Journal of Advances in Drug Research

ISSN: 2230-7761
www.jadr.co.in

Volume 17, Issue 04 | Received 09.09.2026 | Accepted 12.09.2026 | Online 18.09.2026

DPPH-BASED PHYSICO-CHEMICAL ASSESSMENT OF ANTIRADICAL ACTIVITY IN POPLAR ROOT AND WILLOW BARK EXTRACT RATIOS

Mukammal Imomova Yormuhamatovna[1], A'zamjon Turdiboyev Xasanboy ug'li[2,a)], Ibragim Askarov Rakhmanovich[3], Mirjalol Muminjonov Muqimjon ogli[4]

[1] Doctor of Philosophy in Chemistry (PhD in Chemistry), Fergana State University, Fergana, Uzbekistan, https://orcid.org/0009-0001-6784-1424. tabobat_akademiya@mail.ru
[2] PhD student in Chemistry at, FerganaState University, Fergana, Fergana State University, Fergana,, https://orcid.org/0009-0003-6723-1014 .
turdiboyevazamjon@gmail.com
[3]Doctor of chemical sciences, professor of Chemistry Department, Andijan State University, Andijan, Uzbekistan, https://orcid.org/0000-0003-1625-0330
mukammahon75@mail.ru
[4]Doctor of Chemical Sciences, *Andijan State University, Andijan, Uzbekistan,*
https://orcid.org/0009-0002-8896-202X
mmirjalol1994@mail.ru
a) *Corresponding author:* turdiboyevazamjon@gmail.com

Abstract

This study analyzed the antiradical (antioxidant) activity of extracts obtained from the root of poplar (Populus alba) and the bark of willow (Salix) at a 1:1 mass ratio using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The extracts' effects were assessed through DPPH assay on the bioactive compounds with free radical neutralizing properties. Poplar root and willow bark were mixed in 1:3, 1:1, and 3:1 mass ratios during the experiment, which were then extracted in aqueous and alcoholic solutions. Their free radical scavenging activities were identified by DPPH method. Populus alba is a medicinal tree commonly found throughout temperate regions, and its bark, leaves and buds have always been used as anti-inflammatory, analgesic and antiseptic medicines. In this work, however, the less recognized portion—the root—was specifically investigated. Poplar root is rich in flavonoids, phenolic compounds, salicin, glycosides and tannins, organic acids, essential oils and minerals, a complex combination that possesses antioxidant activities and anti-inflammatory properties. Willow bark, in contrast, is recognized as "natural aspirin" because of its high concentration of salicin, flavonoids, tannins, phenolic acids, sterols, essential oils and different minerals which have been scientifically verified to be anti-inflammatory, analgesic, antiseptic, sedative and immune enhancing. For each sample, the IC50 values (the volume of extract needed to neutralize 50% of DPPH radicals) were calculated. This had a greater antiradical activity with a lower value of IC50. At 1:1 mass ratio, the ethanol extract achieved the lowest IC50 value, indicating a synergistic effect of bioactive compounds in poplar root and willow bark. The data for both extracts and

Journal of Advances in Drug Research

ISSN: 2230-7761
www.jadr.co.in

Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

combined extracts were obtained indicating maximal antioxidant activity. Analysis was further based on graphical representations of the illustrated ARF% values of six different samples (aqueous and alcoholic extracts in 3:1, 1:1, and 1:3 ratios) over 30 min. Trend lines were fitted and IC50 values calculated as x = (50 – b)/m. The ethanol extract, at a ratio (1:1), yielded the best results, with ARF% > 60% for the 30 minute mark, indicating strong antioxidant activity. Notably, since the 1:3 ratio (which contains a higher proportion of willow bark) in ethanol, also possessed a notable antiradical effect, most likely from the high accumulation of salicin, flavonoids, and phenolic acids in willow bark. Poplar root was comparatively less studied however, as a combined factor with willow bark, significantly enhancing biological activity.

Keywords:Poplar Root (Populus alba), Willow bark (Salix), DPPH method, Antioxidant activity, Free radicals, Phytochemical analysis, Natural extracts, IC50 value, flavonoids, Bioactive compounds.

Introduction

As of now, the isolation of biologically active compounds from plant sources, assessing their pharmacological and biochemical activities and their possible applications in medicine and industry are among the most promising paths in modern science. Plant extracts, in particular, can have potent antioxidant actions to counter oxidative stress on the human body and protect cells from the detrimental effects of free radicals. Free radicals (such as superoxide, hydroxyl radicals) can oxidize DNA, lipids, and proteins in the cells of organisms, and may participate in the formation of several diseases, such as cancer, cardiovascular disease, and neurological diseases. Thus, the discovery of natural antioxidants and evaluation of their biological activity has consequently become one of the major tasks in modern scientific inquiry. Natural antioxidant-rich medicinal plant: poplar (Populus alba) is one of those plants for anti-inflammatory, analgesic and antiseptic activity. The bark, leaves, and buds of poplar have been well studied, but its root has gotten less attention. The root has phenolic compounds, flavonoids, salicin, tannins, essential oils, and a variety of bioactive ingredients with high radical scavenging ability. Another ancestral medicinal plant is the willow (Salix). Its bark is very rich in salicylates (most notably salicin), natural precursor material for aspirin synthesis. Moreover, willow bark has many other compounds like flavonoids, tannins, phenolic acids, essential oils and other polyphenols that are anti-inflammatory, analgesic, antipyretic and antioxidant. This is why many natural cures and biologically active supplements come from willow bark. For the first time, herein, extracts of poplar root and willow bark were mixed 1:1, using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method for the analysis of antiradical activity. DPPH test is a simple and reliable spectrophotometric test for characterizing the plant-based radical scavenging potential of plant extracts. In the assay, when the extract reacts with the antioxidant content in the extract, then purple-colored DPPH radical is observed which can give a discolored color (yellowish or colourless). The extent of this color change is indicative of the antioxidant ability of the extract. Aqueous and alcoholic solvents were used to extract six different samples. Mixing ratios of poplar to willow were 3:1, 1:1, and 1:3 and each extract was tested 25, 50, 75, and 100 µL against DPPH solution. The

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

absorbance measurements at 517 nm were taken every 5 min, and the antiradical activity % (ARF%) was calculated. To achieve this, the IC50 value determined for each sample which indicate the extract concentration required to achieve inhibition of 50% of the DPPH radicals is used to determine the most effective antioxidant extract. It is found that the biological activity of the poplar root and willow bark extracts is increased when blended. In particular, the ethanol extract at the 1:1 level showed the highest antiradical activity. This phenomenon is ascribed to a synergistic effect, which is the enhanced antioxidant activity by the combined action of both the active medicinal compounds of the two plants that are compared to the extract itself. Moreover, the 1:3 ratio (that with a superior % of willow bark) also exhibited significant antioxidant capacity (i.e., salicin and other phenolic compounds in willow bark). Research conducted thus far has shown that adding the less-studied poplar root and the popular willow bark represents a unique and powerful raw material of antioxidants. These results could also offer information for ecologically safe phytopreparations, cosmetic formulations and supplements. Additionally, the DPPH test remains an essential instrument for evaluating the antioxidant potential of plant extracts because of its simplicity, reliability and high efficiency. Extract preparation and biochemical analysis were included in this study, followed by implementation of IC50 calculations, graphical analyses, and comparative studies, respectively. Therefore, this study had theoretical value as well as practical usefulness. We hope that this study will contribute to the complete investigations of the therapeutic pharmacological literature with the assistance of the pharmaceutical industry in the future.

Materials and methods

The colour shift of the purple-colored 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution suggests that there are some pure antioxidant compounds having hydrogen atom/electrons donating ability. The stable DPPH• radical is widely used in spectrophotometrical analyses as a reagent. Here, the method established by Blois to measure the radical-scavenging activity of DPPH• was employed with some changes.

DPPH• solution preparation in working solution. Then a 7.92 mM solution of DPPH• was prepared in ethanol in a 100 mL volumetric flask. The solution was covered with aluminum foil and kept at room temperature in the dark for 30 min.

Preparation of plant extracts. Poplar root and willow bark mixtures (3:1, 1:1, and 1:3) were prepared in mass ratios, respectively. To extract, 1 g of plant material was added to 25 mL of solvent (distilled water or 96% ethanol) and then extracted in an ultrasonic bath for 20 min. Extracts were filtered by a 0.45 µm syringe filter for analysis. Extracts had been tested against 10-fold diluted fractions based on the high antiradical activity of extracts.

Analysis: Determination of antiradical activity. For the blank samples, 3 mL of DPPH solution and 100 µL of solvent (without extract) was put into a 4 mL quartz cuvette, and absorbance D1 was recorded every 5 minutes and at 517 nm at 30 minutes on a YOKE K7000 spectrophotometer (China). For the following four doses of extract to assess the antiradical activity of 25, 50, 75 and 100 µL of extracts, and 3 mL of DPPH solution. The absorbance values (D2) were further read under similar conditions. The remaining volume was filled with solvent to the total volume of 3.1 mL in the cuvette.

Journal of Advances in Drug Research

ISSN: 2230-7761
www.jadr.co.in

Volume 17, Issue 04 | Received 19.07.2026 | Accepted 06.08.2026 | Online 18.08.2026

$$ARF\% = \frac{D_1 - D_2}{D_1} \cdot 100\%$$

Obtained results:

Table 1.

Measured absorbance and calculated antiradical activity values of the blank sample and the aqueous extract of Poplar root and Willow bark (1:1 ratio) added to the DPPH solution.

Volume, µL	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF %
25	0	0,82	0,00	75	0	0,82	0,00
	5	0,72	12,64		5	0,65	21,02
	10	0,71	14,22		10	0,62	24,79
	15	0,69	15,67		15	0,59	28,07
	20	0,68	17,01		20	0,57	31,11
	25	0,67	18,10		25	0,55	33,54
	30	0,66	**19,56**		**30**	0,52	**36,57**
50	0	0,82	0,00	100	0	0,82	0,00
	5	0,70	14,95		5	0,50	39,13
	10	0,68	17,62		10	0,46	44,11
	15	0,66	19,93		15	0,42	48,72
	20	0,64	22,24		20	0,39	52,98
	25	0,63	24,06		25	0,36	56,38
	30	0,61	**26,49**		**30**	0,32	**60,63**

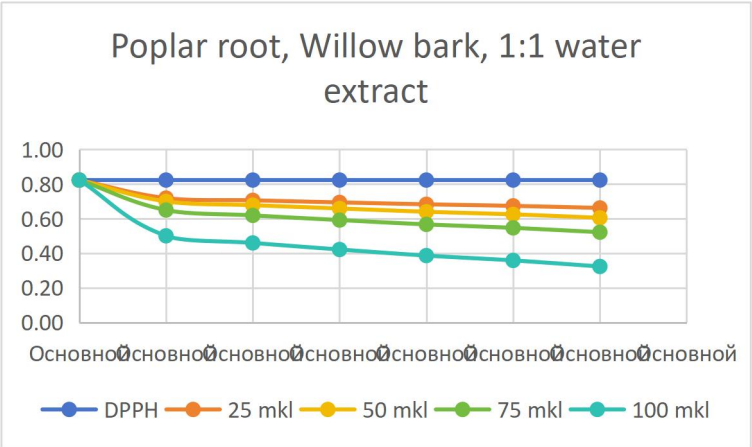


Figure 1. Graphical representation of the measured absorbance of the blank and aqueous extracts added to the DPPH solution.

To determine the **IC_{50}** value – the concentration required to inhibit 50% of the DPPH solution – the antiradical activity values (ARF%) at the 30th minute of each experiment and the corresponding volumes of alcoholic extracts were plotted. Based on the obtained graph, the IC_{50} was calculated using the trendline function.

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

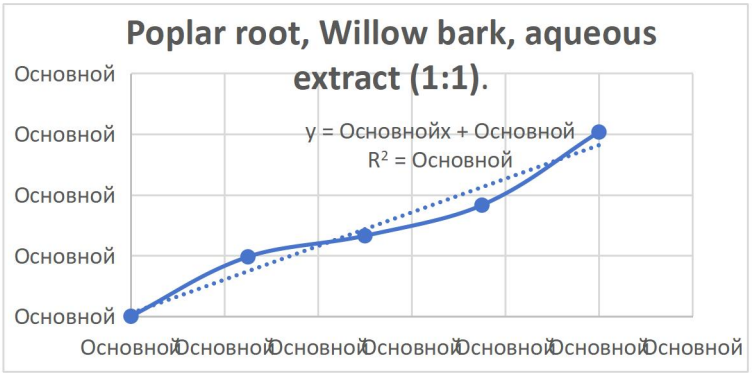


Figure 2. Relationship graph between the ARF% values determined at the 10th minute and the volumes of the aqueous extract.

From the trendline function applied to the graph (formula: $y = mx + b$), the volume corresponding to 50% ARF (IC_{50}) was calculated using the equation:

$x = (y - b) / m$.

$$IC_{50}=\frac{(50\text{-}0{,}9964)}{0{,}5531}=88{,}598\ mkl$$

Table 2. Measured absorbance and calculated antiradical activity values of the alcoholic extract samples of the 1:1 mixture of Poplar root and Willow bark compared to the blank in the DPPH solution.

Volume, µL	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,952	0,00	75	0	0,952	0,00
	5	0,87	8,61		5	0,785	17,54
	10	0,853	10,40		10	0,739	22,37
	15	0,84	11,76		15	0,707	25,74
	20	0,831	12,71		20	0,681	28,47
	25	0,822	13,66		25	0,66	30,67
	30	0,815	**14,39**		**30**	0,641	**32,67**
50	0	0,952	0,00	100	0	0,952	0,00
	5	0,831	12,71		5	0,751	21,11
	10	0,8	15,97		10	0,692	27,31
	15	0,778	18,28		15	0,652	31,51
	20	0,761	20,06		20	0,621	34,77
	25	0,747	21,53		25	0,595	37,50
	30	0,735	**22,79**		**30**	0,572	**39,92**

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 | Received 19.07.2026 | Accepted 06.08.2026 | Online 18.08.2026

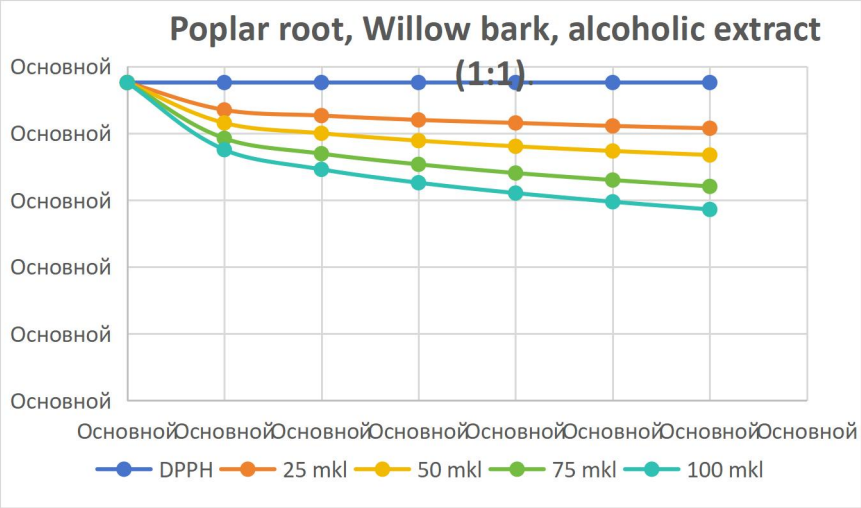


Figure 3. Graphical representation of the measured absorbance of the blank and tested alcoholic extract samples added to the DPPH solution.

To determine the IC_{50} – the concentration required to inhibit 50% of the DPPH solution, the antiradical activity values (ARF%) at 30 minutes for each experiment, and the volumes of added alcoholic samples were used to construct the graph. The IC_{50} value was calculated based on the trend line function fitted to the data.

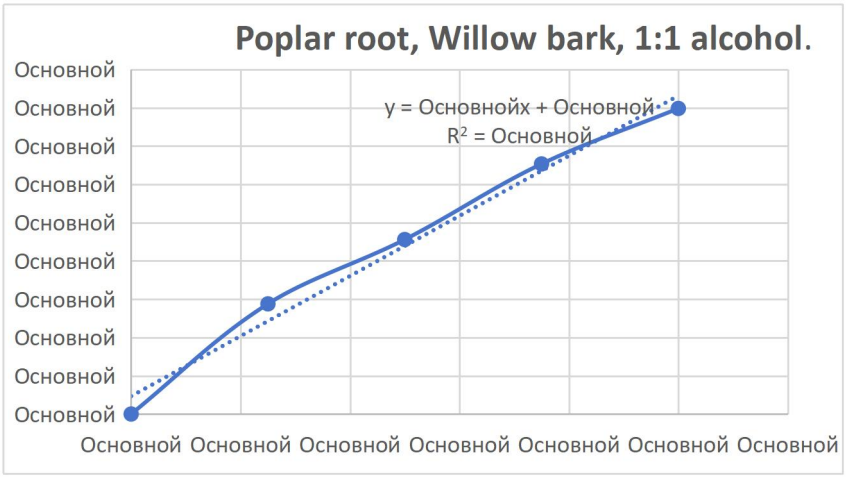


Figure 4. Correlation graph between ARF% values determined at 10 minutes and the corresponding volumes of the aqueous extract sample.

The IC_{50} value (the volume required to achieve 50% antiradical activity) was calculated using the trend line function of the graph. Based on the linear regression equation $y = mx + b$, the IC_{50} value was determined by the formula $x = (y - b)/m$

$$.IC_{50}=\frac{(50\text{-}2{,}3319)}{0{,}3924}=47{,}668\ mkl$$

Table 3. Measured absorbance values and calculated antiradical activity (ARF%) of ethanolic extracts of the *Populus* root and *Salix* bark mixture in a 1:3 ratio, compared with the blank sample, after addition to the DPPH solution.

Volume, µL	Time, min	Sample					
		Time,	ARF		Time,	Abs,	ARF%

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

		min	%		min	D	
25	0	1,009	0,00	75	0	1,009	0,00
	5	0,925	8,33		5	0,816	19,13
	10	0,906	10,21		10	0,78	22,70
	15	0,879	12,88		15	0,721	28,54
	20	0,864	14,37		20	0,686	32,01
	25	0,853	**15,46**		25	0,66	**34,59**
	30	0,842	16,55		**30**	0,629	37,66
50	0	1,009	0,00	100	0	1,009	0,00
	5	0,871	13,68		5	0,752	25,47
	10	0,846	16,15		10	0,713	29,34
	15	0,802	20,52		15	0,652	35,38
	20	0,776	23,09		20	0,615	39,05
	25	0,756	25,07		25	0,586	41,92
	30	0,734	**27,25**		**30**	0,553	**45,19**

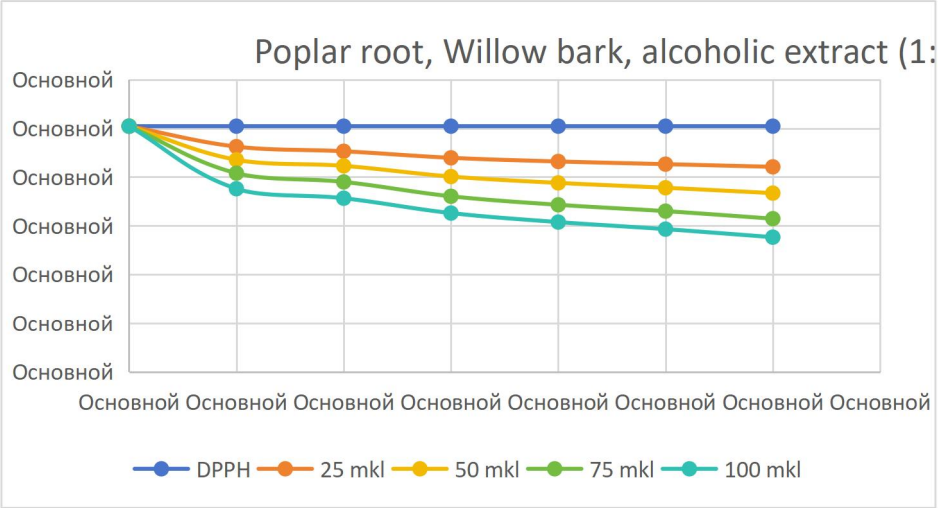


Figure 5. Graphical representation of the measured absorbance values of ethanolic extracts and blank samples after addition to the DPPH solution.

The IC_{50} value-representing the concentration required to inhibit 50% of the DPPH radicals, was calculated based on the antiradical activity values (ARF%) determined at 30 minutes for each experiment and the corresponding volumes of the ethanolic extracts. The trend line function applied to the graph was used to determine the IC_{50} value.

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

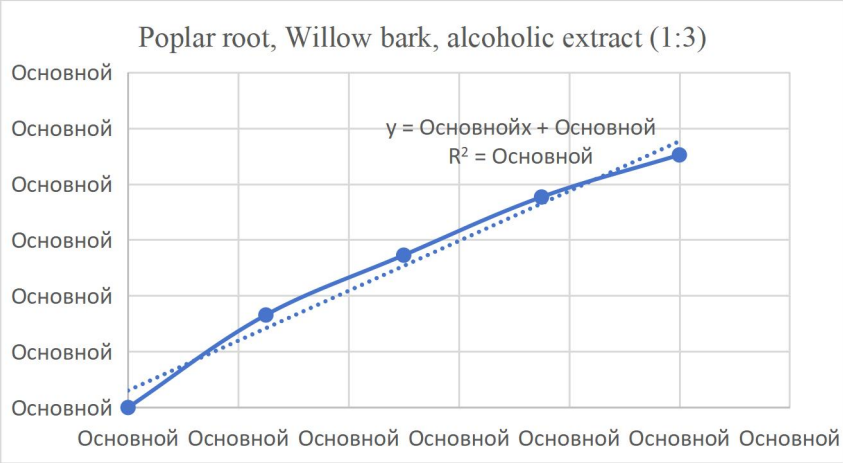


Figure 6. Graph of the relationship between ARF% and volumes determined at 10 minutes after the alcohol was extracted from the sample.

The trend line plotted on the graph was calculated from the function formula y=mx+b, and the volume representing 50% ARF% (IC50) was calculated based on the formula x=(y-b)/m:

$$IC_{50}=\frac{(50\text{-}3{,}0327)}{0{,}446}=105{,}31\ mkl$$

Table 4.

Measured light absorption and calculated antiradical activity of the blank and tested aqueous extracts of the 1:3 plant mixture of Poplar root and willow bark added to the DPPH solution.

Volume, µL	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,904	0,00	75	0	0,904	0,00
	5	0,836	7,52		5	0,758	16,15
	10	0,816	9,73		10	0,705	22,01
	15	0,801	11,39		15	0,667	26,22
	20	0,782	13,50		20	0,624	30,97
	25	0,761	15,82		25	0,573	36,62
	30	0,75	**17,04**		**30**	0,547	**39,49**
50	0	0,904	0,00	100	0	0,904	0,00
	5	0,816	9,73		5	0,728	19,47
	10	0,783	13,38		10	0,669	26,00
	15	0,758	16,15		15	0,623	31,08
	20	0,73	19,25		20	0,571	36,84
	25	0,696	23,01		25	0,511	43,47
	30	0,678	**25,00**		**30**	0,482	**46,68**

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 | Received 19.07.2026 | Accepted 06.08.2026 | Online 18.08.2026

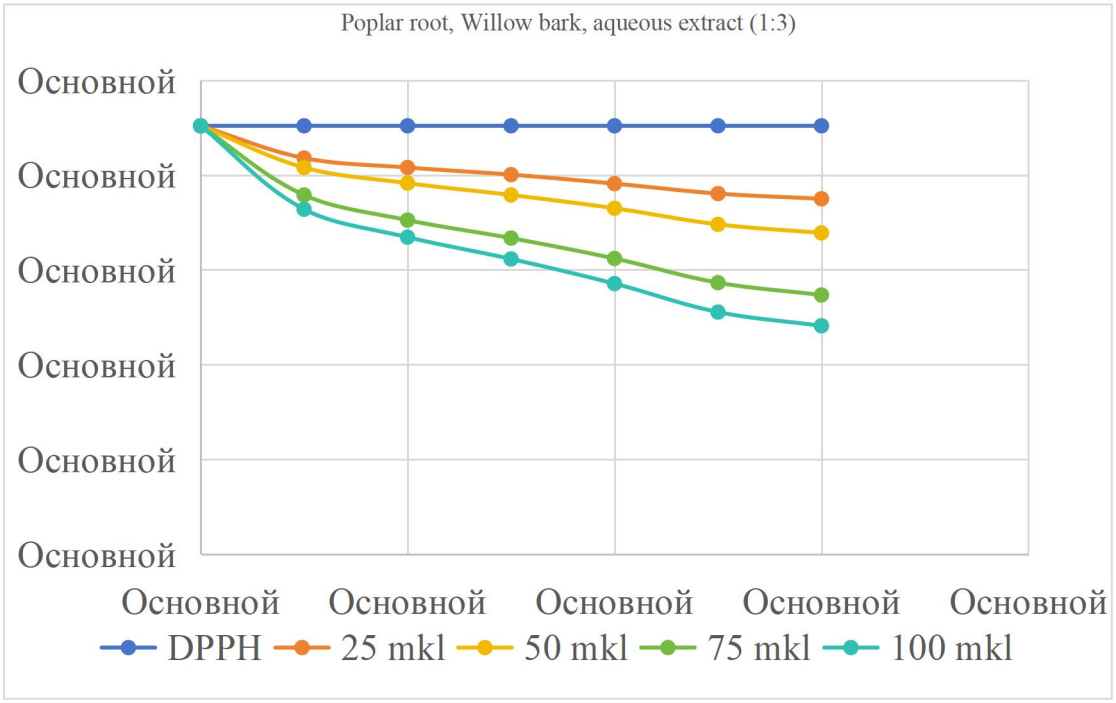


Figure 7. Graphical representation of the measured light absorption of blank and tested aqueous extracted sample solutions added to DPPH solution.

To calculate the IC50 of the samples - the 50% inhibition concentration of DPPH solution, the following graph was constructed based on the 30-minute antiradical activity (ARF%) values and the volume of alcohol samples added in each experiment and calculated based on the trend line function applied to it

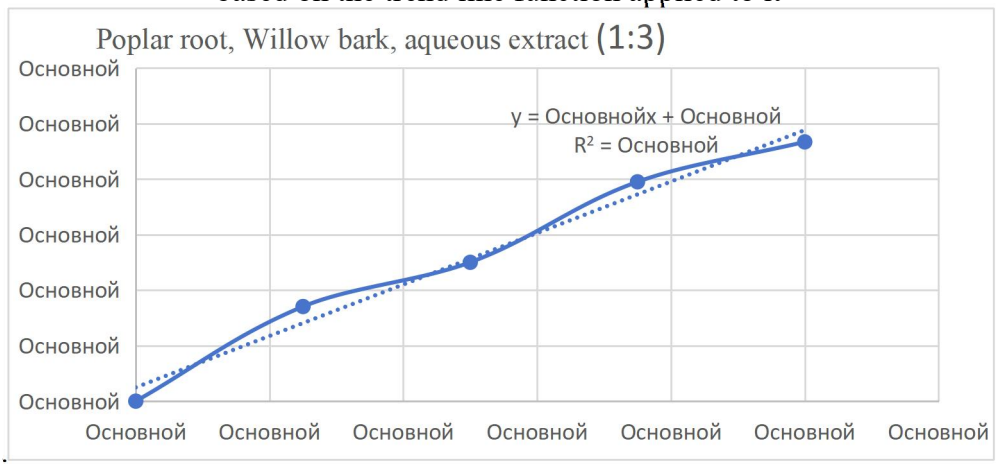


Figure 8. Graph of the relationship between ARF% and volumes determined at 10 minutes of the aqueous extraction of the sample.

The trend line plotted on the graph was calculated from the function formula y=mx+b, and the volume exhibiting 50% ARF% (IC50) was calculated based on the formula x=(y-b)/m:

$$IC_{50}=\frac{(50\text{-}3{,}54)}{0{,}3837}=121{,}08\ mkl$$

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

Table 5.
Measured light absorption and calculated antiradical activity values of alcohol extracted samples of blank and tested 3:1 plant mixture of Poplar root and willow bark added to DPPH solution.

Volume, µL	Time, min	Sample					
		Abs, D	ARF %		Time, min	Abs, D	ARF%
25	0	1,009	0,00	75	0	1,009	0,00
	5	0,932	7,63		5	0,856	15,16
	10	0,926	8,23		10	0,799	20,81
	15	0,899	10,90		15	0,744	26,26
	20	0,884	12,39		20	0,691	31,52
	25	0,863	14,47		25	0,676	33,00
	30	0,855	**15,26**		**30**	0,644	**36,17**
50	0	1,009	0,00	100	0	1,009	0,00
	5	0,89	11,79		5	0,764	24,28
	10	0,866	14,17		10	0,733	27,35
	15	0,822	18,53		15	0,674	33,20
	20	0,799	20,81		20	0,645	36,08
	25	0,776	23,09		25	0,599	40,63
	30	0,754	**25,27**		**30**	0,583	**42,22**

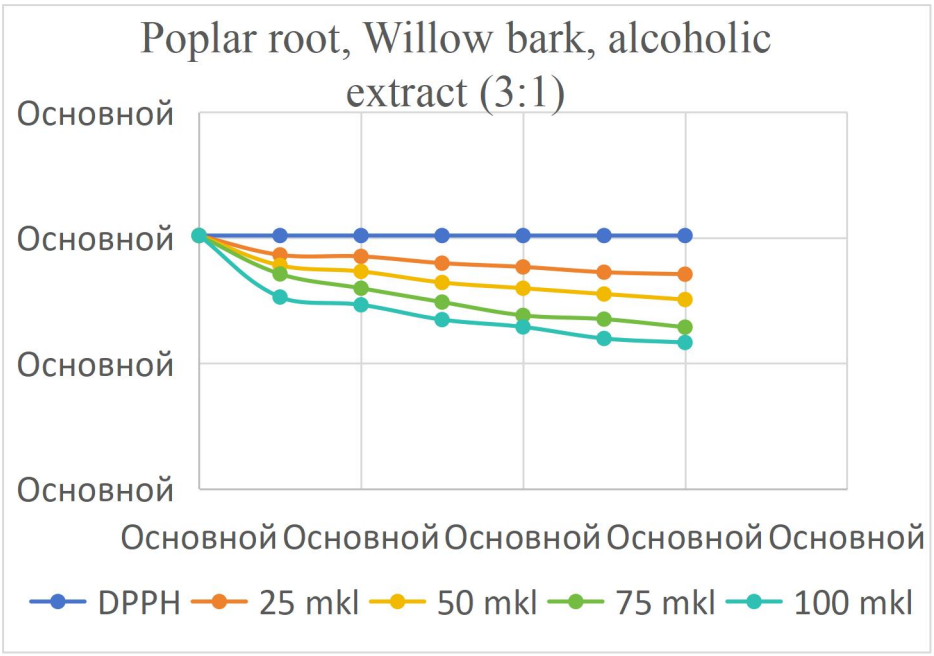


Figure 9. Graphical representation of the measured light absorption of blank and tested alcohol extracted sample solutions added to DPPH solution.

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

To calculate the IC50 of the samples - the 50% inhibition concentration of DPPH solution, the following graph was constructed based on the antiradical activity (ARF%) values at 30 minutes in each experiment, and the volume of alcohol samples added, and the trend line function was applied to it

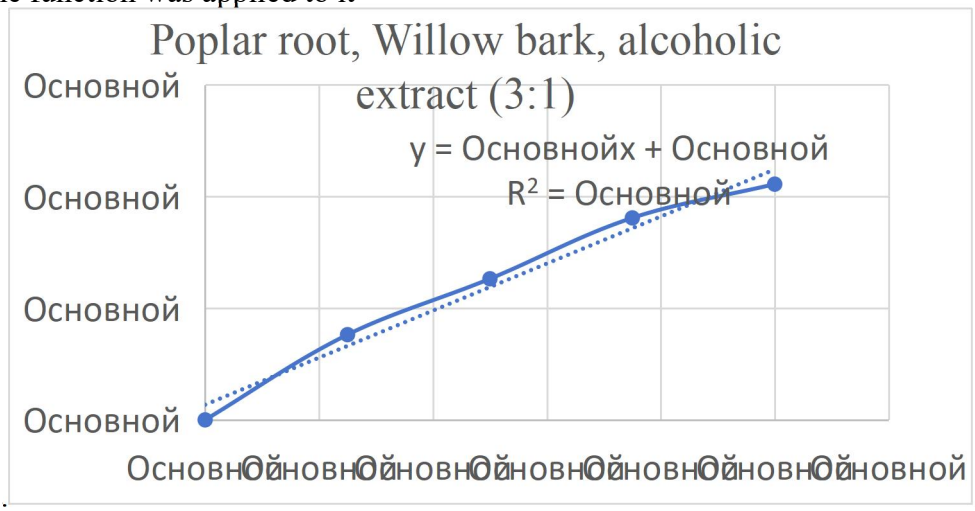


Figure 10. Graph of the relationship between ARF% and volumes determined at 10 minutes after the alcohol was extracted from the sample.

The trend line plotted on the graph was calculated from the function formula y=mx+b, and the volume exhibiting 50% ARF% (IC50) was calculated based on the formula x=(y-b)/m:

$$IC_{50}=\frac{(50\text{-}2{,}7156)}{0{,}4214}=112{,}21\ mkl$$

Table 6.

Measured light absorption and calculated antiradical activity values of aqueous extracts of blank and tested 3:1 plant mixture of Poplar root and willow bark added to DPPH solution.

Volume, µL	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,934	0,00	75	0	0,934	0,00
	5	0,871	6,75		5	0,804	13,92
	10	0,851	8,89		10	0,75	19,70
	15	0,837	10,39		15	0,717	23,23
	20	0,827	11,46		20	0,692	25,91
	25	0,814	12,85		25	0,668	28,48
	30	0,807	**13,60**		**30**	0,649	**30,51**
50	0	0,934	0,00	100	0	0,934	0,00
	5	0,834	10,71		5	0,735	21,31
	10	0,797	14,67		10	0,674	27,84
	15	0,774	17,13		15	0,631	32,44
	20	0,756	19,06		20	0,6	35,76

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

	25	0,736	21,20		25	0,567	39,29
	30	0,722	**22,70**		**30**	0,543	**41,86**

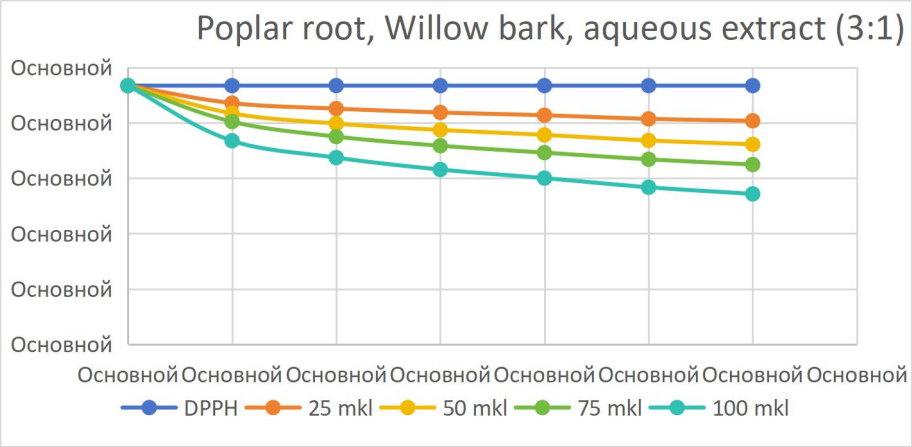


Figure 11. Graphical representation of the measured light absorption of blank and tested aqueous extracted sample solutions added to DPPH solution.

To calculate the IC50 of the samples - the 50% inhibition concentration of DPPH solution, the following graph was constructed based on the 30-minute antiradical activity (ARF%) values and the volume of alcohol samples added in each experiment, and calculated based on the trend line function applied to it

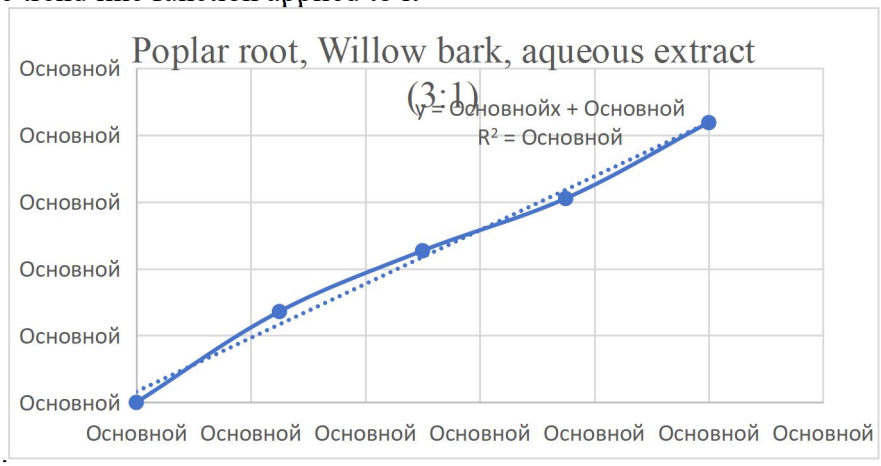


Figure 12. Graph of the relationship between ARF% and volumes determined at 10 minutes of the aqueous extraction of the sample.

The trend line plotted on the graph was calculated from the function formula y=mx+b, and the volume exhibiting 50% ARF% (IC50) was calculated based on the formula x=(y-b)/m:

$$IC_{50}=\frac{(50\text{-}1{,}606)}{0{,}4026}=120{,}2\ mkl$$

Table 7.

Antiradical activity values (ARF%) of sample extracts at 30 minutes in 100 µl

Journal of Advances in Drug Research
ISSN: 2230-7761
www.jadr.co.in
Volume 17, Issue 04 Received 19.07.2026 Accepted 06.08.2026 Online 18.08.2026

Time, min	ARF%					
	1:1 aqueous solution	**alcoholic extract (1:1).**	***1:3*** saqueous solution	**alcoholic extract (1:1).**	***3:1*** **alcoholic extract**	***3:1*** **alcoholic extract**
30-min	60,63	39,92	46,68	45,19	41,86	42,22

Table 8.
IC_{50} of the samples – concentration required to inhibit 50% of the DPPH solution (µL).

Time, min	IC_{50}					
	1:1 aqueous solution	***1:1*** alcoholic extract	***1:3*** aqueous solution	***1:3*** aqueous solution	***3:1*** aqueous solution	***3:1*** alcoholic extract
30-min	88,6	47,66	102,5	105,3	120,2	112,2

Experimental analysis and discussion

Aqueous and alcoholic 1:1 extracts of poplar root (Populus alba) and willow bark (Salix) were observed to neutralize DPPH radicals using the DPPH method. In the aqueous 1:1 extract, the antiradical scavenging activity (ARF %) in 30 min was 60.63% and IC_{50} 88.6µl, while in the alcoholic extract the result was also significant with ARF and IC_{50} slightly lower (less) than in the aqueous extract. These results practically imply that the bioactive elements of the extract (polyphenols, flavonoids, salicin and tannins) show high antiradical scavenging activity. Salix alba (willow bark). Based on ultrasonic extraction results, the willow bark extract gave an IC_{50} value of 3.32 µg/mL, exhibiting high antiradical potency. It was also observed that willow bark extract was more effective than leaves and sap on the total phenolic content as well as on the DPPH ARF. Populus alba (poplar) Leaf water extract displayed an $IC_{50} \approx 43.99$ µg/mL in GC/MS and DPPH tests. The IC_{50} value of 0.18 mg/mL of ether-acetate fractions was found as lowest (strongest action). But P. alba exhibited less antiradical potency than other poplar species. Salix bark extract is not as effective, but does demonstrate large biological activity. The differences among IC_{50} values are influenced by the procedure of extract preparation, solvent species, plant organelles, and pure biologically active substances involved. Aqueous extracts tend to be more potent than alcoholic extracts because molecules whose character-molecules cohere with the idea of neutralising free radicals (e.g. polyphenols) can be more easily isolated when they are in water. Willow bark extracts, mainly the bark extract, have the least IC_{50} and can then be combined to maximize bioactivity across compounds.

Conclusion and recommendations.

In conclusion, the alcoholic and aqueous extracts prepared based off of the tested samples showed antiradical activities. In particular, out of the alcoholic extracts, the highest observed value was the one aqueous extract of Poplar root and willow bark 1:1 which reduced the free radicals by 60.63% in 30 minutes of analysis. The IC_{50} value of this extract is 88.6 µl. Among the alcoholic extracts, the 1:3 sample of Poplar root and willow,

Journal of Advances in Drug Research

ISSN: 2230-7761
www.jadr.co.in

Volume 17, Issue 04 | Received 19.07.2026 | Accepted 06.08.2026 | Online 18.08.2026

which presented 45.19% antiradical activity in 30 min was the best indicator. The IC_{50} of this extract was 105.3 µl, confirming their high antiradical activities. It shows the potential of Poplar root and willow bark, especially the aqueous extract, as natural antioxidant. The Antiradical Properties of Aqua and Alcohol Extracts of 1:1 Combination of poplar (Populus alba) root and willow (Salix) bark were investigated with DPPH (2,2-diphenyl-1-picrylhydrazyl). Free radical neutralization of plants was also examined during the investigation, in the form of mass ratio 3:1, 1:1 and 1:3 prepared samples. The data demonstrated that in aqueous extracts peak of 60.63% ARF (antiradical activity) of the 1:1 sample of 30 min was obtained. In alcoholic extracts, high antiradical activity was found in the sample 1:1, with a maximum of 39.92% ARF. Aqueous extracts have a higher antiradical activity through their lower IC_{50} values (i.e., concentration at volume of the extract that inhibits DPPH radicals by 50%). Aqueous extracts have a higher antioxidant activity, supporting their great bio-active component (flavonoids, phenols, salicin) enrichment. The obtained data indicate that poplar root and willow bark is a relatively effective antiradical compound with a high strength, particularly the aqueous extract adjusted in one:one ratio, meaning it is a natural source of antioxidants. The salicin, flavonoids, phenolic compounds, and tannins formed in them have this bioactivity. This could be further studied in the future with other biological activities (anti-inflammatory, antimicrobial, cytotoxic) of this mixture that could be explored and developed in the pharmaceutical or nutraceutical industry.

References

1. Ainsworth, C. (2000). Boys and girls come out to play: The molecular biology of dioecious plants. *Annals of Botany, 86*(2), 211–221. https://doi.org/10.1006/anbo.2000.1201
2. Alström-Rapaport, C., Lascoux, M., Wang, Y. C., Roberts, G., & Tuskan, G. A. (1998). Identification of a RAPD marker linked to sex determination in the basket willow (*Salix viminalis* L.). *Journal of Heredity, 89*(1), 44–49. https://doi.org/10.1093/jhered/89.1.44
3. Bergero, R., & Charlesworth, D. (2009). The evolution of restricted recombination in sex chromosomes. *Trends in Ecology & Evolution, 24*(2), 94–102. https://doi.org/10.1016/j.tree.2008.09.010
4. Bergero, R., Forrest, A., Kamau, E., & Charlesworth, D. (2007). Evolutionary strata on the X chromosomes of the dioecious plant *Silene latifolia*: Evidence from new sex-linked genes. *Genetics, 175*(4), 1945–1954. https://doi.org/10.1534/genetics.106.069039
5. Beritognolo, I., Piazzai, M., Benucci, S., Kuzminsky, E., Sabatti, M., Scarascia Mugnozza, G., & Muleo, R. (2007). Functional characterisation of three Italian *Populus alba* L. genotypes under salinity stress. *Trees, 21*(4), 465–477. https://doi.org/10.1007/s00468-007-0138-z
6. Bradshaw, H. D., & Stettler, R. F. (1994). Molecular genetics of growth and development in *Populus*. II. Segregation distortion due to genetic load. *Theoretical and Applied Genetics, 89*(4), 551–558. https://doi.org/10.1007/BF00225386
7. Bradshaw, H. D., Ceulemans, R., Davis, J., & Stettler, R. (2000). Emerging model systems in plant biology: Poplar (*Populus*) as a model forest tree. *Journal of Plant Growth Regulation, 19*(3), 306–313. https://doi.org/10.1007/s003440000030

Journal of Advances in Drug Research

ISSN: 2230-7761
www.jadr.co.in

Volume 17, Issue 04 | Received 19.07.2026 | Accepted 06.08.2026 | Online 18.08.2026

8. Brundu, G., Lupi, R., Zapelli, I., Fossati, T., Patrignani, G., Camarda, I., Sala, F., & Castiglione, S. (2008). The origin of clonal diversity and structure of *Populus alba* in Sardinia: Evidence from nuclear and plastid microsatellite markers. *Annals of Botany, 102*(6), 997–1006. https://doi.org/10.1093/aob/mcn189
9. Brunner, A. M., Rottmann, W. H., Sheppard, L. A., Krutovskii, K., DiFazio, S., Leonardi, S., & Strauss, S. H. (2000). Structure and expression of duplicate AGAMOUS orthologues in poplar. *Plant Molecular Biology, 44*(5), 619–634. https://doi.org/10.1023/A:1026590413562
10. Cervera, M. T., Storme, V., Ivens, B., Gusmao, J., Liu, B. H., Hostyn, V., Van Slycken, J., Van Montagu, M., & Boerjan, W. (2001). Dense genetic linkage maps of three *Populus* species (*Populus deltoides*, *P. nigra,* and *P. trichocarpa*) based on AFLP and microsatellite markers. *Genetics, 158*(2), 787–809. https://doi.org/10.1093/genetics/158.2.787
11. Charlesworth, D. (2002). Plant sex determination and sex chromosomes. *Heredity, 88*(2), 94–101. https://doi.org/10.1038/sj.hdy.6800012
12. Charlesworth, D. (2004). Plant evolution: Modern sex chromosomes. *Current Biology, 14*(8), R271–R273. https://doi.org/10.1016/j.cub.2004.03.054
13. Charlesworth, D., & Guttman, D. S. (1999). The evolution of dioecy and plant sex chromosome systems. In C. C. Ainsworth (Ed.), *Sex Determination in Plants* (pp. 25–49). BIOS Scientific Publishers.
14. Charlesworth, D., Charlesworth, B., & Marais, G. (2005). Steps in the evolution of heteromorphic sex chromosomes. *Heredity, 95*(2), 118–128. https://doi.org/10.1038/sj.hdy.6800697
15. Dayanandan, S., Rajora, O. P., & Bawa, K. S. (1998). Isolation and characterization of microsatellites in trembling aspen (*Populus tremuloides*). *Theoretical and Applied Genetics, 96*(6–7), 950–956. https://doi.org/10.1007/s001220050821
16. Dorken, M. E., & Barrett, S. C. H. (2004). Sex determination and the evolution of dioecy from monoecy in *Sagittaria latifolia* (Alismataceae). *Proceedings of the Royal Society of London. Series B: Biological Sciences, 271*(1536), 213–219. https://doi.org/10.1098/rspb.2003.2577
17. Eckenwalder, J. E. (1996). Systematics and evolution of *Populus*. In R. F. Stettler, H. D. Bradshaw, P. E. Heilman, & T. M. Hinckley (Eds.), *Biology of Populus and its implications for management and conservation* (pp. 7–32). NRC Research Press, National Research Council of Canada.
18. Fossati, T., Patrignani, G., Zapelli, I., Sabatti, M., Sala, F., & Castiglione, S. (2004). Development of molecular markers to assess the level of introgression of *Populus tremula* into *P. Alba* natural populations. *Plant Breeding, 123*(4), 382–385. https://doi.org/10.1111/j.
19. Gaudet, M., Jorge, V., Paolucci, I., Beritognolo, I., Scarascia Mugnozza, G., & Sabatti, M. (2008). Genetic linkage maps of *Populus nigra* L., including AFLPs, SSRs, SNPs, and sex trait. *Tree Genetics & Genomes, 4*(1), 25–36. https://doi.org/10.1007/s11295-007-0084-7
20. Grattapaglia, D., & Sederoff, R. (1994). Genetic linkage maps of *Eucalyptus grandis* and *Eucalyptus urophylla* using a pseudo-testcross: Mapping strategy and RAPD markers. *Genetics, 137*(4), 1121–1137. https://doi.org/10.1093/genetics/137.4.1121

Journal of Advances in Drug Research

ISSN: 2230-7761
www.jadr.co.in

Volume 17, Issue 04 | Received 19.07.2026 | Accepted 06.08.2026 | Online 18.08.2026

21. Hamzeh, M., & Dayanandan, S. (2004). Phylogeny of *Populus* (Salicaceae) based on nucleotide sequences of chloroplast *trnT-trnF* region and nuclear rDNA. *American Journal of Botany, 91*(9), 1398–1408. https://doi.org/10.3732/ajb.91.9.1398
22. Hou, W., Fan, J., Zhou, F., & Zhao, S. (2009). RAPD markers related to the sex locus in *Populus tomentosa*. *Frontiers of Forestry in China, 4*(2), 223–226. https://doi.org/10.1007/s11461-009-0025-2
23. Imada, S., Yamanaka, N., & Tamai, S. (2009). Effects of salinity on the growth, Na partitioning, and Na dynamics of a salt-tolerant tree, *Populus alba* L. *Journal of Arid Environments, 73*(3), 245–251. https://doi.org/10.1016/j.jaridenv.2008.10.009
24. Jorge, V., Dowkiw, A., Faivre-Rampant, P., & Bastien, C. (2005). Genetic architecture of qualitative and quantitative *Melampsora larici-populina* leaf rust resistance in hybrid poplar: Genetic mapping and QTL detection. *New Phytologist, 167*(1), 113–127. https://doi.org/10.1111/j.1469-8137.2005.01434.x
25. Kuang, H., Bongarten, B., Richardson, T., Carson, S., & Wilcox, P. (1999). Genetic analysis of inbreeding depression in plus tree 850.55 of *Pinus radiata* D. Don. I. Genetic map with distorted markers. *Theoretical and Applied Genetics, 98*(5), 697–703. https://doi.org/10.1007/s001220051127
26. Lander, E. S., Green, P., Abrahamson, J., Barlow, A., Daly, M. J., Lincoln, S. E., & Newburg, L. (1987). MAPMAKER: An interactive computer package for constructing primary genetic linkage maps of experimental and natural populations. *Genomics, 1*(2), 174–181. https://doi.org/10.1016/0888-7543(87)90010-3
27. Lexer, C., Fay, M. F., Joseph, J. A., Nica, M. S., & Heinze, B. (2005). Barrier to gene flow between two ecologically divergent *Populus* species, *P. alba* (white poplar) and *P. tremula* (European aspen): The role of ecology and life history in gene introgression. *Molecular Ecology, 14*(4), 1045–1057. https://doi.org/10.1111/j.1365-294X.2005.02469.x
28. Li, X. M., & Kakubari, Y. (2001). Photosynthesis and chlorophyll a fluorescence of two poplars under water stress. *Journal of Forest Research, 6*(4), 211–215. https://doi.org/10.1007/BF02762583.·