

Suitability of different volume formula and log length on volume estimation of black poplar (*Populus nigra* L.)

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Abstract

The volume of each logs 2m and 4m length was calculated by using four different formulas (Hossfeld's, Huber's, Smalian's and Bruce). All calculated volume were compared to control volume which was Newton's volume. Data came from selecting logs intentionally with in the yard after falling and cutting trees into (4 meter) and (2 meter) log length. The information was gathered from October 2024. A total (30) logs were selected from black poplar plantation in sub district of khalifan in Erbil Province. As a result, Huber's formula is the most accurate formula as it records the least bias and lowest value of (MAE) and highest R^2 for estimating log volume of 2 and 4-meter log length of black poplar tree species in khalifan sub-district.

Keywords: Log volume, Black Poplar, Huber's formula, Hossfeld's formula, Khalifan.

Introduction

In addition to its wide range across Europe, black poplar can also be found in northern Africa and west Asia. Black poplar is deciduous and fast growing tree, especially in their early year they can reach height 20 meters or more. Some species that have reached a mature enough age can reach a diameter of 1.5 meters. Black poplar prefers a temperate climate, with cool, wet winter and warm, humid summers, they can tolerate a wide range of soil conditions, but prefer moist and well-drained soil. Black poplar is used for timber, which is strong and durable and it's also a popular choice for landscape and wildlife. Since timber is the primary source of revenue for forestry, its amount needs to be carefully considered. Planning for sustainable forest management and decisions about the use of wood may be impacted by the precision of wood volume estimation [10]. Because precise estimates

of wood volume are necessary for both trade-in forest resources and sustainable forest management, wood volume estimation has been a major area of study in forest science.. [4]. The most common utilized formulas are Newton's, Huber's and Smalian's [6]. [8] reported that Newton's formula is considered more exact than other standard formula such as (Smalian's and Huber's formula), Newton's formula requires three diameter measurement small end, mid- point, and large end of a log. The entire inaccuracy in volume estimation comes from two main sources of error in log volume calculation [1]. The volume calculation equation should be looked at first. Newton's formula requires measuring the diameter of a log, but it is more precise than Huber's and Smalian's formulas [8]. [5] indicated that (Johann Hossfeld's) was a German forester in the early 19th century, [7] presented "Hossfeld's method" for obtaining the cubic volume of

a log. Therefore, the aim of this study is describe the different volume equation for estimating log volume for black poplar (*Populus nigra* L.) at (2m and 4m,) logs

Material and Methods

Study area

The study location is located in the northern part of the country, approximately 55 kilometers from the capital city of Erbil, in the Kurdistan region of Iraq, precisely in the Erbil governorate, sub-district of Khalifan. The foothills and the mountains are the two physiographic units that make up the terrain of the Erbil governorate. [9] stated that the temperature range was 5°C in the winter and 35°C in the summer, however in the southern portion of the Erbil governorate, it rises to 50°C. The research area's climate is categorized as Mediterranean (arid and semi-arid) [11].

Data Collection

Data came from selecting logs intentionally with in the yard after falling and cutting trees into (4 meter) and (2 meter) log length. The information was gathered from October 2024. A total (30) logs were selected from black poplar plantation in khalifan. All diameters were measured with a caliper using two measurements of the diameter made at

length and Comparison of these equations to see whether one is best for estimating log volumes at different log length in term of accuracy.

right angles to each other, and the average is calculated by [12]. The logs were in good health prior to any measurements being taken, and there was

Method

Felled trees were cut into sections of 4 and 2 meters, and the diameters of each piece were measured using a caliper. The volume of all methods for 2 and 4 meters' log length calculated by using all different equation methods and comparing to control to know which one of them is more accurate or suitable formula with the different log length [8] stated that Newton's formula, which calls for three diameter measurements of a log's small end, midpoint, and large end, is thought to be more precise than other standard formulas like Smalian's and Huber's formula. The correctness of the equations was compared using Four statistical markers, and the optimal mathematical model-based estimate log volume was chosen.

1. Mean
2. R^2
3. (Mean Absolute Error).
4. Bias

Table (1): Table of data include log length, (B) large end diameters, (M) mid-diameters, (S) small end diameters, and (G) diameter at1/3 of log length from the large end of the log outside bark of 2-meters log length of black poplar.

N	Log length(m)	B(cm)	G(cm)	M(cm)	S(cm)
L1	2	10.2	10	9.6	9.0
L2	2	12.3	12.2	12.0	10.9
L3	2	9.2	8.1	7.6	7.2
L4	2	13.5	13.1	12.9	10.9
L5	2	10.2	9.7	9.0	8.5
L6	2	14.4	13.6	13.1	12.6
L7	2	10.1	9.7	9.5	9.1
L8	2	8.8	8.5	8.4	8.1
L9	2	9.3	8.8	8.5	8.0
L10	2	10.4	9.9	9.6	9.4
L11	2	9.7	9.4	9.1	8.9
L12	2	8.4	7.9	7.5	7.5
L13	2	11.2	10.8	10.5	10.3
L14	2	9.0	8.4	8.1	7.7
L15	2	16.5	14.4	13.1	13.0

Table (2): Table of data include log length, (B) large end diameters, (M) mid-diameters, (S) small end diameters, and (G) diameter at1/3 of log length from the large end of log outside bark of 4-meters log length of black poplar.

N	Log length(m)	B(cm)	G(cm)	M(cm)	S(cm)
L1	4	7.7	6.9	6.4	4.5
L2	4	6.1	5.6	5.0	4.2
L3	4	9.4	8.5	8.1	7.2
L4	4	8.8	7.5	7.8	6.4
L5	4	8.1	7.3	7.1	6.4
L6	4	9.6	8.8	8.3	7.4
L7	4	9.6	9	8.5	7.7
L8	4	7.9	7.7	7.6	6.8
L9	4	8.7	7.1	6.1	5.2
L10	4	7.5	7.1	6.8	5.9
L11	4	7.8	7.4	7.1	6.0
L12	4	7.2	6.7	6.1	5.4
L13	4	9.7	7.6	6.8	5.7
L14	4	9.0	8.5	8.1	7.7
L15	4	7.5	7	6.7	5.7

Results and Discussions

Table (3): Volume estimated of 2-meter's log length of (Black poplar) by different methods

N	Newton's/ Control	Huber's	Smalian's	Bruce's	Hossfeld's
L1	0.01450	0.01448	0.014533	0.013628	0.014962
L2	0.02215	0.02262	0.021214	0.019938	0.022201
L3	0.00962	0.00907	0.010719	0.009431	0.009765
L4	0.02531	0.02614	0.023645	0.021154	0.024883
L5	0.01310	0.01272	0.013846	0.012597	0.013922
L6	0.02756	0.02696	0.028755	0.026847	0.028025
L7	0.01429	0.01418	0.014516	0.013762	0.014337
L8	0.01113	0.01108	0.011235	0.010771	0.011088
L9	0.01151	0.01135	0.011819	0.010936	0.011636
L10	0.01480	0.01448	0.015435	0.014657	0.015016
L11	0.01321	0.01301	0.013611	0.013027	0.013520
L12	0.00921	0.00884	0.009960	0.009398	0.009561
L13	0.01761	0.01732	0.018184	0.017424	0.017908
L14	0.01054	0.01031	0.011018	0.010166	0.010641
L15	0.02952	0.02696	0.034656	0.030601	0.031066

Table (4): Descriptive statistics of volume calculated by different methods for 2-meter log length of Black poplar.

	Control/Newton's	Huber's	Smalian's	Bruce's	Hossfeld's
Average	0.01627	0.01597	0.016876	0.015622	0.016569
Max	0.029523	0.026960	0.034656	0.030601	0.031066
Min	0.00921	0.00884	0.009960	0.009398	0.009561

Table (5): Volume Estimated of 4-meter's log length of Black poplar by different formula

Newton's/ Control	Huber's	Smalian's	Bruce's	Hossfeld's
0.01274	0.01287	0.012494	0.009428	0.012808
0.00405	0.00393	0.004308	0.003539	0.004387
0.01054	0.01031	0.011011	0.009577	0.010548
0.00947	0.00956	0.009299	0.007867	0.008235
0.00807	0.00792	0.008370	0.007402	0.007887
0.01106	0.01082	0.011539	0.010070	0.011274
0.01153	0.01135	0.011895	0.010604	0.011871
0.00889	0.00907	0.008533	0.007898	0.008801
0.00659	0.00584	0.008068	0.006158	0.007001
0.00723	0.00726	0.007152	0.006310	0.007306
0.00781	0.00792	0.007606	0.006630	0.007865
0.00602	0.00584	0.006362	0.005471	0.006434
0.00816	0.00726	0.009942	0.007523	0.008081
0.01054	0.01031	0.011018	0.010166	0.010840
0.00702	0.00705	0.006970	0.006037	0.007049

Table (6): Descriptive statistic of Volume calculated by different methods for 4-meter log length of Black poplar.

	Control/Newton's	Huber's	Smalian's	Bruce's	Hossfeld's
Average	0.00865	0.00849	0.00897	0.00765	0.00869
Max	0.01274	0.01287	0.012494	0.010604	0.012808
Min	0.00405	0.00393	0.004308	0.003539	0.004387

Table (7): The average, bias value, R², and Mean Absolute Error (MAE) for each of the many techniques used to estimate the log volume of black poplar (*Populus nigra* L.) (2 meters' log length).

Formula	Mean	R ²	MAE	Bias
Newton's\Control	0.01627	-----	-----	-----
Huber's	0.01597	0.989	0.0261	0.0045
Smalian's	0.01688	0.963	0.0814	-0.0090
Bruce's	0.01562	0.969	0.0705	0.0097
Hossfeld's	0.01657	0.996	0.05845	-0.0045

Table (8): The average, bias value, R², and Mean Absolute Error (MAE) for each of the many techniques used to estimate the log volume of black poplar (*Populus nigra* L.) (4 meters' log length).

Formula	Mean	R ²	MAE	Bias
Newton's\Control	0.00865	-----	-----	-----
Huber's	0.00849	0.984	0.0296	0.0024
Smalian's	0.00897	0.934	0.0950	-0.0048
Bruce's	0.00765	0.916	1.474	0.0151
Hossfeld's	0.00869	0.971	1.420	-0.0071

Bias value, mean absolute error (MAE), R² and average (mean) for all different methods used for (2-meter) log length volume estimation of black poplar tree species in khalifan sub-district are given in table (7). Mean of newton's formula or control is given (0.01627) and means of Hossfeld's, Huber's, Smalian's and Bruce's are given (0.01657, 0.01597, 0.01688, 0.01562) respectively. Huber's formula gives lower (MAE) which is (**0.02613**), bias value gives (**0.0045**). While Hossfeld's formula gives lower Bias value than other formula for estimating 2-meters log length volume estimation of black poplar which is (**-0.0045**). The MAPE for Hossfeld's formula is (**5.845**) and R² of Hossfeld's and Huber formula was **0.996** and **0.989** respectively we can say that Hossfeld's and Huber's formula are most appropriate methods for estimating volume of 2-meters log length of black poplar tree species. MAE and bias value of Bruce's formula and Smalian's formula give higher than Hossfeld's and Huber's which (MAE) are (**0.07055** and **0.08143**) respectively, bias value of Smalian's and Bruce's formula are (**-0.0090** and **0.097**) respectively. R² of Smalian's and Bruce's formula were 0.963 and 0.969 respectively.

Overall, all of these data points demonstrate that, when it comes to estimating the 2-meter

log length volume of black poplar tree species in the Khalifan sub district, the Hossfeld's and Huber formulas are more accurate than alternative approaches. As shown in table (8) the mean of newton's formula or control is given (0.00865) and means of Hossfeld's, Huber's, Smalian's and Bruce's are given (0.00869, 0.00849, 0.00897, 0.00765) respectively.

Huber's formula gives lower (MAE) than other formula for estimating 4-meters log length volume estimation of black poplar, while MAE and bias value of Huber's formula are given (**2.96**) and (**0.0024**) respectively. MAE of Smalian's, Hossfeld's and Bruce's formula were higher than Huber's which are (**0.950**, **1.420** and **1.474**) respectively, bias value of Hossfeld's, Smalian's and Bruce's formula are (**-0.0071**, **-0.0048** and **0.0151**) respectively. R² of Huber's formula was 0.984 more than other formulas were the Hossfeld's, Smalian's and Bruce's formula's R²(**0.971**, **0.934**, **0.916**) respectively.

In the end, all of these figures demonstrate that, when it comes to estimating the 4-meter log length volume of black poplar tree species, Huber's formula is the most accurate option available.

Conclusion

A relative study on the presentation of different method in estimating the log volume is assessed in terms of the bias and accuracy towards volume estimation of two log section. The outcome shows that Huber's and Hossfeld's formulas have the least bias for 2-meter log length volume estimation. Huber's formula is the least bias compared to other methods for 4-meter log length volume estimation. In the term of mean absolute error

(MAE), Huber's formula record the lowest value for 2-meter and 4-meter log length volume estimation of black poplar tree species in khalifan sub-district. As a result, Huber's formula is the most accurate formula as it records the least bias and lowest value of (MAE) and highest R^2 for estimating log volume of 2 and 4-meter log length of black poplar tree species in khalifan sub-district.

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