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INTRODUCTION AND TESTING OF POPLAR: PROPOSAL FOR AN EXCHANGE AND TESTING PROGRAMME

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Cross breeding by controlled pollinations has brought forth highly productive poplar cultivars grown on ten million ha globally. The success of poplar breeding is due to the hybridisation of differing species, which naturally would not come into contact. Examples of successful hybridisations are *Populus* × *berolinensis* Dippel, *P.* × *canadensis* Moench, *P.* × *canescens* Sm., *P.* × *generosa* A. Henry, *P.* × *jackii* Sargent, *P.* × *wettsteinii* Hämet-Ahti. Prerequisite for breeding is the exchange of germplasm among different breeding institutions. To support this as one activity of promoting poplar cultivation, the International Poplar Commission was founded in 1947 by FAO. However, important and widely distributed poplar species as *Populus laurifolia* have remained largely unexplored in their hybridisation potential. Fast growing and frost resistant cultivars of *P. laurifolia* origin like 'Petrowskyana', 'Brooks' or 'Griffin' raise expectations for the production of further exceptional genotypes by hybridising *P. laurifolia*. A proposal is made to exchange germplasm, e. g., seeds, pollens, cuttings, from natural stands and hybrid poplar clones and to use the material for cross breeding work with respect to suitability testing in a designated region of wood production.
K e y w o r d s : poplar, forest reproductive material, cross breeding, clonal testing.

Successful crosses and poplar species of interest

Over 200 years poplar hybrids have been planted for their fast growth and straight stems. Controlled cross pollinations are ongoing for about 90 years, beginning with the USA and Italy and then additional countries (Table 1). Prerequisite for this work is the exchange of germplasm among the breeders in different parts of the world. In recognition of the great potential of the genus *Populus* to satisfy the increasing need for wood the International Poplar Commission was founded n 1947 under the FAO, Rome, with the aim to promote poplar cultivation in general and also to support the international exchange of germplasm among breeders [6]. The result of poplar breeding is the intensive production of poplar wood on ten million ha globally, especially in the temperate zone where tropical fast growing species like tropical pine species or *Eucalyptus* cannot be grown.

Most crosses were performed between the American species *Populus deltoides* Bartr. ex Marsh. and the Eurasian *P. nigra* L. known as *P.* × *canadensis* Moench. (syn. *P.* × *euramericana* Guinier). Subsequently many additional poplar species were successfully crossed like *P. alba* L. and *P. tremula* L. (= *P.* × *canescens* Sm.) or *P. trichocarpa* and *P. deltoides* Bartr. ex Marsh (= *P.* × *generosa* A. Henry) *P. tremula* L. and *P. tremuloides* Michx. (= *P.* × *wettsteinii* Hämet-Ahti) as well as *P. laurifolia* Ledeb. and *P. nigra* L. (*P.* × *berolinensis* Dippel) (Table 1). The table shows that frequently the place of cultivation of a cultivar differs from its place of origin, which supports the presently proposed exchange of poplar reproductive material. Whereas in earlier times cultivars of European origin were frequently cultivated in America this trend has reversed over about the past six decades and many cultivars bred in America are now used in Europe.

Exchange of plant material has been of different intensity between countries and continents following geo-political patterns. Exchanges between West-European and North-American countries have been comparatively intense while focussing on *P. deltoides, P. nigra, P. tremula, P. tremuloides* and *P. trichocarpa*. However, exchanges between countries with other potentially interesting poplar species remained largely unexplored. Many successful clones used in the Canadian prairies for example are based on *P. laurifolia* Ledeb. occurring in Eurasia [1]. However, only very few genotypes of this species have ever been used and it can be suspected that wider use of this species might bring up successful clones. Conversely *P. balsamifera* L. might have a large potential in the northerly and continental climates of Siberia, where hybrids of this species with the native *P. laurifolia* could be well adapted and suitable for plantation forestry. Also, north-eastern

accessions of *P. nigra* have not been tested sufficiently and utilised much in breeding programmes. The same might apply to *P. tremula* occurring widely in that region. The poplar species of foremost interest for exchanges between the partnering institutions are *P. nigra*, *laurifolia*, *tremula* from Eurasia and *P. deltoides*, *balsamifera*, and *tremuloides* from North America.

Table 1

Examples of widely used poplar cultivars, their parent species, origin and location of use [4]

Cultivar	Species	Origin	Location of production plantations
'Petrowskyana'	*P.* × *berolinensis* Dippel	Germany	Europe, North America
'Allenstein'	*P.* × *canadensis* Moench	Germany	Europe, North America
'AF 2'	*P.* × *canadensis* Moench	Italy	Europe, North America
'Eugenei' (DN34)	*P.* × *canadensis* Moench	France	North America, Europe
'I 214 Casale' (3n)	*P.* × *canadensis* Moench	Italy	Europe, America
'I 45/51'	*P.* × *canadensis* Moench	Italy	Europe, America, Turkey
'NE367 '	*P.* × *canadensis* Moench	USA	USA
'Robusta'	*P.* × *canadensis* Moench	France	Europe, North America
'Walker'	*P.* × *canadensis* Moench	Canada	Canada
'Smith Grey Poplar'	*P.* × *canescens* (Aiton) Sm.	Europe	Europe, North America
'Brooks'	*P. deltoides* × *P.* × *berolinensis*	Canada	Canada
'Monviso'	[*P. deltoides* × *P. trichocarpa*] × *P. nigra*	Italy	Europe
'Unal'	*P.* × *generosa*	Belgium	USA
'Northwest'	*P.* × *jackii* Sargent	Canada	Canada
'Androscoggin' '(NE41)'	*P. maximowiczii* × *P. trichocarpa*	USA	Europe, also 'NE 42'
'Matrix'	*P. maximowiczii* × *P. trichocarpa*	Germany	Europe
'Oxford', 'NE47'	*P. maximowiczii* × *P.* × *berolinensis*	USA	Europe
'Rochester', 'NE52'	*P. maximowiczii* × *P. nigra* var. *plantariensis*	USA	Europe
'Max'	*P. nigra* × *P. maximowiczii*	Japan	Europe, USA (NM2, 6)
'Crandon'	*P.* × *rouleaniana* Boivin	USA	USA
'Astria' (3n)	*P.* × *wettsteinii* Hämet-Ahti	Germany	Europe

Hybrid characteristics

The cultivation of poplar usually bases on species hybrids. An exception is India, where mostly *P. deltoides* cultivars are grown on 3 million ha in agro-forestry systems [2]. Typical for successful hybrids is that the parent species are more or less closely related and inhabit different regions either on the same or even different continents and are brought into contact. The hybrids frequently not only grow faster due to the heterosis effect, but show better stem forms, tolerate diseases better and have a wider range of growing conditions in which they can thrive [8].

Triploid genotypes have also proven to be favourable, e. g. 'I 214'. However, triploids were frequently of natural origin and are not the result of targeted breeding work. Therefore they often do not meet the standards in all of the required characters, e. g. 'I 214' is increasingly susceptible to fungi attack, also the aspen hybrid cultivar 'Astria' turned out to be susceptible to bacterial canker in the adult stage. New methods allowing systematic induction of triploids or polyploids in desired

genotypes resulting from selection programmes may prove a more successful improvement technology [7].

Plant material to be exchanged

The testing environments should be representative for the regions of poplar cultivation. Fundamental principles of matching clone to site start already at a much earlier level. Ideally, results of provenance research reveal geographical variations patterns which may indicate the expected growth potential that can be achieved at a given environment. However, especially in poplar, systematic provenance testing has not been realized as much as in other species under silviculture. An exception is a recent systematic collection of 65 *P. balsamifera* populations across the complete distribution range and their study in four common garden sites in Canada [3]. Much knowledge about the genetic variability of a species across its range of distribution in terms of adaptation can be acquired from such experiments.

The exchange is not confined only to preselected clones but should also focus on indigenous material that has so far not been used for improvement work. Such material may be exchanged in form of seeds, pollens, plants or cuttings as well as scions. For immediate cross breeding the exchange of pollen samples is the most efficient instrument because much time can be saved, disease transfer is reduced, and, owing to their small size, pollen samples can be sent easily by letters.

From Clone to Cultivar

The exchange of material may be focused on clones already in operational use. There are examples of clones which prove suitable for a wide range of sites (generalists) or only for specific site conditions (specialists). An example of such a cultivar may be ‘I 214’, which is presently still used on different continents because of its favourable wood characteristics, however mostly in dry areas with a low infection pressure.

Another group of clones are the ones that have been selected from progenies from breeding programmes. Due to genotype by environment interactions it makes sense not only to use a wider set of candidate clones but also a wider set of environments (climate and soil conditions) for the subsequent testing. Not only from recent but also earlier cross-breeding programmes, there are presumably many clones available, which have not undergone sufficient testing. They usually exist in earlier clonal collections, tests, or archives. A spatial widening of a national testing programme to foreign countries and sharing the testing exercise as well as the costs at international scale among institutions could be beneficial for the participating parties.

Ideally, the exchange between partnering institutions is bilateral on a one-to-one basis giving mutual benefit to both institutions and the countries they serve. This form of framework satisfies both spatial and temporal requirements since institutions cover a certain region and exist sufficiently long to follow up the clonal developments surpassing the period of individual researchers that initiated the improvement programmes. However, exchange programmes with a network character across national boundaries are also possible.

It is advisable to draw up plant material transfer agreements (PMTA) which confine the use of the material for scientific and testing purposes only and exclude any commercial exploitation and thus safeguarding the breeder’s right for the commercial exploitation of successful cultivars. In addition, a PMTA provides a record of the material that has been transferred.

Poplars are prone to diseases caused by fungi, bacteria and insects, especially when only few cultivars are grown in extensive plantations, thus favouring the virulence of diseases. When exchanging material it is therefore of utmost importance to prevent spreading of agents causing diseases by appropriate actions like disinfections and quarantine or other measures like transferring materials in form of *in vitro* cultures.

Testing programme

Thorough testing requires a sufficient number of replications at different sites representing different environments and at the different test sites, e. g. blocks per site. For later approval of selected clones to be marketed under the category “Selected” according to the rules and regulations

for marketing of forest reproductive material, the pertinent requirements should be observed from the beginning. In the European Union clonal poplar cultivars (material propagated vegetatively) may only be marketed in the category "Tested". Besides a sufficient high number of replications one or more standard clones to test against are usually specified. Such standards should have proven useful for a sufficient long period in the region in which the test is to be carried out. For approval, clones must prove significantly superior to the standard in at least one important character according to accepted statistical procedures. Possible evaluation characters are: survival rate, height of the plants/trees, collar diameters/diameter at breast height, branching habit, circularity of stem, incidences of disease, incidences of insects, mean annual increment and yield or biomass production, and any other specific parameter that may be of importance, like certain wood characters.

For clones additional rules apply. Clones shall be identifiable by distinctive characters which have been approved and registered with the responsible administrative body. Clones must consist of trees of such an age or stage of development that the criteria given for the selection can be clearly judged. Adaptation to the ecological conditions prevailing in the region where the clone is to be cultured must be evident. Approval shall be restricted by the member state to a maximum number of years or a maximum number of ramets produced [5].

The current OECD Scheme for the Certification of Forest Reproductive Material of 2007, regulating international trade of forest reproductive materials under provisions of Decision C(2007)69 apply to forest reproductive material of "Identified" and "Selected" categories. Other categories that can involve other types of basic material (seed orchard, parents of family(ies), clone, clonal mixture) are presently under consideration by participating countries [9]. However, explorations of the feasibility to include advanced categories like "Tested" into the Scheme are ongoing.

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ІНТРОДУКЦІЯ І ТЕСТУВАННЯ ТОПОЛІ: ПРОПОЗИЦІЯ ПРОГРАМИ ОБМІНУ І ТЕСТУВАННЯ

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Гібридизація шляхом контрольованого запилення дозволила отримати високопродуктивні сорти тополі, вирощувані нині на десяти мільйонах гектарів по всьому світі. Успіх виведення сортів тополі став можливим завдяки гібридизації різних видів, натуральні ареали яких у природі не контактують. Прикладами успішної гібридизації є *Populus* × *berolinensis* Dippel, *P.* × *canadensis* Moench, *P.* × *canescens* Sm., *P.* × *generosa* A. Henry, *P.* × *jackii* Sargent, *P.* × *wettsteinii* Hämet-Ahti. Необхідною умовою сортового поліпшення є обмін генетичним матеріалом між різними організаціями, що займаються виведенням нових сортів тополі. Для координації робіт у цьому напрямку в 1947 р. у рамках ФАО була створена Міжнародна комісія з тополі. Проте такі важливі та широко поширені види тополі, як *Populus laurifolia*, залишилися серед інших значною мірою недослідженими щодо їхнього потенціалу гібридизації. Такі швидкорослі і морозостійкі сорти *P. laurifolia*, як Petrowskyana, Brooks или Griffin, відповідають сподіванням щодо виробництва в майбутньому видатних генотипів за допомогою гібридизації *P. laurifolia*. У статті висувається пропозиція обмінюватися генетичним матеріалом, наприклад, насінням, пилком, живцями тощо. з природних насаджень, а також гібридними клонами тополь, і використовувати цей матеріал для робіт з гібридизації та випробувань їх на придатність для виробництва деревини в конкретному регіоні.

Ключові слова: тополя, посадковий матеріал, гібридизація, тестування клонів

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ИНТРОДУКЦИЯ И ТЕСТИРОВАНИЕ ТОПОЛЯ: ПРЕДЛОЖЕНИЕ ПРОГРАММЫ ОБМЕНА И ТЕСТИРОВАНИЯ

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Гибридизация путем контролируемого опыления позволила получить высокопродуктивные сорта тополя, выращиваемые в настоящее время на десяти миллионах гектаров по всему миру. Успех выведения сортов тополей стал возможным благодаря гибридизации различных видов, естественные ареалы которых в природе не контактируют. Примерами успешной гибридизации являются *Populus* × *berolinensis* Dippel, *P.* × *canadensis* Moench, *P.* × *canescens* Sm., *P.* × *generosa* A. Henry, *P.* × *jackii* Sargent, *P.* × *wettsteinii* Hämet-Ahti. Необходимым условием сортового улучшения является обмен генетическим материалом между различными организациями, занимающимися выведением новых сортов тополя. Для координации работ в этом направлении в 1947 г. в рамках ФАО была создана Международная комиссия по тополю. Тем не менее, такие важные и широко распространенные виды тополя, как *Populus laurifolia*, остались среди прочих в значительной степени неисследованными относительно их потенциала гибридизации. Такие быстрорастущие и морозостойкие сорта *P. laurifolia*, как Petrowskyana, Brooks или Griffin, отвечают ожиданиям для производства в будущем выдающихся генотипов посредством гибридизации *P. laurifolia*. В статье выдвигается предложение обмениваться генетическим материалом, например, семенами, пыльцой, черенками и т. д. из естественных насаждений, а также гибридными клонами тополей, и использовать этот материал для работ по гибридизации и испытаний их на пригодность для производства древесины в конкретном регионе.

Ключевые слова: тополь, посадочный материал, гибридизация, тестирование клонов

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