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Populus trichocarpa (Black Cottonwood) As a Model for Plant Genomic Studies: A Review

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Numerous plants have been the subject of recent research in the pharmacological, cosmetic, and agro-alimentary domains due to their chemical composition and multiple therapeutic capabilities. *Populus trichocarpa* is one of the most common trees found in deciduous forests (*Salicaceae* family). The current study examines *Populus trichocarpa* as a model plant for plant genomics research, as well as the most recent findings on phytochemical composition and medicinal potential. More than 45,000 potential protein-coding genes were discovered. In the *Populus* genome, a whole-genome duplication event was discovered, with approximately 8,000 pairs of duplicated genes surviving. Furthermore, the reproductive biology of *Populus* provides new opportunities and challenges in the study and analysis of natural genetic and phenotypic variation. In the present review, we endeavour to describe and compile the available knowledge on *Populus trichocarpa* as a model plant for genomic investigations and to bring that material up to date of *Populus trichocarpa's* phytochemical and medicinal properties.

Keywords: Western balsam-poplar; genomics; balsamic; Nisqually-1 (Clone of black cottonwood); dioecious.

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1. INTRODUCTION

Over the beyond decades, the cultivation of medicinal flora has started attaining momentum. However still, a significant part of our requirements continues to be met from wild sources. Although there has been a significant increase in the use of herbal medicine in recent years, there is still a significant demand for research data in this field. Medicinal plants are rich sources of components that can be employed in the manufacture of pharmacopoeial, non-pharmacopoeial, and synthetic medications. We can't get away from nature since we are part of it. They must be promoted to preserve human lives [1]. This study aims to review the current knowledge on *Populus trichocarpa* biological investigations and therapeutic benefits. *Populus trichocarpa* considered as the first tree whose entire DNA code is decoded. The genome sequence of *P. trichocarpa* is a significant tool for employing comparative mapping to investigate the structure and function of genomes in the poplar and related species [2].

Fig. 1. Populus tree

Populus is a genus of deciduous trees in the *Salicaceae* family (*Willow* family) of flowering plants. Flowers in the shape of a long, drooping cylindrical spike-like inflorescence, as well as spirally arranged leaves with a long petiole, distinguish it. It is laterally flattened in other species such that breezes can easily cause the leaves to vibrate from side to side. It may give the entire tree a "shining" appearance in a breeze [3]. Aspen, cottonwood, and poplar are common names for various species while other names are also applicable to other members of the genus. The genus *Populus* is native to the majority of the Northern Hemisphere, including areas north of the Arctic Circle. They excel at developing huge and quickly [4]. The Populus species have bi-level viability due to their self-need for survival, growth, and reproduction which mark their position to benefit the ecosystem and humans [5].

2. PHYSICAL DESCRIPTION

Depending on the taxonomic classification, the Populus genus has anywhere from 25 to 35 species. Members are deciduous trees with trunks having dia of 2.5 m and reaching upto 15 to 50 m in height. Young trees' bark is smooth, color is white -greenish or may be dark grey, with pronounced lenticels; trees' bark is smooth in some older species while rough and extensively fissured in others [6]. The shoots are thick and stout, with a terminal bud present (unlike related willows). The trees grow quickly, but they don't live very long. The spirally organized leaves ranges from triangular to round or (rarely) lobed in shape and are wavy [7].

Fig.2 Flower

Even within a single tree, leaf size varies greatly, with little leaves on shoots and huge leaves present on strong-growing main shoots. During the autumn, the leaves often become a brilliant gold to yellow colour before falling. Poplars are dioecious, which means that the male and female blooms grow on different trees. To aid wind pollination, the flowers start blooming in drooping catkins before the leaves appear [8]. The fruits are small in size having thick-walled capsules which contain numerous tiny seeds covered in cottony tufts of silky hairs. The seeds are frequently released in large numbers and the fluffy seed hairs aid in wind dispersal. Seeds are borne pedunculate catkins that develop from buds being formed in the axils of the previous year's leaves [9,10].

There is no calyx or corolla on the female flower, which consists of a single cell ovary situated in a cup-shaped disc. The style is short having 2–4 stigmas that are lobed in diverse ways and a large number of ovules [11]. Wind pollinates the plants, and the female catkins lengthen significantly between pollination and maturity. The fruit is either two or four-valved green to a reddish-brown capsule that matures in the middle of summer. It has a lot of small light brown seeds that are encircled by tufts of long, soft white hairs that help with wind dissemination [12].

Fig. 3. Cottonwood poplars

Cottonwood poplars are frequently wetlands or riparian trees in the cottonwood division. Cottonwoods are so named because their seeds include tufts of cottony hairs. Aspens are one of the most important broadleaf trees in the boreal region [13,14].

It thrives in light, medium and heavy soils, preferring well-drained soil but capable of growing in thick clay. Acid, neutral, and basic (alkaline) soils are all suitable, and they can even grow in highly acidic soils. It is unable to thrive in the shade [15]. The internal bark is mucilaginous and extraordinarily sweet, but unlike inner barks it ferments and sours easily thus cannot be dried to be used in winters but can be dried under sunlight for immediate use [16].

3. MEDICINAL USES

The herbal products these days, are the symbols of safety in comparison to the synthetic drugs as synthetics are considered harmful for humans as well as environment. In the last few years, the synthetic drugs overcame the importance of natural herbs due to high price based on their aromatic and flavoring qualities. Though, the dependence on synthetic drugs is getting over and people are going back to the naturals with the hope of safety and also of security [17].

Fig. 4. *Populus trichocarpa*

Plants for Future cannot be held liable for any negative consequences of plant use. Always seek the advice of a professional before using a plant medicinally. *Populus trichocarpa* possesses several characteristics that make it an excellent tree model species. It's an anodyne, anti-inflammatory, anti-scorbutic, antiseptic, expectorant, febrifuge, stimulant, balsamic, diureticand tonic [18]. Western balsam poplar has extended records of use as a herbal remedy. It is still widely used in modern herbalism for many of the same purposes [19]. They are used to treatbronchitis and upper respiratory tract infections and are administered orally. Aspirin-sensitive patients should not be given them [20]. The buds are used externally to treat cold-cough, sinusitis, arthritis, and dry skin conditions. To relieve congested nasal passages, soak them in hot water and use them as an inhalant [21]. The buds are plucked before they open in spring and preserved in dry form for later use. As a result, the bark is analgesic, anti-inflammatory, and febrifuge. It is commonly used to cure rheumatism and fevers, as well as to alleviate the pain of menstrual cramps [22].

Populus nigra extract has anti-oxidant, inflammation reducing, CVS, and hepato-protective properties. The antioxidant activity of the plant extract due to flavonoids, was found to be correlated with the endothelium-independent vaso-relaxant effect. Furthermore, histo-

pathological analysis revealed complete protection from AlCl3-induced hepatic toxicity [23].

4. OTHER USES

The wood ashes can be used either as soap substitute or can also be mixed with oil to form soap. The inner bark which is white in color also acts as a soap substitute; which can be further stored to be used later in a dry form. The inner bark can also be used as a scouring pad [24].

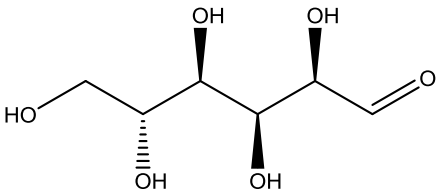
Baskets have been made out of the roots. Wood is soft, relatively strong, easily worked, has a fuzzy texture, has no odour or flavour, is flammable, not durable, and is abrasion-resistant. Boxes, packing material, barrel staves, woodenware, and pulp are all made from it. It is a good source of energy [25].

Populus trichocarpa (Nisqually-1) is a black cottonwood clone that is frequently used as a model woody plant. It was the first one to have a complete genome sequence, and it continues to serve as the model for all woody dicotyledonous plants in terms of growth, metabolism, development, and adaptation. It's one of the most well-annotated plant genomes on the market. It is also being studied to improve bio-energy feed-stocks and learn more about how people react to environmental changes caused by climate change. It is the most researched woody plant in terms of lignin production. Despite its status as a model woody plant, many key genetic uses have been restricted due to its difficulty [26].

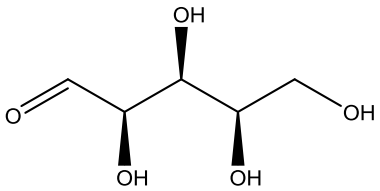
5. CHEMICAL COMPOSITION

The cellulose and lignin content of trees rises with age, according to numerous research. In contrast, the cellulose content of the examined Populus wood was found to be unchanged by tree species, age, or growing environment. The tree type and growth environment, on the other hand, determined the extractive content of poplar wood. The bark and other tree residues (leaves, buds, branches, and exudates) of Populus trees are rich sources of bioactive phenolic compounds of pharmaceutical importance. Because of their antioxidant, anticancer, anti-inflammatory, and antibacterial action, phenols have risen to the top of the food and pharmaceutical industries [26-29].

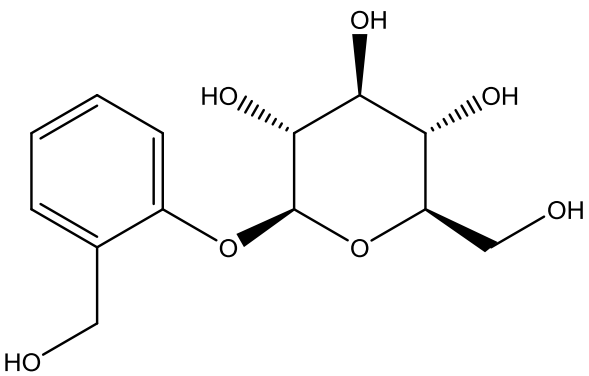
The contents of lignin, glucose, holocellulose, xylose, and minerals were measured in populus species. Lignins are phenolic polymers found in abundance in terrestrial plants' middle lamellae and secondary cell walls. They are thought to offer stiffness and a hydrophobic surface to conducting cells in the xylem, which contributes to the mechanical and physiological relevance of woody tissues. Salicin that converts into salicylic acid on decomposition in the body, is also found in them [30].



Glucose



Xylose



Salicin

6. CONCLUSION

The improvement of the Populus genome sequence has opened up new options for comparative plant genomics, as proven in this investigation. Further in-depth analysis is currently underway to characterize the active compounds that cause the observed effects and confirm the mechanism. Populus has been used as an anti-inflammatory, anti-scorbutic, antiseptic, balsamic, diuretic, expectorant, febrifuge, stimulant and tonic for centuries. The rising expense of energy and chemical raw materials, as well as major environmental concerns associated with synthetic pharmaceuticals, will undoubtedly make herbal therapies more suitable soon.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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