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Black Poplar (*Populus nigra* L.) Wood Density Variation With Tree Planting Spacing

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Key words:
black poplar − *Populus nigra* − Density – Planting spacing.

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ABSTRACT

Twelve (eight-year-old) trees of black poplar (*Populus nigra* L.) were planted at three different spacing, (2.00 X 3.00 meters, 2.50 X 3.50 meters, and 3.00 X 4.00 meters). Samples at three different heights; 1.3 meters (DBH), 2.8 meters, and 4.3 meters, were taken from each tree to determine the variation of the wood density with planting spacing change between trees. The results showed a (4%) difference in wood density with each (0.50 X 0.50 meter) decrease in planting spacing.

The mean wood density of poplar trees was (0.45 g cm^{-3}) at (3.00 X 4.00 meter) spacing. The density increased to (0.47 g cm^{-3}) at (2.50 X 3.50 meter) spacing and to (0.489 g cm^{-3}) at (2.00 X 3.00 meter) spacing.The density was varied from the pith of the trees outside to the bark and did not show strong relationship to the position on the stem; near pith, intermediate between pith and bark, and near the bark or to the height of the tree.

تباين كثافة خشب القوغ الأسود المزروع على مسافات مختلفة

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الملخــص

اخذت عينات خشبيه من اشجار عمرها 8 سنوات من القوغ الأسود (*Populus nigra* L.) المزروعة على ثلاث مسافات بينيه: (2,0 X 3,0 و 2,5 X 3,5 و 3,0X 4,0) متر . اخذت العينات على ارتفاعات ثلاثة لكل شجره (1,3 و 2,8 و 4,3) متر . اخذت نماذج خشبيه لتحديد الكثافة من منطقة قريبه من النخاع وفي منتصف المسافة الى اللحاء وقريب من اللحاء لبحث التباين مع الموقع العرضي للساق. هذه النماذج لتحديد التباين في كثافة الخشب حسب مسافات الزراعة.

بينت نتائج الدراسة ان هناك تباين في كثافة الخشب حسب مسافات الزراعة حيث زادت الكثافة بنسبة 4% مع تناقص المسافات بواقع 0,5 X 0,5 متر . معدل كثافة خشب القوغ الاسود كان 0,45 غم\سم3 عند المسافة 3,0 X 4,0 متر وقد زادت الى 0,47 غم\سم3 عند تناقص مسافة الزراعة الى 2,5 X 3,5 متر ثم الى 0,48غم\سم3 عند مسافة الزراعة 2,0 X 3,0 متر . لم يلاحظ أير واضح في موقع النموذج على المقطع العرضي للساق في مقدار الكثافة وكذلك لم يظهر تأثير الارتفاع على الكثافة.

الكلمات المفتاحية :
القوغ الأسود – *Populus nigra* – الكثافة – مسافات الزراعة .
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INTRODUCTION :

Wood density or specific gravity (wood density divided by water density) is its most important physical property. Most wood mechanical and physical properties are closely correlated with wood density as wood strength and stiffness increase with wood density, (Rao, et al. 2003). The yield of solid wood for final products such as pulpwood is directly related to density. Wood density is the measure of cellular structure of wood, which controls wood physico-mechanical properties and end use products, (Pande and Singh 2005). The species that produces relatively low- or medium-density are preferred as raw material for pulp production and wood composite boards. Black poplar (*Populus nigra* L.), is one of the most important hardwoods for the forest products industry in Iraq as

it is widely planted in the country. Attention has turned towards poplar wood as an alternative source of timber. It is important to maximize black poplar wood volume and density. Black poplar is commonly used for producing various products such as windows, doors, agricultural implement handles, posts and beams for farm housing, and some furniture, (Suleman and Rashid, 1999). In addition to that, there are some search efforts to find out its suitability for pulping and reconstituted wood-based panel products such as the particleboard, fibreboard, and may be OSB (oriented strand board), industries in Iraq. In order to produce high quality wood from poplar, the intensively management plantations must be considered to improve wood quality to meet multipurpose wood products standards.

Density is one of the quality indicators in which the density affects the technical performance of wood as wood strength is directly related to wood density. The pulp yield is a function of both wood volume and density. When wood is used for lumber the density affects strength properties, drying behaviour, machining characteristics, and nail holding. Wood density is therefore, the most frequently applied parameter for measuring wood quality (Landrach 1986).

Spacing is one of the most important silvicultural factors used to control the growth and wood quality by altering growing conditions in utilization of nutrients, water, and sunlight (Jiang, et al. 2007). The density of diffuse-porous hardwoods (poplar is in this group), is influenced by planting distance, (Reghu et al. 2006).

Hussain and Sheikh (1987), found that the biomass production at the closest spacing (0.50 X 0.50) m, was less than that at (1.00 X 1.00, 1.50 X 1.50) m, and (2.00 X 2.00) m spacing of two poplar clones of P*opulus deltoids* P. I-63/51, P. AY-48, on a Pakistani plantation. Buffi (1988) reported that the best spacing for *Populus tremula* is (2.00 X 2.00) m or (3.00 X 3.00) m for 12 year old trees planted at (550-560) m. alt. in South Switzerland. Chow and Rolfe (1989) found that the hydrogen content was higher at (23.00 X 23.00) cm spacing than at (31.00 X 31.00) cm spacing, While carbon content was higher at (31.00 X 46.00) cm than at (23.00 X 23.00) cm of five-short-rotation hardwood species including *Populus deltoids* at northern Illinois, U.S.A. Khan and Chaudhry (2007), reported that wood production was higher under closer spacing of *Populus deltoids*. Willcocks and Bell (1995) concluded that stand density management is a factor that affects specific gravity and related to other wood quality parameters as fibril angle and juvenile wood in the log. They related that change to the growth conditions of trees including water, nutrients, and light. Similar to these findings reported before as Zobel and Talbert (1984) found that 70% of the overall specific gravity variation was due to the factors related to the growth conditions of a tree. Also, Zhang, (1995) reported that wood density increased with slow growth rate.

To find out the suitability of the black poplar wood for the applications demanded by the markets in the area, and based on the wood density as the major indicator of wood quality. The objectives of the present study were to find wood density variation with planting spacing to maximize the density for the highest quality of black poplar wood.

MATERIALS and METHODS :

Samples for this study were obtained from trees of black poplar (*Populus nigra* L.), that were planted from cuttings (the heights and diameters of the trees are included in Table 1), approximately eight-year-old when felled. Four trees were selected for each planting spacing (2 X 3, 2.5 X 3.5, and 3 X 4) meter. Sampling at three different heights per tree was carried out. The three heights were 1.30 m, 2.8 m and 4.30 m. A 5-cm. thick disc was cut from each of these heights. Six samples of (2 X 2 X 2) cm were cut from each disc at the northern side. The samples were taken at 2 radial directions opposite to each other as follows:

Samples 3 and 4 located adjacent to the pith.

Samples 2 and 5 were located half way between the pith and the bark،

and samples 1 and 6 were adjacent to the bark .

The density was determined by dividing the oven-dried weight of the sample by the volume of the wood. The oven-dried weight was determined by keeping the samples in an oven at 98+2^{o}C for 48 hours (drying to constant weight based on ASTM standard). The volume was obtained by the dimensions calculation and was confirmed by water displacement.

Table 1. The height and average diameter of the trees.

Spacing (m)	Trees	Height (m)	Diameter (cm)
2 X 3	1	5.25	13.00
	2	5.10	12.00
	3	5.20	14.00
	4	4.95	14.00
2.5 X 3.5	1	4.85	14.00
	2	4.95	13.00
	3	5.10	13.00
	4	4.90	13.00
3 X 4	1	4.85	15.00
	2	4.70	15.00
	3	4.80	14.00
	4	4.65	14.00

RESULTS and DISCUSSIONS :

The trees planted at a spacing (3 X 4) m, had a density range of (0.477 to 0.453) g cm^{-3} with an average of 0.45 g cm^{-3} as shown in Table 2. From Table 2, there is generally an increase in the average wood density, as the planting distance becomes narrower. The wood density went from 0.450 g cm^{-3} at 3 X 4 m spacing to 0.470 g cm^{-3} when spacing reduced to 2.5 X 3.5 m then to 0.489 g cm^{-3} at spacing of 2 X 3 m. Generally there is an increase of wood density with reducing planting spacing.
The pattern of longitudinal direction variation was not the same for all spacing. From Table 2, there is no certain pattern of variation when the height of the samples was changed from 1.3 m to 2.8 m or even to 4.3 m. When we compared the results of sample heights with position A which is near the pith; at 3 X 4 m spacing we could not find a pattern as the density was 0.448 g cm^{-3} at height of 1.3 m, and did not change when the height increased to 2.8 m while slight difference (0.003) was noticed at 4.3 m with the same position for tree number 1 in the study. There is a slight increase in the density with sample heights increase for position C which is near the bark with three spacing of 3 X 4 m, 2.5 X 3.5 m, and 2 X 3 m. The density went from 0.000 at 1.3 m height to 0.003 increase at 2.8 m height then another 0.005 at 4.3 m height. The samples at position C with other spacing showed slight (0.001 – 0.002) increase in wood density with sample heights increase with tree number 1 but no such trend of increase or decrease was noticed for other three trees. As a conclusion for this variation with heights and position the slight change in wood density could not considered as significant change. These finding agreed with what was reported before, about hardwood density variation with height. It was reported that there was very little consistency of variation with tree height change. Same observation recorded for the radial variation and this finding in agreement with what Panshin and De Zeeuw (1980) reported for hardwood. The average density of black poplar trees decreased as planting spacing became wider. Similar trend of density variation had been reported by Rao et al. (2003).

The phenomenon of density drop with increased spacing may be attributed to the more conductive conditions of growth such as more crown exposure to sunlight and less competition for materials as fewer trees are planted per unit area. As a result, the trees planted at wider spacing grow faster and have larger girth. Beaudoin et al. (1992) reported that vigorously- grown trees were often

characterized by lower density compared to slower-grown timber species. Larson (1969) noted that trees with large spaces for crown development would normally possess a more tapered stem consisting of a large volume of low-density wood.

Table 2. The density of black poplar wood at three different spacing.

Trees	Height m	Spacing: 3 × 4 m			Spacing: 2.5 × 3.5 m			Spacing: 2 × 3 m		
		A	B	C	A	B	C	A	B	C
1	I	0.448	0.449	0.447	0.466	0.473	0.470	0.493	0.492	0.491
	II	0.448	0.452	0.450	0.472	0.471	0.470	0.481	0.494	0.492
	III	0.451	0.449	0.452	0.473	0.475	0.472	0.493	0.490	0.492
2	I	0.447	0.452	0.451	0.468	0.470	0.471	0.490	0.492	0.493
	II	0.452	0.448	0.452	0.472	0.473	0.470	0.492	0.494	0.490
	III	0.447	0.450	0.449	0.468	0.466	0.469	0.492	0.490	0.485
3	I	0.452	0.448	0.453	0.466	0.473	0.466	0.488	0.490	0.484
	II	0.450	0.448	0.451	0.472	0.472	0.470	0.492	0.484	0.488
	III	0.449	0.451	0.450	0.473	0.469	0.472	0.488	0.486	0.485
4	I	0.452	0.450	0.453	0.473	0.474	0.472	0.491	0.489	0.490
	II	0.449	0.449	0.453	0.469	0.473	0.468	0.488	0.486	0.486
	III	0.453	0.453	0.450	0.463	0.472	0.471	0.488	0.490	0.486
Mean (g cm^{-3})		0.450			0.470			0.489		

Positions: A- Near the pith B- Intermediate between pith and bark C- Near the bark
Height: I- 1.3 m II- 2.8 m III- 4.3 m

The results showed that the wood density was affected by planting spacing. Generally, the wood obtained from trees planted at narrower spacing was characterized by a higher density than wood from wider spacing. Wood density was 0.450 g cm^{-3} at spacing of 3 X 4 m, increased to 0.470 g cm^{-3} at spacing of 2.5 X 3.5 m, and increased again to 0.489 g cm^{-3} at spacing of 2 X 3 m. There was a corresponding decrease of density by 4% for an increase of (0.5 X 0.5) m, in planting spacing. The results of this study are in agreement with some findings before (Buffi 1988). The change of wood density of poplar trees could related to the growth rate as the poplar trees normally planted in a condensed stand and the trees compete for the light and they have to grow faster and taller. These findings also agreed with the results of Khan and Chaudhry (2007) on *Populus deltoids*. Since the poplar species are in the group of diffused-porous or semi-ring-porous hardwoods in which there is a relation between wood density change and growth rate as reported before by Bowyer et al. (2007) on close relationship of wood density and growth rate. The findings of this study showed that the trend of variation was affected by the planting distance between trees which is related to the growth rate and other environmental factors affecting growth such as soil, water, and temperature. The planting at wider spacing stimulates rapid stem diameter at the beginning of the growth at early stages of tree rotation. The trend of variation was the wood density increased with the spacing decrease by (0.5 X 0.5) m. Wood density of 0.450 g cm^{-3} with spacing of 3 X 4 m, increased to 0.470 g cm^{-3} at spacing of 2.5 X 3.5 m, then increased to 0.489 g cm^{-3} at spacing of 2 X 3 m.

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