Yield Change Based on the Diameter and Length in Beech (*Fagus orientalis* Lipsky)

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Abstract

In this study; it is determined that quantitative yield have obtained with sawing of 60-80 mm thickness unedged lumbers and 22-30 mm thickness slab boards with live saw method of 3rd quality class logs obtained from Beech (*Fagus orientalis* Lipsky) that is commonly worked up and used a tree species in the lumber industry in Turkey. The logs used in the experiments have chosen among the logs-length 2m, 4m and 6m, midle-diameter 20 cm, 40 cm, 60 cm and 80 cm, taper %3- available in the log yards of the ORUS Duzce Lumber Factory.

As a result, the mean lumber quantitative yield in 20cm, 40cm, 60cm and 80cm diameter classes, 2m length logs are %66.93, %78.93, %80.1 and %79.77; in 4m length logs are %61.1, %71.73, %75.77 and %75.93; in 6m length logs are %61.7, %75.17, %79.7 and %79.53 respectively.

Acording to the results, while log length increases, quantitative yield decreases in all diameter classes. Yield values increase depend on the increase of log diameter in 20 cm, 40 cm and 60 cm diameter class. However, it is undertood that the increasing doesn't continue in 80 cm diameter class.

Key Words: *Beech, yield, live saw*

Kayında Çap ve Boya Göre Randıman Değişimi

Özet

Bu çalışmada; ülkemizde kereste endüstrisinde yaygın olarak kullanılan 3. sınıf kayın tomrukları 60-80m kalınlığında yaları alınmamış kereste ve 22-30mm kalınlığında kapak tahtalarına keskin kesiş metoduyla biçilmiş ve kantitatif randıman tespit edilmiştir. Tomruklar Düzce ORÜS kereste fabrikası tomruk deposundan %3 gövde düşüklüğüne sahip 2, 4 ve 6 m uzunlukta ve 20, 40, 60 ve 80 cm çapında olanlar arasından seçilmiştir.

Çalışma sonucunda; kereste kantitatif randımanı sırasıyla 20, 40, 60 ve 80 cm çapında 2 m uzunluğundaki tomruklarda %66.93, %78.93, %80.1 ve %79.77; 4 m uzunluğundaki tomruklarda %61.1, %71.73, %75.77 ve 6 m uzunluğundaki tomruklarda %61.7, %75.17, %79.7 ve %79.53 olarak bulunmuştur.

Bu sonuçlara göre; tüm çap sınıflarında tomruk uzunluğu arttıkça kereste kantitatif randımanı azalmıştır. Ayrıca 20, 40 ve 60 cm çap sınıflarında çap artmasına bağlı olarak kereste kantitatif randımanı artmış fakat bu artma 80 cm çap sınıfında devam etmemiştir.

Anahtar kelimeler: Kayın, randıman, keskin kesiş

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1. INTRODUCTION

Nowadays, there is a gradual decrease in forest resources. This causes the decrease of low prices. As a result of this, the lumber manufacturers try and afford to get optimum benefit from the raw material. On the other side the importance of beech (*Fagus orientalis* Lipsky) on the world trade is increasing day by day. The quality yield of beech which is treated about hundred thousands m^3 amount countries is getting more importance. The main aim in the production of lumber is to increase the yield rate.

In Turkey, log (diameter 21 cm and up, log length 100 cm) harvesting in state forests is approximately 3,1 million m^3 in the year 2000. Estimated annual log harvesting increase between 2000-2023 is 15%. Since annual log import is 1,2 million m^3, yearly total log request changes between 6,5-7 million m^3 (Avcı2002). At this point when we study the factors that effect the log yield is more than 250 (Özen, 1978). The most important factors are as follows:

a) Cutting techniques: While in live cut the yield is 80% for unedged lumber, the total yield is about 68% for prism cut. Also in live cut the yield decreases to 60% for edged lumber. However, there becomes changes in the width of the produced lumber.
b) Cross section of lumber: Practically the yield increases when the cross section surface area of lumber increases. The reason while the cross section area decreases among the lumbers which have the same width is a decrease of thickness. The increase in the number of cutting leads to the increase of the quantity of saw dust. This means the decrease in the yield. Also, if the cross section of the lumber square, it increases the yield .
c) The characteristics of lumber edge: Practically the yield increases based on the increase of the cant quantity. While measuring the dimensions of lumber the cant is taken in the account. As a result the width and thickness of lumber is more than edged lumber.
d) Log Diameter: The increase in the diameter brings the increase in the yield.
e) Log Length: There is a reverse ratio between log length and yield. The increase in the amount of decrease of diameter increases yield.
f) Log geometry, growing conditions and defects: The yield is high if the log is in cylindrical form while the yield is low if it deviates from cylindrical form.
g) Cutting machines: Since in frame saw and circle saw the cutting saw blade is thick and therefore the width of the teeth spacing is more than the width of the teeth spacing, in the band saw quality yield is low. On the other hand, thin blades which haven't required resistance can not resist against the pressure and this causes lumber to be defected. Thus, yield decreases.

h) Sawing defects: These errors occur because of wrong machine set-up, unskilled operator and his lack of knowledge, internal stress, slope of the saw and its sharpness. Besides, leaving lumber to more than required shrinkage allowance decreases yield.

At present, lumber production and quality yield are not at the optimum level because of the factors such as cutting methods, log edge quality, unsuitable log diameter, unsuitable saw thickness, wrong saw teeth form and its slope, wrong machine set-up, unskilled operator (Çolakoğlu 1996).

In this study, the effect of diameter and log length on quality yield was investigated. The aim of the study is to inform the people and institutions interested in the subject and also to assist beech lumber manufacturers.

2. LITERATURE REVIEW

Bell (1951), grouped perfect and smooth spruce, pine and fir logs from 7.5 cm – 41 cm diameter classes to produce lumber. The study was done to determine the effect of log diameter on lumber yield. The yield of 7.5 cm – 15 cm – 41 cm diameter classes determined as 44%, 45%, 60 % respectively.

Gürsu and Öktem (1975), studied the percentage of lumber yield utilizing different log diameter levels taking into account the waste of slab, edging and trimming pieces and saw dust. Study was done using logs of pine, beech and fir, and saws of frame and band.

According to the results of this study; there compared the usage of frame saw with band saw, the lumber yield is high while using the band saw when the yield for pine, beech and fir is 62.40 %, 54.04 % and 62.79 % respectively, but the yield for pine, beech and fir is 67.55 %, 76.67 % and 70.15 % respectively when we cut the same logs with band saw. There is a decrease in the diameter of logs the increase in the yield reach to the high level by using band saw, when cutting beech with 80 cm diameter the yield is 61.16 %, 84.18 % respectively when same tree species is cut with frame saw the yield is 51.62 % and 87.42 % for the 20 cm log diameter logs respectively.

In cutting pine logs there is a slow increase between the increase in logs diameter and the quantity of saw dust. However, a decrease in other waste materials has been discussed there is a decrease in the waste materials if the logs diameter is increased.

Öktem and Sözen (1996), used oak and spruce logs to determine the yield and waste according to diameter levels by using band saw. Coincidental determined 55 oak logs and 75 spruce logs which used in this study with various diameter classes obtained from saw mills in Demirköy and Ardeşen respectively. The log quality levels and number of logs for oak and spruce are for 3rd class quality 40 oak logs and 61 spruce logs, 2nd class quality 2 oak logs and 14 spruce logs and for 4th class quality 1 oak log respectively. As results of

study in 20 cm – 60 cm diameter range lumber yield was determined for oak and spruce 71.18 % and 70.46 % respectively. The lumber yield distribution was 57.59 % for oak and 65.5 % for spruce in 20 cm diameter class, 84.77 % and 80.39 % respectively in 60 cm diameter class. It was carried out that increase of log diameter increases the lumber yield.

Bell (1951), used 280 spruce logs with 15 cm diameter and 4-6 m length to find out the effect of log length for lumber yield. Lumbers obtained from spruce logs were classified in their thickness for 2.54 cm (16 %), 5 cm (34 %) and 7.5 cm (50 %) respectively. As result of study it was carried out that increase of log length decreases the lumber yield. The lumber yield was find out 44 % for 4 m log length and 37 % for 6 m log length.

Arabacı (1991), determined the quantitative yield for beech for diameter and length in a sawmill (Bartın Sawmill, ORÜS). 3rd class quality logs with 20 – 90 cm diameter range were cut with live cut and prism cut method. It was carried out that yield for prism cut is higher than live cut and log diameter shows linear ratio while log length shows reverse ratio according to lumber yield.

Loehnertz, Lowell, Simpson and Mc Donald (1993), studied the volume yield for 130 pieces lumber obtained from 24 logs. As result, it was determined that increase of log diameter increases the lumber volume. On the other hand, rot percentage is a reason for decrease in yield. Logs with 28 cm and more diameter causes decrease in lumber yield.

3. MATERIALS AND METHODS

In this study, beech (*Fagus orientalis* Lipsky) logs were used that's widespread in lumber industry in Turkey. The logs were provided from Düzce region and cut to lumber in ORÜS sawmill in Düzce province. The logs selected were 3rd class and live cut method was used. In the production phase headrig (1400 mm), ripsaw (1500 mm), edging machine and trimming machine was used. Since the product size of the factory is constant, the thickness of the main product was selected as 60 mm and 80 mm, the slab thickness was 22 mm and 30 mm respectively. The characteristics of the logs are as follows; length 2-4-6 m, middle diameter 20-40-60-80 cm, the decrease in diameter 3 %. For each length and diameter class 30 logs were selected. The total of the logs used is 360. The headrig and ripsaw set to the saw teeth was one sided 0.5 mm.

4. RESULTS

The measured yields obtained from beech logs are given in Table 1.

Table 1. Average log diameter and log length compared yield percentage.

Average log diameter/log length (m)	20 cm	40 cm	60 cm	80 cm
2	66.93	78.93	80.1	79.77
4	61.1	71.73	75.77	75.93
6	61.7	75.17	79.7	79.53

The result of the analysis of variance and Duncan test as related to log diameter in different log lengths (2 m, 4m, 6m) are given in tables 2, 3, 4, 5, 6, 7 and the analysis of variance and Duncan test results for 20 cm and 80 cm log diameter classes related to length are given Table 8, 9, 10, 11.

Table 2. Anova analysis related to log diameter for 2 m logs.

Source of Variance	Degree of Freeness	Totally Variance	Variance	F- Ratio %95	F- Ratio %99	Confidence Level
Between Groups	3	3631.667	1210.556	162.190	162.190	
Within Groups	116	865.8	7.463	>	>	(% 95)S*
Total	119	4497.467		2.68	3.949	(%99)S*

Statistically significant difference for yield was found related to log diameter for 2 m logs, because of F_{cal}= 162.1904 is higher than $F_{0,05;}$ 3;116 = 2.68 and $F_{0,01;}$ 3;116 = 3.949 at the 95 % and 99 % confidence level. The determination which means are significantly different are given in Table 3.

Table 3. Duncan test related to log diameter for 2 m logs.

	Log Diameter (cm)		
Diameter (cm)	80	40	20
60	0.333	1.166	13.166
Rp	1.394	1.467	1.516
80	-	0.833	12.833
Rp	-	1.394	1.467
40	-	-	12
Rp	-	-	1.394

According to Duncan test, there is a significant difference for 2 m log length in yield for 20 cm diameter class. The significance between the other diameter classes are not significant.

Table 4. Anova analysis related to log diameter for 4 m logs.

Source of Variance	Degree of Freeness	Totally Variance	Variance	F- Ratio %95	F- Ratio %99	Confidence Level
Between Groups	3	4366.067	1455.356	95.067	95.067	
Within Groups	116	1775.8	15.308	>	>	(% 95)S*
Total	119	6141.867		2.68	3.949	(%99)S*

Statistically significant difference for yield was found related to log diameter for 4 m logs, because of F_{cal}= 95.067 is higher than $F_{0,05;}$ 3;116 = 2.68 and $F_{0,01;}$ 3;116 = 3.949 at the 95 % and 99 % confidence level. The determination which means are significantly different are given in Table 5.

Table 5. Duncan test related to log diameter for 4 m logs.

	Log Diameter (cm)		
Diameter	60	40	20
80	0.166	4.2	14.833
Rp	1.999	2.104	2.174
60		4.033	14.666
Rp		1.999	2.104
40			10.633
Rp			1.999

According to Duncan test, there is a significant difference for 4 m log length in yield for 20, 40, 60 cm diameter classes. The significance in 80 cm diameter class is not significant.

Table 6. Anova analysis related to log diameter for 6 m logs.

Source of Variance	Degree of Freeness	Totally Variance	Variance	F- Ratio %95	F- Ratio %99	Confidence Level
Between Groups	3	6472.691	2157.564	79.246	79.246	
Within Groups	116	3158.233	27.226	>	>	(% 95)S*
Total	119	9630.925		2.68	3.949	(%99)S*

Statistically significant difference for yield was found related to log diameter for 6 m logs, because of F_{cal}= 79.246 is higher than $F_{0,05;}$ 3;116 = 2.68 and $F_{0,01;}$ 3;116 = 3.949 at the 95 % and 99 % confidence level. The determination which means are significantly different are given in Table 7.

Table 7. Duncan test related to log diameter for 6 m logs.

	Diameter of log (cm)		
Diameter (cm)	80	40	20
60	0.166	4.533	18
Rp	2.665	2.805	2.898
80		4.366	17.833
Rp		2.665	2.805
40 cm çap			13.466
Rp			2.665

According to Duncan test, there is a significant difference for 6 m log length in yield for 20, 40, 60 cm diameter classes. The significance in 80 cm diameter class is not significant.

Table 8. Anova analysis related to log length for 20 cm diameter class.

Source of Variance	Degree of Freeness	Totally Variance	Variance	F- Ratio %95	F- Ratio %99	Confidence Level
Between Groups	2	617.755	308.8778	6.760571	6.760571	
Within Groups	87	3974.86	45.68812	<	>	(% 95)S*
Total	89	4592.62		6.851	4.786	(%99)S*

Statistically significant difference in yield was found related to log length for 20 cm diameter class because of F_{cal}= 6.760 is higher than $F_{0,01;}$ 2;87 = 4.768 at the 99 % confidence level. No signifacant difference determined at 95 % confidence level. The determination which means are significantly different are given in Table 9.

Table 9. Duncan test related to log length for 20 cm diameter class.

	Length (m)	
Length (m)	6	4
2	5.230	5.830
Rp	3.455	3.636
6		0.600
Rp		3.455

According to Duncan test, there is a significant difference for 20 cm diameter class in yield for 2 m and 4 m , 2 m and 6 m log length. The significance between 4 m and 6 m log length is not significant.

Table 10. Anova analysis related to log length for 80 cm diameter class.

Source of Variance	Degree of Freeness	Totally Variance	Variance	F- Ratio %95	F- Ratio %99	Confidence Level
Between Groups	2	277.089	138.544	42.337	42.337	
Within Groups	87	284.7	3.272	>	>	(% 95)S*
Total	89	561.789		6.851	4.786	(%99)S*

Statistically significant difference in yield was found related to log length for 80 cm diameter class because of F_{cal}= 42.337 is higher than $F_{0,05;}$ 2;87 = 4.851 and $F_{0,01;}$ 2;87 = 4.768 at the 95 % and 99 % confidence level. The determination which means are significantly different are given in Table 9.

Table 11. Duncan test related to log length for 80 cm diameter class.

	Length (m)	
Length (m)	6	4
2	0.240	3.840
Rp	0.924	0.972
6		3.600
Rp		0.924

According to Duncan test, there is a significant difference for 80 cm diameter class in yield for 2 m and 4 m , 4 m and 6 m log length. The significance between 2 m and 6 m log length is not significant.

5. DISCUSSION

The yield results for 2 m log length were obtained as follow; 66.93 % at the 20 cm diameter class, 78.93 % at the 40 cm diameter class, 80.1 % at the 60 cm diameter class and 79.77 % at 80 cm diameter class. Yield results for 4 m log length at same diameter classes were determined as; 61.1 %, 71,73 % ,75.77 % ,75.93 % respectively, and for 6 m log length as; 61.7 % ,75.17 % ,79.7 %, 79.53 % respectively.

According to the results it is determined that increasing in log length decreases the quantitative yield in all diameter classes. The quantitative yield is increase with the increasing of tree diameter from 20 cm up to 60 but decrease at 80 cm diameter class level.

National and international studies on this subject proof the obtained results of this study. Özen (1978) determined that yield decrease from 65 % to 45 % while log length changes from 1 m up to 12 m.

Gürsu and Öktem (1975), obtained that the yield for band saw cutted 20 cm and 80 cm diameter beech logs. The yield was determined as 61.16 % and 84.18 % repectively.

Conclusively, higher log diameter increases the yield due to the better utilization of slabs from higher log diameter but that is not the case for lower diameter logs. Logs having higher taper decreases the lumber yield but increase in slabs. This was especially the case for longer logs. The yield loss in the longer cylindrical logs was only due to the trimming.

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