purpose, progenies of Villafranca (*Populus alba*) and willow clones, mainly from *Salix matsudana*, *S. jessoensis* and *S. alba* crosses, are under testing in our Research Unit. Experimental trials, complete randomized block with 3-4 replications, were established in Spring 2008 and 2009 with 1,111 to 1,667 plants per hectare comparing 60 clones of white poplar and 80 genotypes of willow. One-year old pole cuttings of the different clones were utilized. In this work, the results obtained from plantations set up are presented.
A productivity higher than the average has been obtained from half-sib progenies of 'Villafranca'. Among the families obtained with the willow breeding work, including intra-specific hybrids of *S. alba*, some crosses showed higher growth rates and biomass dry matter yields compared to their parents' mean values. Besides there is a great variability in the specific gravity of the wood; there are clones with a very high density close to 0.50 g cm^{-3}, and others with a low density, less than 0.35 g cm^{-3}. These results are important for the selection for biofuel production.

Keywords: poplar, willow, feedstock, biomass yield.

[1] Consiglio per la Ricerca e Sperimentazione in Agricoltura, Unità di Ricerca per le Produzioni Legnose fuori Foresta (CRA-PLF). Strada Frassineto Po, 35, 15033 Casale Monferrato (AL), Italy. E-mail: laura.rosso@entecra.it. Tel. +39 0142 330900. Fax +39 0142 55580

ID-061

POPLARS AND WILLOWS FOR INCREASING THE LIVELIHOOD AND RURAL DEVELOPMENT: A REVIEW

Avtar Singh and Ashok Kumar[1]

Poplars and Willows belong to the Salicaceae family, provide a wide range of wood products (including industrial round wood and poles, pulp and paper, reconstituted boards, plywood, veneer, sawn timber, packing boxes, crates, pallets, wood plastic goods and furniture), non-wood products (fodder, fuel wood-small timber and chips for bioenergy) and services (shelter, shade and protection of soil, water, crops, livestock and dwellings) and have a positive role in rehabilitation of degraded lands, forest landscape restoration, climate change mitigation and livelihood generation in temperate, subtropical regions of the world. The Russian Federation, Canada and the United States have the largest reported areas of naturally occurring poplar and willows, while China, India and Pakistan have the largest planted areas. The cultivation of willow and its processing into furniture and crafts are important to the cottage-industry-based rural economy. The great majority of poplars and willows grow in natural forests and woodlands. Globally, 91 percent of poplars grow in natural forests, 6 percent in plantations and 3 percent in agroforestry systems and as trees outside forests. For willows, the respective figures are 94,5 and 1 percent. China accounts for 73 percent of the world's total poplar plantation area including 53 percent of the global plantations for wood production, nearly all of the plantations for environmental purposes and 49 percent of the plantations established in agroforestry systems.

The Country Report on Poplars and Willows of India estimates that the area under poplars and willows is 505,000 ha, of which the largest share (312,000 ha) is composed of *Populus deltoides*, an exotic species. This has been accompanied by an expansion in planting area from merely 60,000 ha during 2004 to 312,000 ha now The global area of planted willows was 176 000 ha, of which 90 000 ha were for wood production (51 percent). Five countries (Turkey, China, France, Italy and India) reported annual removals of more than 1 million cubic metres of poplar wood from planted forests. In Europe, pulp, paper and cardboard are the most favoured uses for poplar. In Chile, the Russian Federation, India, the Republic of Korea and Sweden they are used to produce matches. Timber and general construction are important end uses in Turkey, Finland and Argentina. In the United States, a surge in house-building resulting from lowered interest rates has led to increased demand for poplar-based composite board. Handicrafts and wicker work are important uses in Chile and the Russian Federation. In Egypt, *P. euphratica*, which grows naturally in newly reclaimed saline lands, is used locally as fuel wood.

Keywords: poplar, willow, livelihood, rural development.

[1] Department of Forestry& Natural Resources, Punjab Agricultural University, Ludhiana-141004. India, E-mail: avtar3@Pau.Edu

ECONOMICS AND MARKET MECHANISM OF POPLAR IN INDIA

H.P. Singh[1], M.P. Singh and J.Venkatesan

Agroforestry has expanded in the developing world due to forest scarcity, an increase in price of timber relative to grain and expansion of farming into land more marginal for annual crop production. It is a sleeping giant which has tremendous potential for generating rural employment, meeting market demand for raw material for wood processing industries and all round economic development. Therefore, integrated development of farm and agroforestry on the one hand and wood-based industries on the other is the need of the day.

Poplar is one of the most popular agroforestry species in northern plains of India. It is estimated that about 10 million plants of poplar are planted annually in western Uttar Pradesh, Punjab, Haryana and plains/ low outer valleys of other states of north India. Some of the agroforestry plantations of poplar give mean annual increment (m.a.i.) of up to 50 m^3/ha/year, the average being 20-25 m^3/ha/year, against an average of 4-5 m^3/ha/year achievable from forest plantations. Farmers have adopted agroforestry due to much higher economic returns from it, as compared to income from agriculture alone.

In India, poplar wood markets are highly unregulated, imperfect and oligopolistic as far as the prices, availability and quality parameters are concerned. Nothing exists like the market information system. The farmers are generally not much aware about the sizes, quality of logs and different ways of wood utilization. They are ignorant about the harvesting decision and negotiate with buyers to get maximum price for their produce. Middlemen, traders and wood-based industrialists take advantages of it and exploit the situation to their favour. Serious efforts were not made to develop suitable marketing system for poplar wood. The sudden steep fall of poplar price to Rs.120 -150/qt in 2002 - it was around Rs. 450 in 1998 - forced the farmers to reduce the plantations of poplars considerably and also led to uproot the already planted ones. However, the price has been increased from its downfall to current rate of Rs.900-1,000/qt. With the rise in price of poplar wood again the plantation rate was also increased. The complex nature of the market made the farmers to make use of the service of the middlemen and contractors. This results in the creation of various marketing channels.

Keywords: market mechanism, contractors, traders, economics.

[1] Resource Survey & Management Division, Forest Research Institute, Dehradun, 248 006, India. E-mail: singhhp@icfre.org

UNDERSTANDING THE DYNAMICS OF POPLARS AND WILLOWS ON HUMAN AND ANIMAL BEHAVIOR FROM PSYCHO EVOLUTIONARY PERSPECTIVE

Vasudha Singh[1]

The environment of an organism affords various actions to the organism. Both animals and humans stand in a 'system' or 'ecological' relation to the environment, thus an appropriate analysis of the environment is crucial for an explanation of perceptually guided behavior. The environment has an immediate effect on humans and animals, particularly the visual and spatial environment. For example how the colors, sounds, or spaciousness of our surroundings might affect our moods or behavior in social transactions. Monkey is a free animal and it is not right to cage him. An experiment done by *Harlow's* was a controversial experiment, they included rearing infant macaques in isolation chambers for up to 24 months, from which they emerged severely disturbed, this experiment so clearly suggest, that if the environment and the organisms living in it are disturbed or are isolated from their natural habitat then it can prove to have a negative impact on them.

These days people are constantly moving towards urbanization in a way disturbing the natural environment, the natural habitat of the organisms and there behavior. As the population is constantly increasing and the majority people are constantly moving towards cities from the rural areas, therefore there is greater need for space and for that the trees are constantly being cut down from the forest area. Poplars and willows are an example of deforestation. These species play a very important role in people's wellbeing. Poplars and willows contribute significantly to people, their lives, and livelihoods through the provision of wood products (industrial round wood 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. Due to urbanization the Poplars and Willow species are getting extinct as a result psychologically affecting the wellbeing of the people dependent on them, especially people living in rural areas, as a result these people are relying on others for basic necessities, there is an anxiety about the future as a result people are having mental disorders.

The poplar and willow species not only help humans but also affect the behavior of the animals living in forest, since this species is getting endangered and there is need for its conservation, it is affecting the behavior of animals, as they are getting more aggressive, uncontrollable and untamed towards humans because obviously their home is being broken down. There is an immediate need to conserve the poplar and willow species in order to maintain balance in the environment and also maintain balance when it comes to the psychology of animals and humans dependent on them. This is very much possible, as this has happened in the past also, in the form of Chipko Andolan which started in the early 1970s in the Garhwal Himalayas of Uttarakhand.

Keywords: Environment, habitat, deforestation, Himalayas.

[1] Researcher, Delhi University, 444, Plot-1, Heritage Towers, Dwarka, New Delhi, 110075, India. E-mail: Vasudhasingh19@gmail.com

ID-019

WHAT DO CITIZENS OF SERBIA THINK OF POPLAR FORESTS?

Mirjana Stevanov[1], Sasa Orlovic and Bojana Klasnja

In Serbia, around 32,000 ha are covered with poplar species (*Populus* sp.). The potential for area increase is seen in afforesting agricultural, degraded and other lands, that would additionally influence the provision of existing goods and services. But do we have information on what Serbian citizens know about poplar forests and what do they think of goods and services they provide?

In order to have a response to these queries, the Institute of Lowland Forestry and Environment from Novi Sad launched the first Serbian monitoring of citizen attitudes towards forests and forestry, within the project "Biosensing technologies and global system for long-term research and integrated management of ecosystems" (43002) financed by the Serbian Ministry of Education and Science within its framework of integrated and interdisciplinary research for the period 2011-2014.

An important part of this monitoring, based on a survey conducted via telephone on the representative sample of 18+ Serbian population, refers to the poplar forests. The main results show that more than two thirds of the citizens know about the existence of poplar forests in Serbia. Also, the majority considers that poplar forests grow much faster than other forests, e.g. pine, beach or oak, while 58% think that poplar wood, as a renewable source of energy, has not been used enough for heating, and half of them believe that planting of poplar forests could highly contribute to mitigate climate change. Information of this kind, as well as other into the socio-economic sphere of forestry, are considered relevant while they can contribute new aspects to the dialogue initiated by the International Poplar Commission under the slogan "Improving Lives with Poplars and Willows".

Keywords: poplar forests, citizen attitudes, forest policy.

[1] University of Novi Sad, Institute of Lowland Forestry and Environment, Antona Cehova 13d, 21 000 Novi Sad, Serbia. E-mail: mzavodj@gwdg.de

ID-058

FIELD PERFORMANCE OF POPLAR AND CHIR-PINE TREATED WITH ZIBOC IN INDIAN CLIMATIC CONDITIONS

Sadhna Tripathi[1] and Himani Pant[1]

During the last few decades an evident decline in natural resources in a number of countries has shifted focus on plantation forests. Plantations provide a potential means for sustained supply of wood for existing enterprises or household needs. Non-durable woods are prone to decay and need chemical protection.

For decades, copper chrome arsenate (CCA) was the primary preservative for treatment of wood used for residential construction. Nowadays, CCA has been placed in hazardous category and is going to be phased out. Keeping in mind the toxicity of conventional preservatives, ZiBOC, an environmentally acceptable new preservative developed in FRI, Dehradun, was evaluated for durability improvements of non-durable *Populus deltoides* and *Pinus roxburghii* stakes treated with three concentrations of ZiBOC and CCA in graveyards at three locations in India for 72 months.

Results revealed complete protection of treated stakes at Chakrata (30° 42'N , 77° 51'E) till 72 months while control was decayed and destroyed. Treated specimens were normal till 45 months in Dehradun (30° 15' N , 79° 15' E) followed by slight attack at lower concentrations while complete protection could be achieved at higher concentration in both the species. Control samples of *P. deltoides* were badly destroyed in three months showing high efficacy of ZiBOC comparable with CCA. Jodhpur (27° 00' N, 74° 00' E) yard has very aggressive termite colonies, hence, 6 and 8 percent preservative were used which completely protected both the species till last observation while controls of both the species were completely decayed in three months. The study suggests marked improvements in durability of both the species.

Keywords: CCA, durability, graveyard, wood.

[1] Wood Preservation Discipline, Forest Products Division, Forest Research Institute, Dehradun 248 006, India. E-mail: tripathis@icfre.org

ID-203

FODDER VALUE OF EUPOPULUS POPLARS LEAVES

A.P. Tsarev[1]

Temperate climate poplars are appreciated not only for their growth speed, various application of wood in the industry, land improvement and a recreation, but also for ability to make non-wood products of great practical value. Poplars leaves used in the fodder purposes are very important products. Some results of leaf fodder value studying two poplars clones of subspecies *Eupopulus* Dode are presented in this publication. *Populus nigra* L, *P. deltoides* Marsh. and three hybrids of the Russian breeding are investigated in section *Aegiri* Dode. *P. balsamifera* L., *P. trichocarpa* Torr. et Gray (three clones) and *P. maximowiczii* Henry were studied in section *Tacamahaca* Spach. The intersection hybrid *'Voronezhsky Giant'* (*deltoides* x *balsamifera*) was included in the research. The plants growing in the author's collections at Semiluksky nursery of the Voronezh region were used. Three trees or bushes for each clone were examined. Collections were carried out in the second half of the growing season (late July-August) from different parts of the tree crown or from the bush from 10 different points on the plant in small portions during two hours. All samples collected from one tree or bushes were mixed in one sample, from which after thorough mixing two middle samples were selected. The mass of each sample was 500 g. The content of digestible and crude protein, crude fat, fiber, ash, nitrogen free extractives substances (NFES), calcium, phosphorus, carotene, fodder units (fu) and others was studied. Those ingredients were studied in natural moisture leaves. Some ingredients were studied in absolutely dried ones.

It is established that the contents of components in leaves by natural humidity at balsam poplars vary for digestible protein from 23 to 31 g/kg, for calcium from 3.2 to 8.3 g/kg, for phosphorus from 0.7 to 0.9 g/kg, for carotene from 53 to 98 mg/kg, crude protein from 3.7 to 5.7%, crude fat from 0.23 to 0.32%, NFES from 15.5 to 15.8%, crude cellulose from 2.6 to 3.3%, ashes from 2.2 to 2.5%. The contents of fodder units fluctuated from 0.22 to 0.28 fu/kg.

The same indicators of black poplars were as follows: for digestible protein 22-33 g/kg, calcium 3.3–10.4 g/kg, phosphorus 0.5-1.0 g/kg, carotene 43-79 mg/kg, crude protein 4.0–5.9 %, crude fat 0.23-0.32 %, NFES 14.6–19.2 %, crude cellulose 4.0–7.8 %, ashes 1.9–4.9 %. The contents of fodder units fluctuated from 0.21 to 0.29 fu/kg. As a whole the black poplars had wider amplitude of variability for the majority of components, than the balsam ones. The intersection hybrid *'Voronezhsky Giant'* had the following indicators: digestible protein 28.7 ± 2.8 g/kg, calcium 4.9 ± 0.6 g/kg, phosphorus 0.7 ± 0.05 g/kg, carotene 87.0 ± 12.5 mg/kg, crude protein 5.2 ± 0.5 %, crude fat 0.35 ± 0.03 %, NFES 17.4 ± 0.6 %, crude cellulose 3.1 ± 0.4 %, ashes 2.2 ± 0.2%. The content of fodder units was 0.24±0.003 fu/kg. On the majority of indicators this hybrid is intermediate between black and balsam poplars.

The study of the leaves at absolute dry humidity showed that the content of fodder value components in this case increases 2-3 times and more. As a whole the nutritional value of poplars leaves is comparable to that received for an alfalfa. Prospects of poplars leaves in the fodder purposes are evident.

Keywords: poplars, leaves, fodder value.

[1] Petrozavodsk State University, 33 Lenin pr. Petrozavodsk, 185910, Karelia, Russia. E-mail: tsarev@psu.karelia.ru; antsa_5@yahoo.com

ID-002

HIGH-THROUGHPUT CHARACTERIZATION OF POPLAR WOOD TO SUPPORT SELECTION AND BREEDING

Joris Van Acker[1], Jan Van Den Bulcke[2], Nele Defoirdt[3] and Manuel Dierick[4]

Poplar and willow wood can be used in many different applications and hence the properties can be optimised for one or more of these. It is possible to grow trees for so-called traditional wood uses like timber for construction or engineered wood products and wood-based panels like plywood and OSB. Such applications may require poplar wood with good mechanical properties and low variability in wood structure and processing also requires high tree quality. Hybrid-clonal poplar plantations have proven to be very adequate in complying with these prerequisites. Next to the potential to use poplar for such material uses, there are also fibre-based products like pulp for paper and e.g. MDF. Here pulping process parameters can be optimised based on the ease to remove lignin. Poplars and willows are however also very well suited for bioenergy production. Besides combustion where a higher lignin content can be beneficial, there is also the potential to use this biomass to produce second generation biofuels with a need for good accessibility of polysaccharides.

Selection and breeding of tree species requires high-throughput characterization of the wood properties in relation to both applications for material and bioenergy use. At the Laboratory of Wood Technology, advanced techniques have been developed for this purpose. A considerable part of the activities was conducted in the framework of the European research project Noveltree co-ordinated by INRA. First, coupled DSC-TGA can be used as a tool to obtain semi-quantitative information on the chemical composition due to the different thermokinetics of the main constituents (lignin, cellulose and hemicelluloses) and gives also a detailed view on the energetical content of the material. Second, a method is developed for using short-wave infrared signals to obtain chemical information on cellulose and lignin composition in a fast and quantitative way. Third, structural properties on different scales are acquired using the multi-resolution X-ray tomography set-up developed at UGCT, the Ghent University Centre for X-ray Tomography. The system offers a large range of operation freedom, all combined in versatile acquisition routines (standard or fast scanning, tiling, helix, etc.). Simultaneously with 3D structural information, (micro)densitometrical detailing is obtained as well. Combining all aforementioned techniques allows for quantitative characterization of key wood properties for selection and breeding taking into account not only mean values, but surely also assess variability within and between trees.

Keywords: wood properties, high-throughput, chemical composition, 3D CT scanning.

[1] Ghent University, Laboratory of Wood Technology & Centre for X-ray Tomography (UGCT), Coupure Links 653, 9000 Ghent, Belgium. E-mail: Joris.VanAcker@UGent.be
[2] Ghent University, Laboratory of Wood Technology & Centre for X-ray Tomography (UGCT), Coupure Links 653, 9000 Ghent, Belgium. E-mail: Jan.VandenBulcke@UGent.be
[3] Ghent University, Laboratory of Wood Technology & Centre for X-ray Tomography (UGCT), Coupure Links 653, 9000 Ghent, Belgium. E-mail: Nele.Defoirdt@UGent.be
[4] Ghent University, Department of Physics and Astronomy & Centre for X-ray Tomography (UGCT), Proeftuinstraat 86 , 9000 Ghent, Belgium. E-mail: Manuel.Dierick@UGent.be

ID-063

LEAF ANATOMICAL AND ULTRASTRUCTURAL RESPONSES TO SALT-STRESS OF THREE *POPULUS ALBA* L. CLONES

M. Abassi[1], Z. Bejaoui[1] and A. Albouchi[1]

Tunisia has large marginal and allomorph areas (about 12% of the total country area). The rehabilitation of degraded zones has been an important strategy proposed in forest management projects. Using fast growing woody species such as *Populus* sp. known to tolerate salinity might be an alternative to revalorize those areas and increase the national wood production. The aim of the present study is to investigate the adaptive leaf anatomical and ultrastructural responses of *Populus alba* L. to salinity.

Three *P. alba* clones (OG (salt-sensitive), MA-195 (moderately salt-tolerant), MA-104 (salt-tolerant)) have been submitted during one year to regular watering to two NaCl concentrations (0, and 6g/l). The study was undertaken in semi-controlled conditions. The salinity tolerance was estimated through leaf micromorphological and anatomical modifications and chloroplast ultrastructure. The salinity effect induced significant increase in trichomes and stomatal density and a reduction in the length and the opening of the mudboils. The clones displayed differences in their responses to salinity. The most tolerant clone (MA-104) has developed the highest density of trichomes and stomata. It showed a plasticity of its stomata, as evidenced by a reduction in their length and the opening of the mudboils. While the sensitive clone (OG) developed the lower stomatal density and no reduction of the opening of mudboils related to low tolerance to salinity. Increase in mesophyll cell size as a response to salinity was noted in the case of MA-104. In the case of MA-195, leaf cuticle and upper epidermis became thicker, but a mesophyll thickness was reduced. Salt stress reduced both epidermal and parenchyma cell size in the case of OG showing an atypical structure in mesophyll in comparison with control. The salinity has induced changes in the chloroplast structure of the *P.alba* clones. The electron microscopy showed a decrease in starch accumulation, an increase in number or size of plastoglobuli and disorganization on the thylakoid structure of chloroplast NaCl treated leaves. However, the clones displayed differences in their responses to salinity. A swelling of thylakoid, an increase in the number and size of plastoglobuli and destruction of chloroplast membrane were produced by NaCl in chloroplasts of the most stressed clone. Whereas, in the tolerant one, thylakoid structure organization was maintained, increases in the number of plastoglobuli as well as a decrease on their size were produced and a peripheral reticulum (PR) was developed.

Keywords: White poplar, salinity, trichomes, mudboils, mesophyll, chloroplast, peripheral reticulum.

[1] Abassi Mejda, Institut National de Recherches en Génie Rural, Eaux et Forêts (INRGREF), BP 10, Ariana 2080, Tunisie. E-mail : mej_abassi@yahoo.fr

INVESTIGATIONS OF PHOTOSYNTHETIC CAPACITY AND WATER USE EFFICIENCY OF ISOGENIC LINES OF POPLAR CLONES DIFFERING IN PLOIDY

Lucía Atanet Alía[1], Dietmar Lüttschwager[1], Dietrich Ewald[2] and Arthur Geßler[1]

The objective of this study was to analyse the implications of the ploidy level of different isogenic lines of poplar clones for plant development, primary productivity and water use efficiency (WUE). Experimental results should support selective breeding of poplar clones with more efficient water use.

Three different fast-growing poplar clones of the section *Populus* were used (Brauna 11 [*Populus tremula*], L447 [*Populus canescens*] and Esch 5 [*Populus tremula x Populus tremuloides*]). Clones were established in tissue culture (2N) and lines of different ploidy level (2N/4N and 4N) were generated by colchicine treatment. Micropropagated plants of two experiments were transferred to soil in a greenhouse in March and April. Additional light was provided from midnight to noon. Growth was measured every two weeks. Approximately 8 weeks after transfer to the greenhouse, photosynthesis and transpiration measurements were made on fully expanded leaves in response to varying light levels using an open-path portable photosynthesis system (n = 10 plants per isogenic line). Measurements were repeated twice during the growing season. Instantaneous water use efficiency was calculated, and light response curves were modelled. Additionally, specific leaf area (SLA) and chlorophyll content of leaves was analysed.

Remarkable morphological differences in development were observed between clones and within the lines. L447 (grey poplar) had the thinnest leaves, and plants of Brauna 11 (aspen) had the thickest leaves. Tetraploid and mixoploid plants had larger leaves than diploid plants. Clones differed significantly in height, however not between all ploidy levels (ANOVA Test). Brauna 11 and L 447 were the tallest plants. Specific leaf area of plants which were transferred to soil earlier (March) was lower than that of those transferred later (April). In both cases, however, leaves of Esch 5 (hybrid aspen) had the highest and of Brauna 11 the lowest SLA values. A strong correlation was observed between chlorophyll content and specific leaf area (R^2 = 0.7 to 0.8, p=0.05). Although tetraploid lines of all three clones had the highest chlorophyll contents, there was no clear relationship between ploidy level and photosynthesis. Grey poplar (L447) had the lowest maximum photosynthetic rate (P. max) in spring and early summer with 5-6 and 9-10 µmol/m²s, respectively, and they performed best under low light intensity. Under low light conditions of springtime, maximum photosynthesis was highest for mixoploid, diploid and tetraploid leaves of hybrid aspen (Esch 5) with 8.8, 8.4, 7.4 µmol/m²s, respectively. Later in the year, the P. max values were much higher for all ploidy variants, but the clone Esch 5 was outperformed by the aspen clone Brauna 11 (maximum 16.5 µmol/m²s). In conclusion, Esch 5 exhibits gas exchange rates more like a shade-plant whereas Brauna's light requirement is stronger. However, the area of all leaves has to be

[1] Leibniz-Center for Agricultural Landscape Research (ZALF). Institute for Landscape Biogeochemistry. Eberswalder Straße 84. 15374 Müncheberg. Germany. E-mail: lucia.atanet@zalf.de; dluettschwager@zalf.de; gessler@zalf.de

[2] Johann Heinrich von Thünen-Institute.Institute of Forest Genetics. Eberswalder Chausee 3a, 15377 Waldsieversdorf. Germany. E-mail: dietrich.ewald@vti.bund.de

considered for an evaluation of the whole plant productivity. Regarding WUE Esch 5 was the most efficient followed by Brauna and L447.

Keywords: poplar, ploidy, tissue culture, photosynthesis, light response, water use efficiency, specific leaf area, growth development.

AEROALLERGENS FROM POPLAR TREES IN THE KASHMIR VALLEY OF INDIA

Gh. Mohiuddin Bhat, Amarjeet Singh, Qasba Shazmeen and Ombir Singh[1]

The Kashmir valley has been witnessing an increase in allergy disorders due to aeroallergens present in the environment. Aero allergy from *Populus deltoides* specifically seed menace is a new addition in the list of aeroallergens in the valley. The seed menace of cottonwood caught the government's attention after tourists and locals falling ill and complained to the government. The female species of the plant has left the valley sneezing and coughing ever since it started shedding seeds in the months of April and May every year. There is a sudden spurt in lung and throat illnesses, and cold and fever, during these days. The seeds are also allergic to eyes and many schools in Srinagar, capital city of Jammu & Kashmir state, have even prescribed masks to the students. School going children, roadside vendors and office goers wearing green masks are a common sight in the valley in early spring days. Due to this reason, nowadays it becomes a popular saying – "Poplars bring money but masks to Kashmir valley". The white fluffy substance, a product of poplar, covers the roads during April/May each year and is often mistaken for sleet or cotton, but goes closer and it could trigger instant sneezing, a runny nose and throat irritation due to allergens presence. However, detailed clinical studies are required to test seed menace of poplar on atopic population in the valley. The strategies and precautions to reduce this seed menace were also discussed in this article.

Keywords: poplars, aeroallergens, seed, remedial measures.

[1] Faculty of Forestry, SKUAST-K, Shalimar, Srinagar, Forest Research Institute, Dehradun - 248006, India. E-mail: ombirfri@yahoo.in Tel: +91-135-2224469, Fax: +91-135-2756865

ID-118

ROLE OF POPLARS AND WILLOWS IN IMPROVING QUALITY OF LIVES OF PEOPLE IN BADGAUM DISTRICT, JAMMU AND KASHMIR, INDIA

Sas Biswas[1] and Musadiq

The Budgam, Jammu & Kashmir District occupies an area of 1,371 sq. km. The district is geographically based on Karewa formation and deposits. These Karewas are very deep, weak, friable and susceptible to heavy erosion, faulty agriculture and removal of its rich soil for rampant selling, thus causing deep ravines and landslides to the miseries of the communities, particularly in Khansahab and Charai-Shrief blocks. This practice of selling soil has resulted in vanishing of almond gardens which produce a costlier fruit of Kashmir and a source of income to a large portion of the population. The district is educationally and economically backward. The soil loss in some areas of Budgam touches 35 tons/ha/year - the highest in this State. The most viable and cost-effective conservation measures of the soil are to use suitable indigenous species like poplar and willow on the lands under the threat of erosion. Poplar helps saving the exposed lands by means of its huge canopy, whereas willow develops profuse root hair system along the banks of nallhas acting as a vegetation measure and preserving soil loss.

The present study was undertaken from the point of view of the role of poplar and willows in soil and water conservation of degraded and catchment areas of Budgam District, thus improving the livelihood conditions of people. The communities have opted for poplar (*phras*) more and more in waste lands, community lands and degraded lands. The species of poplar are *Populus deltoides* (Russi phras), *P. nigra* (Kashmir phras), *P. alba* (Wun phras), *P. casale* (Bulgaria phras) and *P. ciliata* (Kullu phras). Among the willows, locally named as *veer*, cultivated and used as a tool for soil and water conservation works, there are *Salix alba* (White Willow), *S. daphonoides* (Black veer), *S. triandra* (Almond veer), *S. purpurea* (Kala veer) and *S. viminalis* (Lori veer). The height of poplars and willows in these areas is approximately from 22 to 30 m and 17 to 24 m, respectively. In Rakhs like Kawoosa, Hokarsar, Rakh Aarth of Budgam District, they have willows to the extent that they can be called as willow (*Salix*) forest to the benefit of the people. The approximate girths of poplar and willow are 30 to 210 cm and 30 to 300 cm, respectively. Among the ten villages, namely Lakhripora, Mahwara, Narakara, Wadwan, Shahpora, Batpora, Razwan, Palapora, Shalteng, Tengpora, the studied number of trees of poplar grown by the communities range from 2,544 to 12,282.

The paper presents comprehensively: (1) The need for consistent policy, (2) Legal and regulatory framework to help the farmers to have the confidence in investing in poplar and willow forests, (3) Decentralization and strengthening of the capacity of different institutions engaged in the soil and water conservation, (4) Involving research and training institutes to integrate the new planning scientific and mechanical tools into technical and extension services to transfer knowledge and technology to the primary beneficiaries, particularly smallholders, (5) Securing development funds from different agencies and attracting public and private (corporate and smallholder) investors, (6) Prioritization of most vulnerable areas, (7) Mass awareness programmes and development of sense of belonging among the stakeholders. The measures proposed, if adopted, can prove useful for the public in their larger interests and improve the quality of lives of the people. Poplars and willows planted in ecologically fragile and

[1] Department of Forestry, Dolphin Post Graduate Institute of Biomedical and Natural Sciences, Dehradun, India. E-mail: biswassas@gmail.com

degraded lands have improved the livelihood of the communities in terms of employment, revenue generation and sustainable utilization of resource.

Keywords: Karewa formation, degraded and catchment areas, mass awareness, primary beneficiaries.

CLIMATE CHANGE IMPACT ON VOLATILE ORGANIC COMPOUND EMISSIONS FROM POPLAR

Mauro Centritto[1]

Biogenic volatile organic compound (BVOC) emissions are generally closely linked to photosynthesis in many forest and agroforestry species, but they may play a contrasting role in the biosphere-atmosphere interactions. Forest and agroforestry vegetation is a dominant sink for the atmospheric CO_2 and ties about 90% of the globe's biomass carbon. In contrast, BVOCs may play a major role in the production of tropospheric ozone and aerosols. Given the importance of both BVOC emissions and carbon assimilation for the biosphere-atmosphere interactions, the consequences of environmental changes for the biogeochemical carbon cycle and for the atmospheric chemistry are potentially extremely large. In addition, these environmental factors may alter the developmental stage at which BVOCs are released into the atmosphere.

A number of independent field and laboratory experiments to investigate the effect of rising temperature, elevated [CO_2], drought, shortwave radiations, heavy metal and fire on BVOC emissions were conducted on *Populus* spp.. Plants have evolved an extraordinarily diverse suite of protective mechanisms against biotic and abiotic stresses. The question is whether these ammunitions will be also able to protect photosynthesis from novel stresses such as exposure to elevated temperatures, air or soil pollution, and increasing UV radiation. Abiotic stressors generically involve production of reactive oxygen species in plant cells, that volatile isoprenoids (isoprene, monoterpenes and sesquiterpenes) are reactive molecules whose biosynthesis is elicited by a general stress condition, and that BVOCs generally exert signaling functions. We propose that volatile isoprenoids mitigate the effects of oxidative stress on photosynthesis by mediating, directly or indirectly, the oxidative status of the leaf. Finally, the results of these studies are also important for estimating the overall budget of BVOCs in the atmosphere in response to climate change, air pollution and reduced water availability, and to scale-up BVOC impact on air chemistry and quality at regional and global level.

The purpose of this paper is to review the response of BVOC emissions and carbon assimilation (photosynthesis, light and dark respiration) to changing environmental conditions.

Keywords: air pollution, abiotic stress, carbon assimilation, elevated [CO_2], isoprenoids, rising temperature, UV radiation.

[1] Institute of Plant Protection, National Research Council, Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy. E-mail: mauro.centritto@cnr.it

ID-062

USE OF SALICACEOUS GENOTYPES FOR PHYTOREMEDIATION: THE EXPERIENCES OF THE CRA RESEARCH UNIT FOR INTENSIVE WOOD PRODUCTION OF CASALE MONFERRATO IN ITALY

Pier Mario Chiarabaglio[1], Giuseppe Nervo[1], Gianni Facciotto[1], Lorenzo Vietto[1] and Giovanni Mughini[1]

The Research Unit for Intensive Wood Production of the CRA (CRA-PLF) in Casale Monferrato (Italy) has carried out several activities with the aim to select poplar and willow genotypes for environmental uses, in particular for the protection of surface waters from pollution and for the rehabilitation and decontamination of soils contaminated by industrial waste (phytoremediation).

Buffer strips have been established using native species (particularly *Populus nigra*, *P. alba* and *Salix alba*) between rivers and agricultural land intensively cultivated with maize or rice. A short-rotation forestry plantation was established with pioneer species in a typical Mediterranean environment of southern Italy and irrigated with water coming from a urban waste-water treatment plant. The phytoextraction ability of different poplar and willow genotypes in cases of heavy metal soil contamination was assessed and compared. *P. nigra* var. *Italica* was fertirrigated with olive mill wastewater in a phytodepuration plantation specifically established to evaluate the ability of poplar to grow in polluted soil and to degrade polyphenols in wastewater.

Other ongoing experiences are focused on the use of poplars and willows for the bioremediation of hydrocarbon contaminated soil. The results obtained so far show the high adaptability and the ability of *Salicaceae* to grow in different environments also under high stress conditions. Moreover, the CRA-PLF has achieved genetic transformation of *P. alba* 'Villafranca' for the improvement of its cadmium phytoextraction capacity. These GM plants are maintained *in vitro* in a secluded grow chamber.

Keywords: phytoremediation, poplar, willow, pollution.

[1] CRA-Unità di Ricerca per le Produzioni Legnose fuori Foresta, str. Frassineto 35, Casale Monferrato 15033 (AL), Italy. E-mail: piermario.chiarabaglio@entecra.it

CO_2 BALANCE: ENVIRONMENTAL SUSTAINABILITY OF POPLAR STANDS IN COMPARISON WITH NATURAL FOREST

Gabriele Demichelis[1], Deborah Solarolo[1], Pier Mario Chiarabaglio[1] and Giuseppe Nervo[1]

In order to stock CO_2 to reduce the effects of climate change, the Kyoto Protocol promotes afforestation practices. Considering that fast-growing cultivated poplar stands represent an important sink for this Green House Gas (GHG), this paper presents a comparative analysis of the CO_2 balance of four poplar plantations and four natural forests located nearby.

The CO_2 stored in the trees is computed by assessing the dry matter of the stems and branches (using different formulas for poplar stands and for natural forests) and of the roots (estimated by application of a coefficient). Soil carbon stock was not computed. To calculate the emission of GHG, all cultivation practices were considered: planting material preparation, soil preparation, planting, cultivation (including treatments against pests and diseases, weed control, irrigation). The farmers were interviewed and planting and maintenance practices were recorded for each stand, including type and characteristics of the tractors, weight of the equipments, products used and time (machine and human work) for each operation. The GHG was estimated by application of suitable emission factors. The environmental sustainability was calculated as the ratio of captured CO_2 to the CO_2 emitted during cultivation practices. The data of poplar stands were compared with those of natural forests.

The study also allowed to quantify the sustainability of each cultivation practice and to compare two different cultural models based on cultivation of the traditional clone (*Populus* ×*canadensis* Mönch 'I-214') and of *P.* ×*canadensis* Mönch 'San Martino', resistant to the main foliar diseases.

Keywords: CO_2 balance, sustainability, green house gas, poplar stands.

[1] CRA-Unità di Ricerca per le Produzioni Legnose fuori Foresta, str. Frassineto 35, Casale Monferrato 15033 (AL), Italy. E-mail: piermario.chiarabaglio@entecra.it

THE IMPACT OF WILLOW AND POPLAR SHORT-ROTATION CROPS GROWN ON AGRICULTURAL LAND ON WATER AND SOIL QUALITY

Ioannis Dimitriou[1], Blas Mola-Yudego[1,2], Pär Aronsson[1], Jan Eriksson[3]

The area of agricultural land cultivated with short-rotation coppice (SRC) of willow or poplar for production of biomass for energy is expected to increase in the short-term in several European countries. This will have implications for various environmental issues, among others water and soil quality. As a perennial crop, SRC differs from arable crops in physical traits and management practices. Concerning groundwater quality, results so far imply low nutrient leaching when SRC compared to other "conventional" crops, but the long-term effects of SRC plantations applied with recycled by-products as sewage sludge and wastewater must also be considered. Extensive sampling of groundwater in several commercial SRC fields in Sweden and in adjacent, conventionally cropped farmland was been conducted showing that concentrations of NO_3-N in the groundwater of SRC are much lower than the respective in adjacent fields. For PO_4-P in the groundwater, a similar reduction was not obvious and more measurements need to be conducted. Similar comparisons between commercial SRC fields and adjacent fields were conducted in order to evaluate the effects of SRC cultivation on soil. Differences in heavy metal content (with special focus on Cd), pH, total carbon and nitrogen in the top and subsoil of such fields were conducted, indicating reduction of Cd (ca. 10% in the top soil on average) in SRC fields and increase of soil C in the same fields.

Keywords: bioenergy, environmental services, short rotation coppice.

[1] Department of Crop Production Ecology, Swedish University of Agricultural Sciences (SLU), P.O. Box 7016, S-750 07 Uppsala (Sweden). E-mail: ioannis.dimitriou@slu.se
[2] School of Forest Sciences, University of Eastern Finland, PO Box 111, 80101, Joensuu (Finland)
[3] Department of Soil and Environment, Swedish University of Agricultural Sciences (SLU), P.O. Box 7014, S-750 07 Uppsala (Sweden).

ID-003

IMPROVING BIOMASS PRODUCTION AND PHYTOREMEDIATION USING NATURAL ENDOSYMBIONTS OF POPLAR AND WILLOW

S.L. Doty[1], J. Knoth, Z. Khan, J.W. Kang, D. Roman, S.-H. Kim and G. Ettl

The interior of poplar and willow provides habitat for a diversity of microbes, termed endophytes, that benefit the plant host by increasing nutrient acquisition, drought stress tolerance, and pollutant degradation. Nitrogen fixed biologically by plant-symbiotic bacteria is ecologically friendly, reducing the need for chemical fertilizers that cause environmental damage.

We have isolated a variety of microorganisms able to grow under nitrogen-limitation from the stems of native poplar (*Populus trichocarpa*) and willow (*Salix sitchensis*) in riparian zones in the Pacific Northwest. Cloning of nitrogenase sequences from the isolates, incorporation of ^{15}N from labeled dinitrogen gas, and nitrogen mass balance studies support our hypothesis that some of these endophytes can fix atmospheric nitrogen. The presence of these diazotrophic microorganisms may help explain the ability of these pioneering tree species to grow under nitrogen-limiting conditions. In a greenhouse study, inoculation of poplar plants with a consortium of the native endophytes nearly doubled the fresh weight of the plants compared to uninoculated control plants.

A field study is underway and the results will be presented. Utilization of nitrogen-fixing endophytes may enable plantations of these important bioenergy crops to be grown more sustainably and at less cost. In addition, some natural endophytes of poplar degrade important environmental pollutants including PAHs and TCE. Introduction of the PAH-degrading poplar endophyte into willow plants strongly reduced pollutant toxicity and improved phytoremediation potential.

Keywords: nitrogen-fixation, endophytes, remediation.

[1] School of Environmental and Forest Sciences, College of the Environment, University of Washington, Seattle, WA, USA. E-mail: sldoty@uw.edu

HIGH YIELD AND CARBON STORAGE IN 9-YEAR-OLD HYBRID POPLAR RIPARIAN BUFFERS IN SOUTH-EASTERN CANADA

Daniel Gagnon[1], Julien Fortier[2], Benoit Truax and France Lambert[3]

Agriculture produces 10-12% of the global emissions of greenhouse gases. Hybrid poplar riparian buffers have great potential for increasing carbon and nutrient sequestration in agro-ecosystems over a short time period, while providing farmers with wood and biomass. There are few data on C stocks in these systems (above and belowground biomass, soil).

Our objectives were : (1) to determine the woody biomass and volume yield, across four sites, in three hybrid poplar clones growing in riparian agroforestry sytems, and (2) to determine C stocks in all riparian buffer compartments (coarse and fine roots, stems, branches, leaves, and soil), after 9 years of growth (2011). All four buffers were planted during one week in May 2003, on both banks of agricultural streams (90 m long, 5.5 m wide on each bank). All four sites are in the Eastern Townships region of Quebec, Canada. Clones used in this study are: *Populus deltoides* x *nigra* (DxN-3570); *P. canadensis* x *maximowiczii* (DNxM-915508); *P. maximowiczi* x *balsamifera* (MxB-915311). Soils were excavated in 2011 (4 sites x 4 blocks x 3 clones = 48 plots) and sampled to obtain soil C data, root (coarse and fine) biomass and C content. One poplar tree was cut in each of the 48 plots to determine volume, biomass and C content for the three clones. These harvested trees were used to generate predictive regressions for accurate estimates of volume, biomass and C content for the aboveground compartment. We obtained strong relationships between site fertility (soil nutrient stocks and supply rates) and poplar yield. The highest yield after 9 years was obtained at the most fertile site (soil P and K). Yield increased from the 6th to the 9th year on all sites, with the largest increase on the least productive sites. Volume and woody biomass yields ranged from 26.3 to 49.9 $m^3ha^{-1}yr$ and from 11.4 to 21.4 $tha^{-1}yr$ on three of four sites. Total coarse root biomass ranged from 9.2 to 27.3 tha^{-1}. Most coarse root biomass (61-73%) was between 0 to 20 cm soil depth. Total fine root biomass ranged from 1.86 to 2.62 tha^{-1} and most (61-78%) was also found between 0 to 20 cm. Non negligible root biomass was seen at the lowest soil depth (40-60 cm). Deep roots are important for increasing the active denitrification zone, and are also important for the uptake of nutrients migrating from upland agricultural land use, as well as for stream bank stability. Total soil C in hybrid poplar buffers ranged from 78.4 to 109.8 tha^{-1}. At most sites (3 of 4) soil C decreased with soil depth. Total aboveground C (poplar biomass) ranged from 34.8 to 107.5 tha^{-1}. Total belowground carbon (root biomass) ranged from 5.5 to 14.8 tha^{-1}. Total C (above & belowground biomass and soil) ranged from 118.7 to 200.7 tha^{-1}. We conclude that hybrid poplar riparian agroforestry systems have a very high potential to rapidly produce wood volume/biomass. It is also clear that these riparian buffers can be a very active and fast-growing C sink in the agro-ecosystems of south-eastern Canada. Funding from Agriculture and Agri-Food Canada's Agricultural Greenhouse Gas Program is gratefully acknowledged.

Keywords: agroforestry, *Populus* hybrids, tree biomass, root biomass, carbon stocks, soil C.

[1] University of Regina, Regina, SK, Canada. E-mail: Daniel.Gagnon@uregina.ca
[2] Centre for Forest Research, UQAM, QC, Canada. E-mail: fortier.julien@courrier.uqam.ca
[3]Eastern Townships Forest Research Trust, St-Benoît-du-Lac, QC, Canada. E-mails: btruax@frfce.qc.ca and france.lambert@frfce.qc.ca.

EVALUATION OF *SALIX* CLONES IN FLOODPLAIN SOILS OF THE DEPRESSION OF THE SALADO RIVER, BUENOS AIRES PROVINCE, ARGENTINA

Mario Alfredo Galetti[1] and Carlos Alberto Esparrach

Afforestation through the assessment of four clones of the genus *Salix*, in the Depression of the Salado River, attempts to improve the ecological conditions of this environment through two processes: the absorption of excess water and the contribution of source woody material, the changes taking place in the floristic composition of the site and ther creation of repair creating mountains for livestock on land which were not used for this purpose. GPS coordinates are 35° 41' 01 "Lat, South-57° 46' 45" Long. West, at 10 m.s.n.m. in two sites identified in the region such as: low sweet and *espadañal* (low bulrush), located in the Party of Chascomús, Buenos Aires province, Argentina. They are characterized by being semi-filled lagoons, with almost permanent waterlogging, salinity and alkalinity; concave relief, with very slow or no runoff. At the time of planting (August 1993), the water level was 70 cm on low with bulrush.

The values of survival were analyzed and growth data are presented as complementary data, as well as the changes that occurred in the floristic composition of the plots. In both sites, 120 cm stakes were used and the materials evaluated were: *Salix babylonica* var. *sacramenta* - American willow, *Salix babylonica x Salix alba* cv. 131-25, *Salix babylonica x Salix alba* cv. 131-27 and *Salix nigra* cv. *"* Alonzo *nigra* 4".

In low sweet, survival was zero for all treatments after an implantation of three years. On the low with bulrush, at the sixth year a taking of 100% of the clone *Salix nigra* 4 was verified, standing out significantly from the rest of the treatments that were 32% for clone 131-25, 22% for clone 131-27 and total mortality for the American willow.

Regarding variants detected at the sixth year in the flora, the progress of existing vegetation in low sweet about the community bulrush has to be highlighted. The bulrush (*espadaña*) *Zizaniopsis bonariensis* has been replaced by other species, among which *Leersia hexandra*, *Althernathera philocercides*, *Glyceria multiflora*, *Eryngium echinatum*, *Panicum milioides*, *Ambrosia tenuifolia*, *Heleocharis* sp and *Cyperus* sp were detected, thereby changing the floristic composition of the plots with *Salix nigra* 4.

From an environmental perspective, the positive effects derived from a greater PPN (net primary production), both for forestry production by improving the soil conditions for other plants, and the transformation of a reducing substrate, producer of methane and sulfides (greenhouse effect gases).

Keywords: excess water, salinity, alkalinity, floristic composition.

[1] EEA, INTA Balcarce, Buenos Aires. Argentina.

DROUGHT AND SHADE EFFECTS ON MORPHOLOGY, PHYSIOLOGY AND GROWTH OF *SALIX* CLONES

A.B. Guarnaschelli[1], A.M. Garau[1], F.D. Caccia[1], E. Cincotta[1], P. Gonzalez Otharán[1] and S. C. Cortizo[2,3]

Resource deficiency severely impacts on plant survival and growth during forest establishment. Although both biotic (like weed competition) and abiotic factors may cause water and light restrictions, the rise in the frequency of extreme drought events and the expected increase in global dimming due to climate change require nowadays a better understanding of how plants may respond to such uncertainties. Phenotypic plasticity, the ability of plants to express different phenotypes according to growth conditions, is considered an important trait by which they may cope to environmental heterogeneity and may confer them adaptive potential. In recent years the study of plant responses to multiple stresses has increased considerably; however scarce information is available about how *Salix* may respond to such stressful conditions.

The purpose of this study was to evaluate the capacity of physiological and morphological acclimation of two willow clones growing under drought and shade conditions and how their potential phenotypic changes may contribute to maintain plant survival and growth. Stem cuttings of *Salix babylonica* var. *sacramenta* 'Soveny Americano' and *Salix matsudana* x *S. alba* 'Barrett 13-44 INTA', clones of economic importance in the Paraná River Delta (Argentina), were planted in September 2011 in 15 l pots filled with organic soil. Two months later, plants were assigned to a combination of three irradiance levels (full sunlight -FS-, moderate shade -MSh- and severe shade -SSh-, which implied 100%, 25% and 10% of PAR) and two water regimes (well watered -WW- and watered stressed -WS-). The reduction in the availability of light and water produced a decrease in plants stomatal conductance, however the effect of drought was not significant under SSh. Similarly water potential and relative water were less affected by drought SSh plants, especially in clone 'Soveny Americano'. Lower values of osmotic potential were observed in MSh plants and in WW plants. The effect of drought and shade on specific hydraulic conductivity (Ks) varied with clones. There was only a drought-induced reduction in Ks of 'Barrett 13-44 INTA'. By contrast, shade did not affect Ks. Shaded plants, especially those of 'Barrett 13-44 INTA' had higher values. Survival was not affected, but WS and SSh plants had lower total dry mass. In FS-WW and MSh-WW plants, stem and total dry mass were similar. There were significant changes in the pattern of carbon allocation. Leaf area increase in MSh plants and decrease in WW plants, while shoot/root ratio only increased with shade. These results indicate that both clones developed physiological and structural phenotypic changes, and some of them allowed the plants to cope with multiple resource deficiency. The drought response of the two clones depended on the light environment. For several physiological characteristics, the impact of drought was less intense under shade. However the impact on plant growth varied according to the type of stress, the level of light restriction and the interaction between both factors.

Keywords: *Salix*, water stress, low irradiance, phenotypic plasticity, growth.

[1] Department of Vegetal Production, Faculty of Agronomy, University of Buenos Aires. Buenos Aires, Argentina. E-mail: guarnasc@agro.uba.ar
[2] Department of Applied Biology and Food, Faculty of Agronomy, University of Buenos Aires. Argentina.
[3] Delta del Paraná Experimental Station, National Institute of Agricultural Technology (INTA). Campana, Buenos Aires, Argentina.

ID-095

VARIATION IN DROUGHT RESPONSES AND GROWTH OF FOUR *POPULUS* CLONES CULTIVATED IN ARGENTINA

A.B. Guarnaschelli[1], A.M. Garau[1], S.C. Cortizo[2,3], H. Bergamini[1] and S. Giavino[1]

In the Paraná River Delta (Argentina) poplar plantations have been exposed in the last few years to a great variation in the availability of water, derived from droughts (frequent events in the ongoing global climate change scenario) and local growth conditions (farms surrounded by dikes, that produce a decline in the level of the water table). Under such circumstances, that usually threat the growth and survival of forest plantation during the establishment, it is of great relevance to characterize the responses of the cultivated clones to water restriction, information that would be useful for a more accurate clonal selection under drought and would allow to predict the potential influence of water stress conditions on stand productivity.

Therefore the aim of the present study was to assess under a period of water restriction several morphological and physiological attributes closely linked to drought resistance and to assess their relationship to growth. The experiment, established under controlled conditions, was a combination of four clones (*Populus deltoides* 'Australiano 129/60', 'Stoneville 67' and 'Carabelas INTA' and *Populus* x *canadensis* 'Conti 12') and two water regimes (well watered -WW- and watered stressed -WS-) imposed during four months (December 2009 to March 2010). Drought conditions produced significant changes in most of plants attributes. Stomatal conductance, water potential and relative water content decreased, but differently according to clones. There were significant drought-induced changes in tissue water relations and hydraulic conductivity. Only WW plants of 'Stoneville 67' showed the capacity to develop osmotic adjustment (0,28 MPa), while in contrast, all WW plants exhibited an increase in tissue elasticity (5,72 MPa). Leaf abscission was considerably important in plants subjected to water restriction, however those of 'Australiano 129/60' and 'Conti 12'showed lower levels of defoliation. At the same time, they had higher root dry mass. Drought stress significantly reduced plant height, diameter as well as above- and below-grown dry mass. There was a significant and highly positive correlation between dry mass and leaf area. Despite 'Stoneville 67' plants had greater size and total dry mass under drought conditions, 'Australiano 129/60' was more efficient because it produced higher stem dry mass per unit leaf area.

Our results indicate that the four clones responded differently to water deficit conditions, displaying a varied number of drought adaptation mechanisms that allowed them to avoid and/or tolerate water stress to certain level, but at the same time they confirm the sensitivity of poplars to water stress. The establishment of productive poplar stands in drought-prone sites will involve a proper clone selection. While greater productivity has been associated to greater leaf area, which was also observed in the present study, these results highlight also the importance of growth efficiency per unit of leaf area as another key attribute to consider in dealing with clonal selection for high yields under drought conditions.

Keywords: poplars, water stress, stomatal conductance, leaf abscission, osmotic adjustment, growth efficiency.

[1] Department of Vegetal Production, Faculty of Agronomy, University of Buenos Aires. Buenos Aires, Argentina. E-mail: guarnasc@agro.uba.ar
[2] Department of Applied Biology and Food, Faculty of Agronomy, University of Buenos Aires. Argentina.
[3] Delta del Paraná Experimental Station, National Institute of Agricultural Technology (INTA). Campana, Buenos Aires, Argentina.

ID-094

ENVIRONMENTAL MODELLING OF BIOETHANOL DERIVED FROM THE IMOLA POPLAR CLONE

Miao Guo[1], Gianni Facciotto[2], Changsheng Li[3], Sara Bergante[2] and Richard Murphy[1]

Imola, an Italian poplar elite clone grown under short or very short rotation coppice (SRC or VSRC) management in a plantation located at Casale Monferrato, is a potential lignocellulosic feedstock for the production of bioethanol. This hybrid poplar clone was obtained by controlled crossing of *Populus deltoides* Bartr. with *Populus nigra* L. and has the characteristic of very high biomass yield, excellent rooting ability and resistance to rust (by *Melampsora* spp.), leaf disease (by *Marssonina brunnea)* and woolly aphid *Phloeomyzus passerinii* Sign.

To gain an in-depth understanding of the potential environmental impacts of using Imola for bioethanol production in Italy, a Life Cycle Assessment (LCA) approach was undertaken. Different scenarios were developed to represent combinations of cultivation methods (SRC or VSRC) and processing technologies (e.g. different pre-treatment technologies). The environmental impact of each scenario was compared with conventional gasoline ('benchmark'). The LCA inventory was developed using primary, site-specific data collected from plantations, laboratory experimental results combined with results from computer simulations. A process-oriented biogeochemistry model Denitrification-Decomposition (DNDC-poplar) was developed to simulate carbon and nitrogen dynamics in the Imola plantation agro-ecosystem. The field emissions results (N_2O, NH_3, N leaching, CO_2 and CH_4 emitted from the cultivated land) simulated using DNDC-poplar was used to represent a wider range of factors that are involved in the nitrogen and carbon cycles in such poplar agro-ecosystems than is typical of LCA studies of agriculture-based products. The effects of using DNDC-poplar to predict site-specific greenhouse gas (GHG) profiles for Imola based bioethanol was compared with the use of the broad values derived from the commonly used Intergovernmental Panel on Climate Change (IPCC) Tier 1 empirical model. Statistical methods were also used to analyze the inventory data quality and characterize the uncertainty in the LCA results. Overall, bioethanol derived from the Italian poplar elite clone Imola represents a promising alternative transport fuel to gasoline. The LCA outcomes indicate that significant overall environmental savings are attainable compared with gasoline for several Imola bio-ethanol scenarios (including prospective scenarios for 2020 and 2030). This benefit increases significantly from improved poplar feedstock and processing technology projected to come on-stream in the future. The environmental profiles, especially GHG profiles of Imola-based bioethanol, are sensitive to how the irrigation system is managed in plantation. The same modelling approach is also adapted to model biofuel derived from other poplar genotypes.

The overall LCA results suggest that research on manipulating the cell wall composition of poplar biomass to allow for easier conversion requiring lower inputs of process chemicals and enzymes will be valuable for optimizing the environmental footprint of poplar derived bioethanol fuels. The forward-

[1] Department of Life Sciences, Imperial College London, SW7 2AZ, United Kingdom E-mails: miao.guo06@imperial.ac.uk; r.murphy@imperial.ac.uk. *Corresponding authors.
[2] Research Units for Intensive Wood Production (PLF), Agriculture Research Council (CRA), Casale Monferrato, Italy. E-mails: gianni.facciotto@entecra.it; sara.bergante@entecra.it
[3] Institute for the Study of Earth, Oceans, and Space, Morse Hall, University of New Hampshire, Durham, NH 03824, USA. E-mail: changsheng.li@unh.edu

looking environmental model presented here is being used to provide scientific insights into poplar biofuels within the European Union and to maximize the environmental benefits from implementation of this technology.

Keywords: poplar, biofuel, LCA, Denitrification-Decomposition (DNDC), field emissions.

THE COMPARISON OF SOILS BETWEEN THE POPLAR PLANTATION AREA AND CORN AND HAZELNUT CULTIVATED AREAS BASED ON SOME PLANT NUTRIENTS

Ahmet Karakaş[1], Mustafa Zengin Ph.D.[2], Dilek Tuğrul[2] and Süleyman Memiş[2]

The objective of this study, carried out in adjacent areas of Sakarya/Akyazi and Düzce Plains, is to compare some plant nutrients in the areas where poplar, hazelnut and corn were cultivated. There is an understanding that poplar plantations, whose cultures are done intensively in our country, decrease the level of nutritional elements in the soil by absorbing them extremely. This study ascertained whether this idea was accurate or not.

The study has shown that the macro- and micro-element values in Düzce soil are higher than in Akyazi soil. Although the values in Akyazi are lower, this has not led to any trouble in corn, hazelnut and poplar breeding. In both sample plots, poplar tree consumes more magnesium than corn and hazelnut, all of which consume copper at the same level, and poplar absorbs lower phosphorus than the other two plant species. Although nitrogenous manure was given to the areas where corn and hazelnut were cultivated of both sample plots, it was found that nitrogen values were similar in the poplar, hazelnut and corn cultivated areas. It can be concluded that corn and hazelnut use more nitrogen in the soil than poplar.

In conclusion, it has been observed that poplar trees consume less nutritional elements of their cultivated soils than corn and hazelnut, and that poplar does not consume the nutritional elements in the soil as it is considered and just takes no matter how much it needs.

Keywords: poplar, hazelnut, corn, plant nutrient materials

[1] Head of Foreign Relations, Education and Research Department, General Directorate of Forestry, Ankara, Turkey. E-mail: ahmetcaracas@gmail.com

[2] Directorate of Poplar and Fast Growing Forest Trees Research Institute, İzmit, Turkey. E-mail: kavak@kavak.gov.tr

ID-055

EFFECTS OF CADMIUM (II) AND NICKEL (II) IONS ON RADICAL SCAVENGER CAPACITIES AND TOTAL PHENOLIC CONTENT IN SOME POPLAR CLONES

M. Kebert[1], S. Orlović [1], B. Klašnja[1], D. Štajner[2], B. Popović[2] and A. Goscik[3]

Numerous studies have been reported about detrimental effects of heavy metal, especially cadmium and nickel ions, upon plants' growth, metabolism and physiological and biochemical processes. Heavy metals are prone to produce a high concentration of reactive oxygen species (ROS) and reactive nitrogen species (RNOS) in so-called Fenton's reaction leading to the oxidative stress in plants and oxidation of crucial biomolecules such as lipids, DNA or proteins. A great diversity of fenolic compounds, as products of secondary metabolism, in plants showed a tendency to cope with oxidative burst by scavenging ROS and RNOS. Most of recent studies concerned about heavy metal toxicity, have set experiments hydroponically or in tissues culture, but this study was focus to estimate Ni^{2+} and Cd^{2+} ion effects of three poplars clones (M1, B229 and PE19/66) in pots under controlled conditions in greenhouse. Poplars clones with different phytoextraction potentials, were exposed for two months at artificially polluted soils with range of concentration of 25, 50, 100, 150 ppm of Ni^{2+} and 1.5, 3, 6, 9 ppm of Cd^{2+}, respectively.

The present research work aimed at estimating radical scavenger capacities (RSC) of ethanolic poplars' leaf, shoot and root extracts against nitric oxide (NO), hydroxyl radical ($OH^{\cdot}$) and synthetic 2,2'-diphenyl-1-pycril hydrazyl (DPPH) radical spectroscopically. In addition, gallic acid equivalent (GAE) of total phenolic contents (TPC) of poplar clones were determined using Folin-Ciocalteau reagent as well as flavonoids content expressed as quercetin equivalents using aluminium chloride mediated assay.

Results in the Ni^{2+} treatments revealed that under the top concentration leaf extract of clone PE 19/66 showed highest RSC against NO (RSC_{NO}= 64.53%) and highest phenolic content (24.52 mg GAE/g), while under same treatment clone B229 showed the highest radical scavenger capacity against DPPH radical (RSC_{DPPH}=49.59 %) and hydroxyl radical (RSC_{OH}=51, 06 %). On the other hand, clone M1 had highest radical scavenger potency against hydroxyl radical at top Cd^{2+} treatment (RSC_{OH}^{-}83, 8%), while in the same treatment (at 9 ppm Cd^{2+}) clone PE 19/66 expressed highest scavenger activity against NO radical (RSC_{NO}=73, 84%) as well as the largest amount of total phenolics (27,52 μg GAE/g FW) and highest flavonoids content (25, 09 μg of quercetin equivalents/g FW). All three clones showed dose dependence in Cd^{2+} treatments, where increase of Cd^{2+} treatment concentration in soil caused increase of total phenolic and flavonoides contents which can be attributed to antioxidant and radical scavenger effects of these compounds. Application of both metals led to the reduction of leaf scavenger capacity against OH radical, which confirms that both metals induce overproduction of this toxic radical oxygen species. Roots and shoots showed significantly lower radical scavenger capacity against all tested radical species as well as lower TPC. Obtained results should be used in selection of cadmium- and nickel-tolerant poplar clone with interesting perspectives in phytoremediation technologies application.

Keywords: poplar clones, cadmium, nickel, radical scavenger capacity, total phenolic content.

[1] University of Novi Sad, Institute of lowland forestry and environment, Antona Cehova 13, 21000 Novi Sad, Serbia. E-mail: markokebert@yahoo.com
[2] University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovica 8, 21000 Novi Sad, Serbia.
[3] Warsaw University of Life Sciences, Nowoursynowska 166, Warsaw, Poland.

STATUS OF SOIL HEALTH UNDER POPLAR PLANTATION IN HARYANA

Parul Bhatt Kotiyal[1]

Soil health is used to assess the ability of a soil to sustain plant and animal productivity and diversity, maintain or enhance water and air quality, support human health and habitation. The basic assessment of soil health and soil quality is necessary to evaluate the degradation status and changing trends following different land use and smallholder management interventions. In Asia, adverse effects on soil health and soil quality arise from nutrient imbalance in soil, excessive fertilization, soil pollution and soil loss processes. Haryana government has framed its own forest policy in 2006. The policy has fixed the goal of achieving 10% forest and tree cover by 2010, and eventually 20% in the state. This goal can be achieved by plantation forestry. The high productive varieties are both water and fertilizer responsive. Poplar is a fast-growing species which is widely grown in Haryana and indiscriminate use of water, fertilizer and pesticides over the years led to soil health degradation and affected yield sustainability.

Soil samples were collected from Yamunanagar and Kurukshetra districts of Haryana in the year 2011 under poplar plantation and samples were analyzed for various chemical and biological properties which are indicators of soil health status. The pH of the soil varied from 6.5 to 8.5, Organic Carbon content ranged from 0.5 to.0.8%, Nitrogen content ranged from 350- 500 kg/ha, Phosphorus content 44-60 Kg/ha, Potassium content ranged from 58 - 68 Kg/ha, Bacteria population under Poplar plantation was found to be 50–350 Colony Forming Units, Fungi population under Poplar plantation was reported 20-250 Colony Forming Units.

The overall status revealed that the poplar generally performs best on fertile loam or clayey loam soils, rich in organic matter. Saline and alkaline soils are not suitable for plantation. In the area where pH is more than 8, growth is reduced. Poplar prefers porous soil with adequate moisture.

Keywords: poplar, soil health, soil nutrient, management interventions.

[1] Scientist-C, Forest Soil and Land Reclamation Division, Forest Research Institute Dehradun Uttarakhand, India. E-mail: kotiyalpb@icfre.org

ID-136

LEAD TOLERANCE AND ACCUMULATION IN WHITE POPLAR *IN VITRO*

Branislav Kovacevic[1], Dragana Miladinovic[2], Sasa Orlovic[1], Marina Katanic[1], Marko Kebert[1] and Jovana Kovincic[3]

The lead tolerance and accumulation of five white poplar genotypes after 35 days *in vitro* cultivation on media supplemented with lead was examined. Following $Pb(NO_3)_2$ concentrations were examined: 0, 10^{-6}, 10^{-5}, 10^{-4} and 10^{-3} M. Chosen lead concentrations appeared not to be lethal. Even more, obtained results showed that tested lead concentrations had positive effect on the number of formed roots, shoot moisture content and shoot height. Tolerance indices based on morphological, biomass accumulation and photosynthetic pigments' content revealed poor differences among examined genotypes in their lead tolerance. The best differentiation among examined genotypes was gained by tolerance indices based on shoot height on 10^{-4} M $Pb(NO_3)_2$. The lead accumulation and lead shoot content significantly increased on 10^{-4} and 10^{-3} M $Pb(NO_3)_2$ media.

Comparing to "Villafranca", two examined genotypes (LCM and LBM) had significantly better lead accumulation and lead shoot content (almost 200% and 125% higher, respectively). Further investigation is needed to relate testing *in vitro* to field conditions in order to finally select genotypes for their implementation in phytoextraction projects.

Keywords: *Populus alba*, tissue culture, phytoextraction, selection.

[1] University of Novi Sad, Institute of Lowland Forestry and Environment, Novi Sad, Serbia. E-mail: branek@uns.ac.rs
[2] Institute of Field and Vegetable Crops, Novi Sad, Serbia
[3] University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia

ID-082

INFLUENCE OF WILLOW PLANTATION ON WHEAT UNDER WATERLOGGED SOIL OF UTTAR PRADESH

S. Kumar[1], G.R. Gupta[1], M. Kumar[1], S.K. Vishwakarma[2] and Munendra Pal[1]

The study was conducted in 2009-2010 and 2010-2011 at the Farm of KVK, Lakhimpur Khiri, Chandra Shekhar Azad University of Agricultural and Technology, Kanpur Uttar Pradesh.

The experimental site falls in northern part (Tarai region) of Uttar Pradesh, representing 80˚60 East longitude and 28˚70 N latitude. The area receiving an annual rainfall of 1050 mm, the soil of the site is sandy loam with pH 7.6 and low in organic carbon. Sowing of wheat variety PBW 343 was done in *rabi* 2009 and 2010 with recommended dose of fertilizer (120:60:60 kg NPK/ha) and package of practices. In the month of January 2010, 16 types of willow clones were transplanted at 5x4 m distance with three replications in the same field of wheat in earlier lay out plan. The trail consisted of seventeen treatments viz, T_1-UHFS-1 clone of willow transplanted at 5x4 distance and T_2 – UHFS-2 and so on upto T_{16} –UHFS-16 and one plot of control.

Grain yield data showed that maximum grain yield of wheat 45.20 and 46.00 q/ha in control plot and minimum grain yield 43.10 and 39.00 q/ha in wheat under T_3 treatment (UHFS-3 clone of willow) during 2009-2010 and 2010-2011 respectively. There was no significant difference in 2009-2010 while in 2010-2011 a significant difference was observed because of crown growth of willow trees increased at remarkable rate.

Keywords: willow, waterlogged soil, wheat and agroforestry.

[1] Department of Soil Conservation & Water Management, India.
[2] KVK Lakhimpur Khiri, Chandra Shekhar Azad University of Agricultural and Technology, Kanpur, 208002 , India. E-mail: sarvesh200517@rediffmail.com

ID-145

ABSORPTION AND ACCUMULATION OF HEAVY METAL BY LEAVES OF *POPULUS CANADENSIS* CV. 'NEVA' PLANTATION IN WASTE FIELD

Jin-Hua Li[1], Yan He[2], Jian-Ping Duan[2], Qi-Wen Zhang[1]

Absorption and enrichment of heavy metal elements by leaves of *Populus canadensis* cv 'Neva' were analyzed through content assessing of heavy metal elements in soils of three different green forest lands at Fangshan District, in the southern suburb of Beijing city. These green forest lands with plantation of 'Neva' were around with the cement, stone plants, sewage and garbage, different sources of pollution.

Content of the heavy metal elements such as Cd , Pb , Cu , Zn in soil samples and leaves of 'Neva' growing in the three forest lands were investigated. The results show that the soils of three forest lands were polluted with heavy metal elements, Pb, Cd, Cu and Zn in different degrees. Contents of Pb, Cd and Cu in soils were significantly different among three forest lands, whereas average content of Cd (0.0776mg/kg) was less. but that of Pb, Cu, Zn (24.6, 18.7 and 57.5mg/kg respectively) were more than the average background value of Beijing. Contents of Pb, Cd, Cu and Zn in leaves of 'Neva' were different among the three forest lands. With the content changes of heavy metals in soil samples, there was no regularity on the content changes of different heavy metal contents in leaves of 'Neva' growing in different forest land. "Neva' can absorb and accumulate the heavy metals Pb, Cd, Cu and Zn in soil but showed different capacities of absorption and accumulation with the trend of Cd> Zn> Cu> Pb. Especially its capacity of absorption and accumulation with Cd was strong with maximum enrichment factor of more than 16 and showed high accumulation on low background, whereas its enrichment capacity of Pb, Cu was relatively small with an average enrichment factor of less than 1.

At different forest lands, there was great difference on absorption capacity of 'Neva' with the same heavy metal.

Keywords: *Populus canadensis* cv. 'Neva', *P. ussuriensis* Kom., soil, leaves, metal absorption, enrichment, growth traits, branch, frost hardiness, electrical impedance spectroscopy (EIS), electrolyte leakage (EL)

[1] State Key Laboratory of Tree Genetics and Breeding, Research Institute of Forestry, Chinese Academy of Forestry, Beijing 100091, P. R. of China. E-mail: lijinh@caf.ac.cn
[2] Beijing Management Bureau of Forest Seed and Seedling, Beijing, 100011, P.R. of China.
[3] Yanqing Management Bureau of Forest Seed and Seedling, Beijing, 102100, P.R. of China.

ID-027

GROWTH PERFORMANCE OF POPLAR TREE UNDER AGROFORESTRY SYSTEM IN NORTHERN INDIA

B.S. Mandal, Y.P. Singh[1] and J.C. Kaushik

Poplars are among the world`s fastest growing industrial softwood, which can be used as pure or mixed plantations as well as in association with agricultural crops. These are multipurpose tree species. Poplar is a deciduous tree and has no shading effect on crops and very suitable for agroforestry system. It adds to soil fertility through its leaf litter. Environmental amelioration is another intangible benefit from poplar planting. It has been estimated that poplar grows 36 times faster than other Indian forest trees and, therefore, utilizes 36 times more carbon dioxide. Growing auxiliary crops with poplar is highly beneficial to the tree crop. Its growth has been enhanced up to 40 per cent. This is because of regular irrigation, weeding, hoeing and fertilizer application during cultivation of the secondary crops.

The present studies were conducted at Krishi Vigyan Kendra`s Farm of CCS Haryana Agricultural University, Kurukshetra (Haryana) during the years 2001-2002 and 2002-2003, with the objectives of assessing the growth performance of poplar. Two rabi (winter) season crops, i.e. wheat (*Triticum aestivum* L.) var. PBW-343 and berseem (*Trifolium alexandrinum*) var. BL-1 and two kharif (monsoon) season crops, i.e. sorghum (*Sorghum bicolar* L. Moench) var. H. C. 260 and dhaincha (*Sesbania acculeata* L.) var. local were grown as per the standard technique. The poplar (Clone G-48) was planted at a spacing of 5x4 m in February 1999 in North to South direction. Thirteen plots of 12x5 m were laid out keeping in view that during the second year, each and every possible tree-crop combinations/sequences envisaged were available. T-1 was the control of plantation area, i.e. poplar only. The experiment was conducted in randomized block design with three replications.

The present investigation showed that the average height, girth, crown spread, leaf fall, green and dry weights of poplar trees were more under different tree-crop combinations than tree alone. The maximum increase in the growth parameters of poplar occurred with wheat-sorghum-wheat-sorghum crop sequence.

Keywords: crop, growth, sequence.

[1] Department of Forestry, CCS Haryana Agricultural University, Hissar, India. Forest Pathology Division, Forest Research Institute, Dehradun 248 006, India. E-mail: mandal.balwan@rediffmail.com

POPLARS AND WILLOWS IN HILL COUNTRY – STABILIZING SOILS AND STORING CARBON

I. R. McIvor[1] and G. B. Douglas[2]

Poplar and willow trees are effective in preventing or reducing a range of soil erosion processes on pastoral slopes. They achieve this through the development of an extensive root system which achieves its maximum potential when it interconnects with root systems of adjoining trees to form a reinforcing network across a slope, thereby strengthening the soil. In comparison to unplanted sites, wide spaced poplars and willows reduced soil slippage by 95% during severe rain storms. A consideration of spacing is important to achieve soil stability in the shortest possible time.

These trees contribute to the soil carbon pool and are eligible for carbon credits under the New Zealand Government Emissions Trading Scheme (ETS) providing the area planted exceeds one hectare, the trees are sufficiently close to achieve 30% canopy cover and occur in a block wider than 30 m at any point. Gaps of 15 m or more between trees constitute a new block. The carbon stocks from the trees are calculated from look up tables based on tree age. Trees planted to achieve 30% canopy cover will reduce pasture production by around 10% during the period the trees are in leaf. At maturity, poplar and willow trees can stabilize soil on slopes at a canopy cover less than 30%, the amount depending on the clone. Trees vary in form, so a consideration of canopy spread will assist in choosing appropriate species and clones for the complementary purposes of soil conservation and carbon storage. Benefits to pastoral farming from the presence of poplar and willow trees in addition to their soil stabilization and carbon storage counteract the loss of pasture production.

Keywords: spaced trees, soil conservation, carbon farming, erosion, tree roots.

[1] The New Zealand Institute for Plant & Food Research Limited, Private Bag 11030, Palmerston North, New Zealand. E-mail: ian.mcivor@plantandfood.co.nz
[2] AgResearch Limited, Private Bag 11008, Palmerston North, New Zealand.

INFLUENCE OF *SALIX* CLONE ON GROWTH AND YIELD OF WHEAT INTERCROP UNDER SHALLOW WATER TABLE CONDITIONS OF NORTHERN INDIA

H.S. Mishra, Ashutosh Singh and Salil Tewari[1]

Wheat production in the foot hills of Northern India is facing two main constraints for achieving maximum yield. These are: below optimum night temperature during vegetative and above optimum day temperatures during reproductive stages. Agroforestry proves great potential as land management alternative for sustainable production and maintaining soil fertility. For the success of agroforestry systems, it has been recognized that tree species with intercrops should have water and nutrients without affecting their normal requirement for which the system must be modified/managed in such a way that positive effects should appear in the production system.

A field experiment was conducted at the Horticulture Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar during *Rabi* season of 2006-2007 to study the effect of *Salix* clone on growth and yield of wheat intercrop under shallow water table conditions of Northern India. Five treatments (4 clones and control) were tested in randomized block design with five replications. Tree spacing was 8 × 5m and the experimental field consisted of 25 plots of 40 × 25 m plot size. Wheat variety PBW 373 was sown on 7 December 2006 as intercrop with a row spacing of 23.0 cm. Only one irrigation at 26 days after sowing was provided. Fertilizer doses were applied @ 120 kg/ha, 60 kg/ha and 50 kg/ha as N, P_2O_5 and K_2O, respectively. Water table during the wheat season fluctuated between 60 cm to 150 cm.

Results revealed that grain yield of intercropped wheat differed significantly under agroforestry and control treatments. Grain yield under *Salix* clones of *Salix alba I* cv. *coerulea* and *Salix alba II* cv. *coerulea* was significantly higher than control but control treatment was statistically at par with *Salix alba I* cv. *vitellina* treatment. However, yield under *Salix babylonica* was significantly lower than control treatment. Also, different *Salix* clones affected the grain yield of intercropped wheat significantly. Highest yield was observed in *Salix alba I* cv. *coerulea* which was significantly different from *Salix alba II* cv. *coerulea*, *Salix alba* cv. *vitellina* and *Salix babylonica*. However, *Salix alba II* cv. *coerulea* treatment differed significantly from *Salix alba* cv. *vitellina* and *Salix babylonica* treatments.

Keywords: agroforestry, soil fertility, control treatment, grain yield.

[1] Agroforestry Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, 263145 Uttarakhand, India. E-mail: saliltewari@yahoo.com

ID-171

GLOBAL GREEN ECONOMY POLICY PERSPECTIVE FOR PLANTED POPLARS AND WILLOWS

Maharaj Muthoo[1]

Green Economy policy has to evolve and address the global rush for land, water, forests and fossil fuels. Willow and poplar plantations can contribute increasingly in this context through expanded tree cover to combat climate change and water vagaries and to meet burgeoning need for food**,** fibre, fuel and forest products. Pertinent plantation programmes should strategically support Sustainable Development Goals and leverage their largely untapped potential for mutually benefiting from multilateral environmental agreements and financing arrangements, *inter-alia*, for biodiversity conservation, afforestation, reforestation, reduced deforestation and desertification, Billion Tree Campaign and the Green Climate Fund.

The revisited Green Economy agenda of Rio+20 for the 'The Future We Want" should recognize willows, poplars and other short-rotation trees outside forests with regard to their tangible monetary benefits for local livelihoods and inclusive economic growth. Productive poplar propagation and harvesting have to be placed on firm footing of legality and sustainability, such as through certification and payment of ecosystems services**.** With requisite codes and standards, the versatile willow and poplar products can vouch for their green credentials in emerging market arena of ethical trade, clean energy and green buildings. However, their non-market value chain is not adequately captured, internalized and remunerated. Policy level leadership should endeavor to do so stoically and motivate farmers, foresters and the private sector for concomitantly improving human welfare and safeguarding the Earth's ecosystems**.**

Case studies provide model examples for planning poplar plantations and willows worldwide. That includes creative agroforestry, raw materials for industry and homesteads, green jobs and greenery in urban and rural landscapes, while contributing to agriculture habitat and food security, nutrient recycling, renewable energy, wasteland restoration, soil stabilization and water phytoremediation. This calls for linking financing, institutional mechanisms, innovative science and adaptive technology for cost-effective and efficient plantations through due diligence and convergent cooperation -locally, nationally and internationally.

With futuristic policy perspectives, global Green Economy can prosper in harmony with humanity and the environment. Multifunctional willows and poplars planted by the people, for the people, privately and publicly, is a challenging opportunity for this laudable goal.

Keywords: certification, climate change, Green Economy, land and water; private-public-people partnerships, payment of ecosystems services, renewable energy.

[1] President, Roman Forum, Via Teosebio, 00124 Rome, Italy E-mail: muthoo@rforum.org

INVESTIGATION OF POTENTIAL OF DIFFERENT POPLAR CLONES FOR BIOMASS PRODUCTION ON DIFFERENTLY CONTAMINATED SOILS THROUGH INVESTIGATION OF SOME PHYSIOLOGICAL PARAMETERS

Andrej Pilipovic[1], Sasa Orlovic[2], Srdjan Stojnic[3], Verica Vasic[4] and Sasa Pekec[5]

Climate change presents one of the major threats to the modern civilization. Mitigation of climate change can be partly achieved through increased use of wood biomass plantations, but the competitiveness with food production is evident. The solution can be seen through the use of contaminated soils for establishment of biomass plantations.

This paper presents an investigation of the effect of differently contaminated soils on growth and physiological parameters on different poplar clones grown for biomass production as part of the project "Studying climate change and its influence on the environment: impacts, adaptation and mitigation" financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research for the period 2011-2014.

The experiment was established at the experimental estate of the Institute as poplar biomass plantation with spacing of 2.0 x 0.25 m divided into seven plots containing different treatments. Treatments were as follows: (1) Cadmium - 10,6 kg/ha; (2) Nickel – 183,3 kg/ha; (3) Copper - 247 kg/ha; (4) diesel fuel – 6667 l/ha; (5) Pendimethalin – 1320g/ha; (6) Oxyfluorfen - 236 g/ha and (7) non contaminated plot. Selected poplar clones were *Populus deltoides* cl. "Bora", *Populus deltoides* cl. PE 19/66 and *Populus x euramericana* cl. "Pannonia". Net photosynthesis (A), transpiration (E), stomatal conductance (gs) and chlorophyll fluorescence (Fv/Fm) were assessed during vegetation, while height and diameter were measured after cessation of the growth of plants. Investigated results showed significant differences between clones regarding net photosynthesis, stomatal conductance and transpiration. Chlorophyll fluorescence showed less significant differences between treatments and investigated clones.

Keywords: poplars, contamination, biomass production, photosynthesis, growth.

[1] University of Novi Sad, Institute of Lowland Forestry and Environment, Antona Cehova 13, Novi Sad, Serbia. E-mail: andrejpilipovic@yahoo.com
[2] University of Novi Sad, Institute of Lowland Forestry and Environment, Antona Cehova 13, Novi Sad, Serbia. E-mail: sasao@uns.ac.rs
[3] University of Novi Sad, Institute of Lowland Forestry and Environment, Antona Cehova 13, Novi Sad, Serbia. E-mail: srdjan_stojnic@yahoo.com
[4] University of Novi Sad, Institute of Lowland Forestry and Environment, Antona Cehova 13, Novi Sad, Serbia. E-mail: vericav@uns.ac.rs
[5]University of Novi Sad, Institute of Lowland Forestry and Environment, Antona Cehova 13, Novi Sad, Serbia. E-mail: pekecs@uns.ac.rs

ID-043

RAPID LIGHT-RESPONSE CURVES OF PS II CHLOROPHYLL FLUORESCENCE PARAMETERS IN THE LEAVES OF WILLOWS UNDER CADMIUM-ION STRESS

Yongqiang Qian[1]

The effects of Cd^{2+} on rapid light-response curves of photochemical and non-photochemical chloropyll fluorescence quenching parameters were investigated under different cadmium treatments based on the determination of chlorophyll fluorescence parameters, including Dark fluorescence yield (Fo), Maximal fluorescence yield (Fm), Maximal PS II quantum yield (Fv/Fm), and latent PSII quantum yield (Fv/Fo) of *Salix leucopithecia* by a MINI-IMAGING-PAM Chlorophyll Fluorometer.

The results showed that Fo and Fm present a trend of first increased and then decreased, and the two parameters reached the maximum under stressed of 200 $mg \cdot L^{-1}$ Cd^{2+} for 4 weeks. Fv/Fm and Fv/Fo were inhibited significantly, and them showed tend of first decreased and them increased. The rapid light-response curves of chlorophyll fluorescence parameters showed that Effective PS II quantum yield (Y(II)), Coefficient of photochemical quenching (qP) decreased according to the increase of light intensity. The Y(II) and qP declined significantly under high-concentration Cd2+ stress at the same light intensity. The parameters of quantum yield of regulated energy dissipation (Y(NPQ)), coefficient of non-photochemical quenching (qN), and electron transport rate (ETR) increased with elevation of light intensity. The Y(NPQ), qN , and ETR increased sharply under high-concentration Cd2+ stress at the same light intensity. Quantum yield of non-regulated energy dissipation(Y(NO)) kept a lower level stably, although Y(NO) increased slightly with the aggrandizement of light intensity. The results indicated that *Salix leucopithecia* showed tolerence to Cd^{2+} by reversible inactivation of PSII reaction center.

Keywords: *Salix leucopithecia*, chlorophyll fluorescence, cadmium-ion stress, rapid light-response curve.

[1] Chinese Academy of Forestry, China. E-mail: ljx-295@163.com

ID-187

THE GENUS *POPULUS* IN LESOTHO
ECOLOGICAL AND SOCIO-ECONOMIC PERSPECTIVES

Tlotliso E. Ramanyaka[1] and Sekoati E. Sekaleli[2]

Lesotho is a small landlocked country that occupies 30,588 km^2 that is inhabited by an almost homogeneous ethnic group. The country experiences extreme climatic conditions and is characterized by high levels of environmental degradation that include severe soil erosion due to the ragged nature of the terrain. The growing season for many crops is limited.

Native forests cover 97,000 hectares (2.2%) of the total land area of the country, and remain a very important resource to rural communities by providing fuelwood, construction materials, medicines, forage and shelter. Trees of the genus *Populus* are a significant portion of the forest ecosystems of Lesotho.

Overexploitation for wood and indiscriminate cutting lead to a compromised air and water quality and an exacerbated downstream flooding. In Lesotho, poplars are useful for providing ecosystem (provisioning, regulating, supporting, cultural) and socio-economic (traditional medicine, roadside planting, fuel for cooking and space heating, thatched roofing) services.

Research on poplars in Lesotho has included biomass studies with *Populus canescens* and Provenance *cum* Propagation Trials Results reveal that poplars thrive exceptionally well in Lesotho. There is need for research into mechanisms of adaptation to changed environmental conditions.

Keywords: *Populus*, Lesotho, ecosystem services, research.

[1] Forestry Department, P.O. Box 774, Maseru, Lesotho. E-mail: tramanyaka@gmail.com
[2] Forestry Department, P.O. Box 774, Maseru, Lesotho. E-mail : forestrydepartment@leo.co.ls

ID-130

SALIX DASYCLADOS USED FOR PHYTOREMEDIATION OF DREDGED SOIL AT SITE IN PUBLIC RECREATION AREA IN OSLO, NORWAY

Mauritz Ramstedt[1]

Salix dasyclados, clone "Gudrun" (REAB, Sweden) was used for remediation of contaminated soil deposited at site in a recreation area to be in the city of Oslo, Norway. The former park area to be restored and developed to a recreation site with a pond for fishing was found to be heavily contaminated in the pond sediments. This is a result of former industrial activities upstream the small creek ending up in the diked pond in the south-east end of the area. The removal of sediments appeared costly and disturbing as it is located within the domestic area. A solution for treatment at site was, therefore, a priority option. The plantation is a good example of the use of phytoremediation as a method within domestic areas where excavation and massive soil transportation would cause major disturbances for the local inhabitants.

Keywords: heavy metals, remediation, *Salix*.

[1] Department of Forest Mycology and Plant Pathology, SLU, Box 7026, SE-750 07 Uppsala, Sweden. E-mail: Mauritz.Ramstedt@slu.se

OPPORTUNITIES TO ENHANCE WOOD FUEL YIELDS IN SEMI-ARID REGIONS OF INDIA USING WASTEWATER

D. Riddell-Black[1], O.P. Toky[2], P. J. C. Harris[3], R.K. Srivastava[4], A. Pandey[4] and P. Vasudevan[5]

Wood fuel is widely employed in India for cooking purposes and winter heating. It is also used by industry to raise steam for power generation and to produce heat for use in industrial processes. In semi-arid rural areas, the availability of wood fuel can be limited due to high demand and by climatic limitations on tree productivity, as well as by the need to fully employ land and water for food production. However, the demand for energy in India continues to grow as a consequence of rising population and rapidly expanding economic and industrial activity. Alongside this increasing energy demand is the need to exploit local energy sources that do not contribute to national carbon emissions, are less subject to supply chain issues and that are less subject to the significant price variations typical of diesel and LPG.

The sustainable exploitation of biomass energy resources in semi-arid areas of India was explored by the joint Indian-UK project 'Enhanced biomass and energy conversion for use in water-scarce areas of India'. The project aim was to utilize biomass to produce steam, electricity and cooling for the supply of small local industries and households. In order to optimize the productivity of wood fuel supplies, the application of wastewater to wood fuel plantations was explored to provide a means of both managing the wastewater and producing a saleable crop in the form of wood fuel.

The principal sources of wastewater available are the discharge from treatment facilities handling industrial or domestic wastewater, following complete or partial treatment, and from sullage ponds. Sullage ponds are typically natural ponds or low lying areas where grey water discarded from households, small commercial operations and shops has accumulated.

Trials and demonstration sites were established in three locations: at the municipal wastewater treatment works at Palwal, some 50 km south east of New Dehli, at Surajgarh in Rajasthan, and at Pantnagar in Uttarakhand to investigate the impact on tree growth and wood quality of employing wastewater effluent and to determine the extent to which dirty water could be managed using wood fuel plantations. A range of native and non-native tree species were investigated including poplar and willow. The paper will describe the activities undertaken at each site and discuss the manner in which their outcomes may be applied in India.

Keywords: wood fuel production, wastewater management, semi-arid.

[1] Lupus Science, Nuffield, Henley-on-Thames, Oxfordshire, United Kingdom. E-mail: drusilla@lupus-science.co.uk
[2] Department of Forestry, CCS Haryana Agricultural University, Hisar-125004, India. E-mail: optoky@gmail.com
[3] Department of Geography, Environment and Disaster Management, Coventry University, Priory Street, Coventry CV1 5FB, United Kingdom. E-mail: p.harris@coventry.ac.uk
[4] Department of Environmental Science, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarrakhand -263145, India. E-mail: rajeevsrivastava08@gmail.com
[5] Centre for Rural Development, Indian Institute of Technology Deli, Hauz Khas , 110 016 New Delhi, India. E-mail: padmav10@hotmail.com

ID-051

CAPACITY OF POPLAR AND WILLOW CLONES TO WITHSTAND HIGH LEVELS OF WASTEWATER APPLICATION

William Schroeder[1], Jaconette Mirck[1], Shahid Khan[2], Kurt Rasmussen[2] and Norman Henderson[3]

The paper focuses on water tolerance research where three poplar (*Populus* x 'Walker'. *P.* x 'Okanese' and *P. tristis*), two willow clones (*Salix acutifolia* 'Acute' and *S. alba sericea* 'Silverleaf') and orchardgrass (*Dactylis glomerata*) were planted under different intensities of municipal wastewater application.

The intent is that the poplar, willow and grass combination will utilize treated municipal wastewater effluent in a 100 percent containment system with zero discharge. This system could provide small communities an affordable alternative to meet new effluent discharge regulations. The research is comparing the capacity of the different poplar and willow cultivars to withstand various wastewater application intensities and maintain vigorous growth and high water uptake. To accomplish this poplar and willow clones were nested in 1951m^2 plots which received varying effluent treatment levels consisting of a control (no effluent) 0.5x, 1.0x, 1.5x and 2.5x the base rate of 100m^3/ha/day.

Results show good growth under all application intensities, however fall hardiness acclimatation of some clones were affected by the high intensity treatment.

Keywords: poplar, willow, effluent, wastewater, environmental application.

[1] Agroforestry Development Centre, Agriculture and Agri-Food Canada, #2 Government Road Indian Head, Saskatchewan Canada S0G 2K0. E-mail: bill.schroeder@agr.gc.ca; jaconette.mirck@agr.gc.ca

[2] SaskWater, 200-111 Fairford St. Moose Jaw, Saskatchewan Canada S6H 1C8. E-mail: shahid.kahn@saskwater.com; kurt.rasmussen@saskwater.com

[3] Prairie Adaptation Research Collaborative, 120-2 Research Dr. University of Regina, Regina, Saskatchewan Canada S4S 7H9. E-mail: norman.henderson@uregian.ca

ID-044

ECOFRIENDLY RESTORATION OF PROBLEMATIC SOIL THROUGH WILLOW AND POPLAR SPECIES

Avtar Singh[1] and Ashok Kumar

Gradual desertification, mainly caused by human activities (overgrazing, wood cutting, shifting agriculture and tillage agriculture inside the forest) has been accelerating. Willow and poplar species in Salicaceae family are also used to restore damaged/degraded soil. Plantings on farms have been used to stabilize gully, earth flow and slope erosion. Tree root systems take time to develop to the extent that they effectively stabilize unsaturated soil. Willow is an effective genus for ecological restoration of wetlands, in both structure and functions and commonly installed in riparian restoration programs as a "nurse crop" for the establishment of larger and longer-lived woody species. Fast stabilization of chemically degraded land surfaces and re-establishment of a biologically active soil surface can be achieved using *Salix* species. *Salix* species are able to establish on waste grounds and badly degraded soils with scarce topsoil, such as industrial spoils, mines and gravel pits, spoil-heaps of lignite mines, overburdens, quarries, highly eroded soils, waste sites and roadsides. Resistance of willows to some metals (Cd, Cu, Zn, Ni, Pb, and Fe) and its ability to accumulate significant amounts of these metals in plant tissues had been documented and its possible use suggested for metal extraction. The high evapo-transpiration rate and root tolerance of willows in flood conditions allow the use of high irrigation rates.

In Bulgaria and in Chile, willows are planted along river banks to stabilize them and reduce sedimentation. In China, poplars are used extensively for shelterbelts and sand dune stabilization. In the United Kingdom, they provide shelter and ground cover for free-range chickens whose produce is sold as "woodland eggs". In Canada, the Forest 2020 Programme is establishing fast-growing plantations, of which poplar is a major component, on previously non-forested lands (primarily agricultural lands) for carbon storage.

Through short-rotation forestry programmes, willow and poplar have produced the highest woody biomass production.

Keywords: phytoremediation of soils**,** erosion control, shelterbelt.

[1] Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana, 141004, India. E-mail: avtar3@pau.edu

POPLAR AS A CLIMATE MITIGATION OPTION UNDER REDD+ – A CASE FROM THE NORTH INDIAN STATE OF HARYANA, INDIA

Tajinder Pal Singh[1]

Reducing Emissions from Deforestation and Degradation, along with conservation, sustainable management of forests, and enhancement of carbon stocks, collectively known as REDD+, is an innovative climate mitigation option decided by the Cancun Meeting of the Conference of Parties of the United Nations Framework Convention on Climate Change. Poplar plantations outside the traditional forest areas offer tremendous potential for enhancement of carbon stocks in developing countries.

An assessment of trees outside forests has been carried out in the North Indian State of Haryana and found that poplar is the most dominant tree species, a position that was occupied by Eucalyptus in the past. The carbon sequestration potential of poplar plantations outside forests is found to be much higher than the carbon sequestered in the natural forests. In addition, a high density of poplars in agricultural fields near reserve and protected forests helps in reducing biomass extraction from natural ecosystems and eventually results in conservation of biodiversity and sustainable forest management. Thus poplar plantations outside traditional forest areas offer good scope for improving lives of local people through sale of carbon credits in upcoming REDD+ carbon markets apart from ensuring sustainable development in the region. The challenge, however, lies in inclusion of agroforestry in national REDD+ Strategy and action plan for India, availability of upfront REDD+ finance, and development of measurement, reporting and verification (MRV) protocols for poplar plantations.

Keywords: REDD+, carbon sequestration, poplar plantations, trees outside forests.

[1] Assistant Director-General, Forests and Climate Change, Indian Council of Forestry Research and Education, P. O. New Forest, Dehradun-248006, India. E-mail: tpsingh@icfre.org

ID-068

CHARACTERIZATION OF POPLAR GENOTYPES GROWING IN SRF UNDER WATER STRESS CONDITIONS

H. Sixto[1], M.M. Sánchez [1] and I. Cañellas[1]

In many Mediterranean areas, with low rainfall in the growing season, irrigation is a necessary practice for growing poplar in SRF, if productions of economic interest are pursued. However, under the current climatic change scenario, poplar cultivation may be forced to lower inputs of water. Hence, exploring the genetic variability of species and hybrids within the genus is definitely of interest.

The objective of this work is to characterize, in terms of production and efficiency in water use, basic material used in SRF plantations in the Mediterranean area, in situations of optimal irrigation and water stress. On agricultural land previously used for cereals in central Spain, a trial was established which included four clones belonging to different poplar hybrids ('I-214', 'AF2', 'Pegaso' and 'Monviso'). The plantation was established at high density (20,000 trees ha -1) and was watered automatically using different watering regimes. For the purpose of this study, data is displayed regarding doses as a percentage of field capacity and two stress scenarios (70% and 30% of the field capacity). To reliably control water application, tensiometers and humidity sensors were used.

Height and diameter were evaluated during the whole rotation (1, 2 and 3 yrs) and yield was recorded at the end of the rotation (3 yr). Intrinsic water use efficiency (IWUE) was assessed, based on gas exchange measurements. C 13 isotope discrimination was also recorded (Δ, ‰).In terms of yield (Mg dm ha -1), significant differences between the different irrigation scenarios were detected, as well as for the genotypes and their interaction. The cumulative yield (Mg dm ha-1) fell by 38% when moderate watering was applied (70% of field capacity), and 77% when a very restrictive irrigation regime (30% of f.c.) was applied, although in both cases plants showed no symptoms of decay apart from the decline in growth. 'Monviso' and 'AF2' were the most significantly productive clones at field capacity. Under stress conditions 'Monviso', 'AF2' and 'I-214' showed a similar production. At the end of the rotation, Δ values showed greater efficiency in those treatments that caused stress versus control (30%> 70%> 100% of f.c). Between genotypes, 'I-214'was the least efficient, followed by 'AF2'.Genotype*Irrigation interaction not having been detected. Δ and IWUE were significantly correlated (-0.6713, $p<0.001$). IWUE was better correlated with stomata conductance (-0.8500, $p<0.001$), than with photosynthesis rate (n.s.). There was no correlation between biomass production and isotopic discrimination, pointing to the possibility of selection in both respects independently as suggested previously by other authors. 'Monviso' showed high yield and high water use efficiency, inferred from Δ, in a rotation of 3 years under the test conditions.

In areas with a Mediterranean climate at least, the necessity for a clonal offer adapted to conditions of greater xericity obliges us to consider water use efficiency as a selection criteria in breeding programs.

Keywords: poplar, biomass, water stress, SRF, water use efficiency.

[1] INIA-CIFOR. Crta. de la Coruña km 7,5, 28040 Madrid, Spain. E-mail: sixto@inia.es

ENERGY RETURNED ON ENERGY INVESTED FOR POPLAR STANDS IN COMPARISON WITH NATURAL FORESTS

Deborah Solarolo[1], Gabriele Demichelis[1], Pier Mario Chiarabaglio[1] and Giuseppe Nervo[1]

Wood biomass is an important source of renewable energy, and traditional poplar stands (10-year rotation) can provide a considerable amount of energy stored in wood. This paper compares the energy provided by poplar stands (output) with the energy taken by all cultivation practices (input). The energy stored in wood was calculated using the higher heating value of the dry matter produced by stems, branches and roots. All cultivation practices were computed: preparation of planting material, soil preparation, planting, cultivation (including pest and disease treatments, weed control, irrigation). The farmers were interviewed and planting and maintenance practices were recorded for each stand, including type and characteristics of the tractor, weight of the equipments, products used and time spent (machine and human work) for each operation.

The energy was calculated by applying the suitable content energy for the mechanical equipment and the equivalent energy for the products used. The energy sustainability was calculated using the EROEI index (Energy Returned on Energy Invested). The results were compared with the energy stored in natural forests located near the poplar stands and in the same site conditions, where no cultivation practice were carried out. In all cases plantations proved sustainable: the index indicated that cultivated poplar stands are more sustainable, from the point of view of energy, than natural forests, due to their fast growth and to the high amount of energy stored. The study also allowed to identify the less sustainable cultural practices and to evaluate different cultural models depending on the resistance or susceptibility of the different clones to foliar diseases.

Keywords: energy balance, EROEI, sustainability, poplar.

[1] CRA-Unità di Ricerca per le Produzioni Legnose fuori Foresta, str. Frassineto 35, Casale Monferrato 15033 (AL), Italy. E-mail: piermario.chiarabaglio@entecra.it

CLIMATE-DRIVEN ADAPTIVE TRAITS IN PHENOLOGY AND ECOPHYSIOLOGY OF *POPULUS BALSAMIFERA* L.

Raju Y. Soolanayakanahally[1], Robert D. Guy[2] and Salim N. Salim[3]

Plant species occupying broad-ranges at high latitudes display strong local adaptation to differences in growing season length and climate.

In this study, by making use of over 500 *Populus balsamifera* L. (balsam poplar) trees sourced from 35 populations, we looked at seasonal phenological events and ecophysiology traits that lead to local adaptation. Balsam poplar populations planted into common gardens display strong latitudinal cline to spring and autumn phenophases. Spring leaf flush occurred within a short period of time upon accumulation of certain heat sums whereas, the height growth cessation (bud set) and autumn leaf senescence were tightly controlled by photoperiod. Trees from high-latitudes stopped height growth and set terminal buds much earlier than the trees from low-latitudes in preparations for winter, leading to differences in height growth.

As a result of this, low-latitude trees acquired greater above-ground biomass compared to high-latitude trees. When photosynthetic rates, stomatal conductance and water use-efficiency were measured under extended photoperiod in a greenhouse without resource limitation, the high-latitude trees tend to outperform those from low-latitude. Multiple traits measured either in outdoor common garden or in a greenhouse point to photoperiod as a strong driver of adaptation in balsam poplar.

Keywords: *Populus balsamifera*, phenology, growing season length, photoperiod, photosynthesis, water use-efficiency, adaptation.

[1] Science and Technology Branch, Agriculture and Agri-Food Canada, Indian Head, Saskatchewan, S0G 2K0 Canada. E-mail: raju.soolanayakanahally@agr.gc.ca
[2] Department of Forest Sciences, University of British Columbia, Vancouver, British Columbia, V6T 1Z4 Canada. E-mail: rob.guy@ubc.ca
[3] Science and Technology Branch, Agriculture and Agri-Food Canada, Ottawa, Ontario, K1A 0C6 Canada. E-mail: salim.silim@agr.gc.ca

ID-045

IMPACT OF TREATED WASTEWATER IRRIGATION ON SOME ECOPHYSIOLOGICAL PARAMETERS OF *SALIX BABYLONICA* L.

Wafa Soussi, Zoubeir Béjaoui, Mejda Abassi and Ali Albouchi[1]

In Tunisia, rehabilitation of marginal lands confronted to the economical and environmental challenges encountered by the forestry arouse a special attention to the new management modes. The reforestation of damaged grounds with the appropriate trees, in particular willow, appears as the challenges to take up. Willow, plant in water, is more and more appreciated in several tropical countries, for its productive and protective benefits. Therefore, treated wastewater use will be beneficial as a water and mineral resource.

In order to evaluate *Salix babylonica* cleaning capacity, two hydrous patterns were adopted for the young seedlings, including a treatment with tap water (control) and another with treated wastewater (TWW). Several morpho-physiological parameters were monitored during the experiment. Seedlings irrigated with TWW showed morphological and physiological modifications, in particular after 30 days, characterized by appearance of chlorosis, youngest leaf rolling up, early senescence and a marked ramification of the root system. After 60 days, the irrigation with TWW does not have any significant effect on the total dry mass produced. However, repartition of biomass was clearly in favour of the roots. The use of this water increased the chlorophylls content of 38% compared to the witness and caused a loss of the cellular membranes integrity.

Keywords: reforestation, *Salix babylonica*, waste water, produced biomass, membrane integrity.

[1] Abassi Mejda, Institut National de Recherches en Génie Rural, Eaux et Forêts (INRGREF), BP 10, Ariana 2080, Tunisie. E-mail : mej_abassi@yahoo.fr

MITIGATION AND ADAPTATION STRATEGY TO CLIMATE CHANGE: A CASE STUDY OF *POPULUS DELTOIDES*-BASED AGROFORESTRY SYSTEM IN CHHATTISGARH, CENTRAL INDIA

S. L. Swamy[1], Alka Mishra and Sushma

One of the major issues of global concern today is the increasing levels of green house gases (GHGs) in the atmosphere and its consequence on climate change. Agro-ecosystem is very climate sensitive and particularly tropical agriculture with subsistence farming systems are most vulnerable since the majority of farmers have small land holdings and practice low input agriculture. Livelihoods and economy of farmers are affected due to lack of adequate resources, support, access to novel technologies and thus reducing their capacity to adapt them to changing climate.

Under these circumstances, agroforestry is emerging as a promising technology, which has strong potential to mitigate and adapt to climate change through increased rates of carbon sequestration and ameliorating the microclimate thus creating conducive environment for crop production. Improved agroforestry practices systems reduce vulnerability of tropical agroecosystems and help in achieving sustainable crop production. With this hypothesis, the present study has been conducted to examine the mitigation and adaptation potential of *Populus deltoids*-based agroforestry system in sub-humid tropic of India. Five clones of *P. deltoides viz.,* G3, G48, 65/27, D121 and S7C1 were evaluated for growth, carbon sequestration and productivity of soybean crop under an agrisilviculture system. The ecophysiological studies were carried out in crop to find out the influence of clonal effects and finally adaptation of soybean with different clones. Diameter at breast height (dbh) and tree height were consistently higher in clone 65/27 and lowest in clone S7C1. Mean annual increments (MAI) in dbh and height were 1.6 and 1.3 times higher in clone 65/27 compared to clone S7C1. Total biomass varied from 48.5 to 62.2 Mg ha^{-1} in 6-year-old clones. C storage in clones was in the order: 65/27 > D121 > G48 > G3 > S7C1. PAR decreased by 10– 44% under 5 yr-old clones, which was further reduced by 15-49% under 6-year old clones. Overall the transpiration rate was decreased by 16-35% in soybean grown under poplar clones. The decrease of PAR, transpiration and leaf temperature was highest under clones G3, G48 and 65/27. The yield and yield attributes of soybean were significantly decreased under poplar clones. Grain yield varied from 9 to 15.9 q ha^{-1} and Stover yield from 24.4 to 36.7 q ha^{-1}. The reduction in grain and stover yield of soybean in different clones was in the order: S7C1<D121<65/27<G48<G3. The paper discusses role of soybean-poplar based agrisilviculture system for mitigation and adaptation to climate change in sub-humid tropics of Central India.

Keywords: carbon sequestration, clonal variation, eco-physiology, nutrient export, photosynthetically active radiation.

[1] Guru Ghasidas Vishwavidyalaya, Bilaspur (C.G.) 495 009, India. E-mail: swamy_101@yahoo.com

PROBLEM OF FLYING COTTON FROM *POPULUS* IN KASHMIR VALLEY AND SOME REMEDIAL MEASURES

Syed Tariq[1] and Deepak Khanna

Populus species have been extensively planted in the Kashmir valley of India. The plantations mostly consist of unidentified clones. Planting without judicious use of clones has led to the creation of nuisance of flying cotton. After reaching reproductive phase, the trees start producing seeds which are embedded in light cotton-like strands. The cotton mass with seed flies with even a gentle breeze and is dispersed over long distances. The cotton is causing pollution which is, in turn, resulting in several respiratory problems to people over large area.

There is an urgent need to identify the male and female clones of poplar and avoid the planting of female poplar clones which are responsible for producing cottony seeds. As it is not easy to identify the sex of the tree unless it reaches reproductive stage, DNA markers are needed to identify and functionally characterize male and female cultivars in poplars and, hence, minimize flying cotton menace during the months of seed dispersal. The establishment of germplasm banks with proper clonal identity with respect to their sex and their mass multiplication will allow farmers and growers to maintain clonal identity of growing elite cotton-free male poplar germplasm that will eventually lead to more efficient economic and environmental gains.

Keywords: male and female clones, seed dispersal, clonal identity.

[1] State Forest Research Institute, Near Wood Land School, Sonwar, Srinagar, Kashmir, Jammu and Kashmir, 190001, India.

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ECONOMICS OF POPLAR PYROLYSIS STEMMING FROM PHYTOREMEDIATION OF METAL POLLUTED SOILS

Theo Thewys[1] and Tom Kuppens

The Campine is a vast cross-border area in the northeast of Belgium and the southeast of the Netherlands that has been contaminated with heavy metals. As traditional excavation techniques are too expensive, phytoremediation is preferred. Economically viable conversion techniques for the biomass are searched for in order to lower reclamation costs and to guarantee the income of the local farmers, mainly cultivating roughage for dairy cattle rearing. Cooperative energy generation by means of pyrolysis of poplar from short-rotation coppice seems to be very interesting.

In order to investigate the economic feasibility of flash pyrolysis of metal accumulating poplar, a cost-benefit analysis is being performed from the point of view of both an investor in renewable energy and the farmer confronted with heavy metal pollution. First, the net present value (NPV) of cash flows generated by an investment in flash pyrolysis of metal containing poplar grown on farmland for electricity and heat production have been calculated. In a second step, uncertainties have been taken into account and Monte Carlo simulations have been performed in order to calculate the maximum poplar price (i.e. guaranteeing a 95% chance of a positive NPV for the investor in electricity generation) under different scenarios. Finally, these maximum prices have been used to determine farmer's maximal earned income.

Because it is expected that only a limited number of farmers will participate, the best economic option for small-scale electricity production – i.e. flash pyrolysis – has been studied more thoroughly and pathways have been investigated to turn flash pyrolysis more profitable. One option is to co-pyrolyse poplar with biopolymer waste, resulting in pyrolysis oils with lower water content and higher calorific values and hence better economic profits. Further research is ongoing concerning the economic value of the metal containing char by-product of flash pyrolysis as a possible resource for active coal production or as a soil amendment (after metal extraction *via* acid treatment or metal immobilization).

Keywords: short-rotation coppice, poplar, pyrolysis, cost-benefit analysis, net present value, sensitivity analysis.

[1] Centre for Environment, Hasselt University, Agoralaan, B-3590 Diepenbeek, Belgium. E-mail: theo.thewys@uhasselt.be

SOIL NITRATE PRODUCTION AND ASSIMILATION IN RIPARIAN HYBRID POPLAR PLANTATIONS

Ye Tian[1], Zhenyang Xia[1], Yajun Zhao[1], Hao Song[1] and Shengzuo Fang[1]

Because of the ecological preferences for moisture and nutrients, most hybrid poplar plantations in China are established on riparian land for timber production and also for maintaining healthy aquatic ecosystems as buffering zones. However, due to the generally high water table, in some cases, riparian forests could also act as a source of nitrogen leaching through mineralization and nitrification. In the present study, using laboratory incubations with the addition of different N forms and nitrification inhibitors, we aimed to analyze soil N mineralization and nitrification processes, to evaluate the relative importance of autotrophic and heterotrophic nitrification, and to assess soil microbial nitrate (NO_3^--N) assimilation, in riparian hybrid poplar *(Populus* × *euramericana* cv. "Nanlin-95") plantations near Hongze lake of Jiangsu Province, China.

The results showed that N mineralization process of the top 10 cm soils did not differ much among different planting densities. NO_3^--N was the dominant inorganic N form during mineralization process, which indicated significant nitrification and NO_3^--N production. Net NO_3^--N production increased significantly with the addition of both ammonium (NH_4^+-N) and glycine. In addition, the experiments with the addition of autotrophic or heterotrophic nitrification inhibitors revealed that nitrapyrin inhibited significantly the soil nitrification process while cycloheximide showed no obvious effects. Moreover, after the co-addition of nitrapyrin and glycine, net NH_4^+-N produced significantly while no net NO_3^--N produced. Contrarily, the co-addition of cycloheximide and NH_4^+-N showed significant net NH_4^+-N consumption and NO_3^--N production. Such facts revealed that autotrophic nitrification was the dominant process controlling soil N transformation into NO_3^--N in the riparian poplar plantations. Further experiments with the addition of NO_3^--N showed that NO_3^--N could not be consumed by soil microorganisms during the 2-week incubation period. However, with the co-addition of NO_3^--N and glucose, the immobilization of NO_3^--N was observed, which indicated rapid microbial assimilation of NO_3^--N after C availability increase. The results implied that the increase in C supply could convert NO_3^--N to the less mobile form through microbial consumption and thus prevent N from leaching.

Keywords: nitrification, nitrification inhibitor, nitrate consumption, soil incubation, poplar.

[1] Nanjing Forestry University, 159 Longpan Road, Nanjing, China. E-mail: tianyes@hotmail.com

SUSTAINABILITY IN BIO-ENERGY PRODUCTION OF POPLAR AND WILLOW WITH RESPECT TO NITROGEN FIXATION

Georg von Wuehlisch[1]

The demand for biomass, including wood in form of chips and pellets, is increasing dramatically and globally prices are rising, especially in countries dedicated to sustainability in fulfilling international agreements. Diverse measures to accelerate biomass production are implemented, among them fertilizer application. Nitrogen (N) has strong potential of increasing yields; however at the same time anthropogenic N is a major pollutant of atmosphere, waters, and soils and in many regions passing the pollution load capacity. Additionally, high levels of N in soils result in harmful emissions of nitrous oxide (N_2O), a strong greenhouse gas 298 times more effective than CO_2 and highly persistent in the atmosphere. A rigorous reduction of N emission and fertilisation is thus necessary.

Despite of the world-wide area of 10 million ha of intensive poplar and willow plantations, little is still known concerning the fertilizer requirements of these species and their widely planted varieties. The fast growth lets expect a high demand for fertilizer, especially N. However, no correlation between the applied amounts of N and the produced amount of biomass can be established. In the same sense, fertilizing recommendations are not consistent, ranging from 0 to over 100 kg N * ha^{-1}. Discoveries of plant growth promoting bacteria in both, poplars and willows might give an explanation for these findings. Among the endophytic bacteria found in the tissues of *Salicaceae*, diazotrophic bacteria were identified, able to convert inert N_2 into plant accessible reactive nitrogen. These bacteria enable poplars and willows to fix airborne N_2 like legumes do. For tree breeders this is a new character to account for and marker-assisted selection may fail because N_2 fixation is not controlled by the genome of the host tree. In face of high levels of noxious nitrogen compounds in the environment, N_2 fixation is of advantage for the sustainable use of poplars and willows because no additional N needs to be applied. Compared to other high yielding biomass producing plants requiring large amounts of N fertilizer, poplars and willows are much more sustainable and exhibit higher energy efficiency, when relating energy output to total energy input in the process of energy production. Also, poplars and willows are especially suitable in agroforestry systems since they do not compete for N as much as other fast-growing tree species requiring N.

Keywords: *Populus*, *Salix*, fertilization, nitrogen-fixation, diazotrophic bacteria, nitrous oxide, agroforestry.

[1] Johann Heinrich von Thuenen-Institute, Institute for Forest Genetics, Sieker Landstrasse 2, 22927 Grosshansdorf, Germany. E-mail: georg.vonwuehlisch@vti.bund.de

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EFFECT OF IRRIGATION BY TREATED WASTEWATER ON GROWTH AND PHOTOSYNTHESIS OF POPLAR SEEDLINGS

Houda Zarati, Zoubeir Béjaoui, Mejda Abassi and Ali Albouchi[1]

Tunisia is deploying a lot of efforts to overcome the major environmental issues (soil degradation, desertification and water shortage). The deforestation of the extensive marginal with the appropriate trees, in particular poplar, appears to bring some solution to the problem. This fast-growing trees shows a great payback in its use (wood production, biocombustible and protection of water and soil). However, its water requirement will limit its interest in poor water resources zones. Therefore, treated waste water will be appreciated not only as a water source, but also as a nutritive elements source.

The present study is about young seedlings of black poplar (I-488). During the experiment, the seedlings were subjected to two hydrous modes, maintained to field capacity. A first batch of seedlings irrigated with tough water was used as control (C) and the second, with treated waste water (TWW). The impact of the irrigation by waste water was estimated by the measuring of growth, biomass accumulation and photosynthetic activity parameters. TWW significantly amplified the stems growth in height, during the first 40 days. But the diameter growth did not vary significantly compared to the regular irrigation. The use of TWW gave 30% excess in the total dry mass compared to the witness after 60 days of irrigation. This attributed to increased root dry mass, of a clear increase in total surface area reaching 150% compared to the control C in 60 days and of a high photosynthetic activity.

Keywords: reforestation, poplar, waste water, fertilizing, growth, photosynthesis.

[1] Abassi Mejda, Institut National de Recherches en Génie Rural, Eaux et Forêts (INRGREF), BP 10, Ariana 2080, Tunisie. E-mail : mej_abassi@yahoo.fr

SUB-COMMITTEE ON NOMENCLATURE AND REGISTRATION

STATUS AND DISTRIBUTION OF WILLOWS IN TEMPERATE AND COLD ARID REGIONS OF JAMMU & KASHMIR

R. Banyal, S.K. Gupta[1] and Raja Ali Abidi

Jammu & Kashmir has broadly five types of vegetation extending from sub-tropical dry evergreen to alpine forests constituting about 9.08 per cent of the total geographical area. Forests are largely distributed in Kashmir and Jammu province while Ladakh is devoid of forest cover. The willows constitute an important group owing to their multipurpose usage and presumed to be fastest growing species of the region. Willows are indigenous to Kashmir and Ladakh province. Of the 27 known willow species, 24 are found in Himalayan region only. However, willows of commercial significance were introduced in the state between 1917 to1929. These introductions have naturalized in the specific regions. Willow cultivation started for firewood production has found large supplies of various trades. The public utility nature of willows involving fruit growers, farmers, carpenters, artisans and foresters have made this species an indispensable component of farming systems of the region especially Kashmir and Ladakh. The estimates available have revealed that willow plantations account for 36 per cent (approx. 38 million trees) of the total broad leaved trees growing in the Kashmir valley. The present paper discusses the status & distribution pattern including the commercial significance of important willows growing in the Kashmir and Ladakh province of Jammu & Kashmir state.

The distribution pattern of willows is strictly random in the region. The main willow species growing in Kashmir province are *Salix alba*, *S. triandra*, *S. viminalis*, *S. fragilis*, *S. babylonica*, *S. purpurea*, *S. dickymat*, *S. matsudana*, *S. rubra*, *S. amygdaloides*, *S. daphonoids*, *S. phylisifolia*, *S. caprea*, etc. There are twelve *Salix spp.*, out of which only six are of commercial significance viz. *S. alba*, *S. tetrasperma*, *S. sclerophylla*, *S. hastate*, *S. eleganus* and *S. daphnoides* (in Ladakh province). The willow occurs in the form of block, boundary of agricultural fields and farms, avenue, admixed with other broad leaved species in sporadic fashion in the Kashmir Valley, whereas, in Ladakh, the people usually prefer planting of willows along with some grasses like alfa-alfa but largely as boundary plantation or along the water courses and rarely on barren lands where moisture is available in plenty.

Willows of Kashmir have rolled into many national and international trades like cricket bat industry, green energy, artificial limbs, packaging, plywood, paper and pulp and wicker work besides, source of firewood and fodder. In Ladakh, willows are mainly used as fodder, roof thatching and firewood for cooking and even to have warmth in the winter. *Salix alba* cv. *caerulea*, a female cultivar is used for manufacturing of cricket bat but the industry is under resource crunch due to over exploitation in

[1] Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Camp Wadura, Sopore (J&K), India, 193 201. Division of Agroforestry, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, P.O. Chatha, Jammu (J&K), India, 180 009. E-mail: drbanyal08@gmail.com; rbanyal08@yahoo.co.in; sushilgupta67@rediffmail.com

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the past as depicted by a whooping annual production of 1.5 million cricket bat for local and national market. Wicker willow plantations (*S. triandra*, *S. dickymat* and *S. rubra*) occur in all the districts except Kupwara in Kashmir province. Such plantations contribute to 35.34 per cent of the farmers' average income in Srinagar as against 1.27 per cent in Pulwama district. The strongest and finest species used for basketry is *S. triandra* (almond willow). The major problem being faced by the industry are dearth of trained personnel, destruction of natural habitats, lack of capital investment in tools and equipments and lack of quality of raw material. The ecology and economy of the region is based on willow plantations. So, the need of the hour is to address the constraints by commercialization of willow production under short-rotation intensive culture in this part of the Indian sub-continent.

Keywords: willow, firewood, plantation, status, distribution, Kashmir, cold arid, ecology.

CERTIFICATION OF POPLAR NURSERIES IN ARGENTINA

S. Cortizo[1] and A. Garau[2]

The National Seed Institute (INASE) enacted in 1999 the Resolution No. 256 which regulates the production, certification, marketing and imports of seeds of forest species in order to organize the production and use of germoplasm. To encourage the use of certified material, the government granted an additional 10% (Res. SAGyP 102/2010) in the payment of non-repayable financial support to forest plans (Law No. 25.080 of "Investments in Forestry"). To apply for this benefit the growers must submit a "Record of origin of certified forest reproductive material" issued by a certifying nursery registered at the National Seed Institute and the official hologram attached to it. Currently, there are eight clones of *P. deltoides* and five clones of *P. x canadensis* inscribed on the National Register of Cultivars from presentations made by the National Institute of Agricultural Technology (INTA) and the National University of Cuyo, and 28 certifying nurseries. In 2010, the nursery of the INTA Delta Cooperative Association made the first sale in Argentina of certified forest agamic propagation material, which corresponded to the clone '*P. deltoides* Carabelas INTA', starting then the certification process with poplar material. During that year, the certified material represented 79.7% of the nursery sales, while this percentage reached 99% during 2011.

INTA Delta has been a pioneer in the development of tools for identification and certification of *Populus*, and their nursery sales of certified material (60,000 m of average annual production) represent near 6-7% of the total poplar certified material sales of Argentina. For the characterization of different poplar clones, a modified version (adapted to the Argentine conditions) of the standards established by the UPOV (Union for the Protection of New Varieties of Plants) was adopted by the INASE for the registration of clones in the Register of Varieties. The characterization takes into account 58 morphological and phenological characteristics described using 1-year-old plants in nurseries. These characteristics are particularly useful to check the purity and homogeneity of the material and they guarantee the absence of mixtures in commercial plantations. It is relatively easy to separate off-type plants, especially in some phases of the crop, using for example the color of the foliage or the dates of bud burst and leaf fall. Based on them, we could build a simplified key that allows the recognition of the five clones most planted in the Paraná Delta region. However, for some clones these morphological and phenological characteristics may be insufficient and therefore descriptors based on SSR polymorphisms were generated. They were included as additional characteristics when the clones were registered. These descriptors allow accurate genotypic identification and will be used during the process of certification of the identity of the clones inscribed into the National List of Forest Basic Materials.

Since the establishment of the certification process in forest nurseries, there has been a significant progress in the normalization of the commercialization of forest plant material in Argentina. We will continue working to include in the National Register all the clones used in different regions of the country not only for commercial plantations but also for shelterbelts, and to complete the molecular patterns of the clones that, unlike those registered by INTA, have not been yet characterized.

Keywords: *Populus deltoides*, *P. x canadensis*, certification, identification.

[1] INTA, E.E.A. Delta del Paraná, Cátedra de Genética FA-UBA. Argentina. E-mail: scortizo@correo.inta.gov.ar
[2] Cátedra de Dasonomía FA-UBA. Argentina. E–mail: agarau@agro.uba.ar

INDIAN POPLARS WITH SPECIAL REFERENCE TO INDIGENOUS SPECIES

H.B. Naithani[1] and S. Nautiyal[1]

Salicaceae family embraces poplars (*Populus*) and willows (*Salix*). Genus *Populus* Linn. includes 30 species in five sections. These are widely distributed in the temperate and sub-tropical regions of the Northern Hemisphere. In the plateaus of Near-East and in the borderlands of Mediterranean Sea, since antiquity, people have been planting poplars near their homes, around their fields or along ditches and roads; these trees not only furnish fuel and timber for domestic use as well as forage to cattle but also provide shade, shelter and greenery. *Populus* is usually dioecious, rarely monoecious, viz., *P. lasiocarpa* Oliv., native of Western China . It is exceptionally bisexual in *P. jacquemontii* var. *glauca*, a species endemic to Eastern Himalaya.

Realizing the importance of poplars, a National Poplar Commission was created in France in 1942 and subsequently an International Poplar Commission was set up under the aegis of the FAO in 1947. India became a member of this Commission in 1965 and constituted a National Poplar Commission with the objective of cultivating poplars to meet the requirements of timber, fuelwood, etc.

Eight species of poplar are distributed in India, viz., *P.alba* Linn., *P.euphratica* Oliv., *P.microcarpa* Hook. & Th., *P. nigra* Linn, *P. laurifolia* Led., *P. balsamifera* Linn., *P.ciliata* Wall. ex Royle, *P. gamblei* D. and *P. jacquemontii* var. *glauca* Haines. There is a controversy regarding the indigenous poplars in India. Many people considered *P.laurifolia*, *P. euphratica* and *P.alba* as indigenous. In fact, these are exotic viz. *P.euphractica* has a remarkable geographical distribution. It occurs in Ladakh, plains of the Punjab and Sind (Pakistan), Tibet; westwards, it is indigenous on riparian areas in Afghanistan, Turkey, Iran, Iraq and Palestine, which exhibits a wide range of leaf polymorphism. *P.alba* and its cultivars known from Southern Europe, Western Siberia and Central Asia, were introduced and naturalized in Kashmir and Ladakh, known by the local name 'Safeda' and 'Mal'. Black poplar (*P.nigra*) and its cultivars are native of temperate Europe, introduced in Kashmir, Himachal Pradesh and in some parts of Garhwal Himalaya. Balsam poplar (*P.laurifolia* Ledeb.), *P.balsamifera* Linn., a species of Central Asia, was planted in Leh (Ladakh), Lahaul and Spiti (Himachal Pradesh) and Tawang district of Arunachal Pradesh, where it is generally planted by the Buddhists near monasteries. Eastern cottonwood (*P.deltoides*) from North America is very commonly planted by the farmers in agroforestry plantations in Punjab, Haryana, Uttar Pradesh and Uttarakhand.

Keywords: leaf polymorphism, endemic, indigenous, poplars and willows.

[1] Botany Division, Forest Research Institute, Dehra Dun (Uttarakhand), India. E-mail: nautiyals@icfre.org

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CONSTRAINTS AND CHALLENGES IN FOREST CERTIFICATION OF AGROFORESTRY PLANTATIONS OF *POPULUS DELTOIDES*: A CASE STUDY FROM NORTH INDIAN STATES

Shiv S. Panse[1], Pramod Chauhan and Kshitij Malhotra

Forest certification is a tool for monitoring of forests of both type i.e. natural or plantation under community, social or agroforestry; and identification, segregation, tracing, labeling and promoting legal trade of wood and paper products and non-timber forest products. The quality of management is judged through environmental, social and economic perspectives. Forest certification refers to separate processes viz., Forest Management certification (FM), chain of custody certification (COC) and controlled wood certification (CW). FM and CW certification processes verify that an area of forest/ plantations from where the wood/ fiber are extracted is managed to a defined standard. COC certification is a process of tracking forest products from the certified forest to the point of sale to ensure that product originated from a certified forest and reducing a chance of mixing illegal or otherwise controversial sources. There are several certification schemes operating globally of which Forest Stewardship Council (FSC) certification, Program for the endorsement of Forest Certification (PEFC), Sustainable Forestry Initiative (SFI) are few of them credibly operating in India.

The number of COC certifications COC issued in 2007, 2008, 2009, 2010, 2011 and 2012 are 1, 7, 29, 104, 170 and 107 respectively, and clearly indicates an interest of buyers and sellers to adopt responsible sourcing. Till August 2012 around 300 certificates have been issued and this number is expected to increase in subsequent years. However, not much forest area or private plantations have been certified in India yet, therefore most of the panel producers have to depend mainly on import to work in FSC Certified system. Buyers have started adopting responsible sourcing in their policies and practices which in turn reward suppliers using wood from legal sources either well managed forests and discouraging suppliers using it from unknown sources.

Certification scenario is being adversely affected due to lack of understanding of procedures of certification, non-parity in states policies pertaining to raw material harvesting being operated in forest areas, private plantations etc. This situation has led producers to show disinterest towards FSC certification due to less demand of certified products in local market which is one of the key factors strongly.

In India most of the wood-based industries situated in North India use poplar as their main ingredient for panel products. Movement of wood raw material takes place from farmer's fields of different states to various wood markets in North Indian states through different marketing channels. Middle men and other agencies such as Mandi Samitee, Wood trader's Associations and other local authorities who work as a bridge between wood products buyers and suppliers. These agencies can support both buyers and suppliers in meeting mandatory requirements of certification by educating industries and farmers to provide certified raw material through capacity building and skill upgradation programmes.

Keywords: forest certification, agroforestry, private plantation, wood-based industries.

[1] Forest Research Institute, Dehradun-248006, Uttarakhand, India. E-mail: sspanse@gmail.com

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