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# The Effect of Altitude on Juvenile Wood Formation and Fiber Length, a Case Study in Iranian Beech wood (*Fagus orientalis* L.)

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## ABSTRACT

**The mean fiber length of three beech trees (*Fagus orientalis L.)* at the lower and higher points (1% and 75% tree height) of the stem at an intermediate altitude (500-1000m) in the Caspian forests in Sari region were 1.36 and 1.22mm respectively, close to the values in three trees at high altitude (1000-1500m), that were found to be 1.39 and 1.36 mm. The mean fiber lengths of the whole stem, using stem formula, were considered as 1.31 and 1.38mm at intermediate and high altitudes and so were very close each other. Juvenile wood portions in the stem comprised 17 annual rings, which took up 7.3% of the stem by volume at intermediate altitude. At high altitude, these values were obtained as 18 annual growth rings, and 8.75% juvenile wood in the stem. The reason for greater juvenile wood at high altitude was somehow a wider ring width at higher elevation. The mean ring width of lower and upper points of the stem at intermediate altitude were found to be 1.82 and 2.95mm respectively; meanwhile, at high altitude, the findings were 2.97, 3.37mm. Despite the data obtained, t- test comparison was conducted between mean fiber lengths of the two heights of the stems at two altitudes, and no significant differences were found at the 1% level. The exploitation age was strongly dependent on how much juvenile wood there was in the stems, that at high altitude was greater than at intermediate. However, statistical comparison showed no significant differences between that and the 1% level. Therefore, altitude in the range of about 500m showed no important impact on beech fiber length, exploitation age or juvenile wood border in Caspian forests.**


**Keywords:** Beech, Exploitation age, High altitude, Intermediate altitude, Juvenile wood, Mature wood, Papermaking, Wood fiber.

## INTRODUCTION

Information shows us that the recognition of juvenile wood rate production in tree stems is very important from the viewpoint of wood utilization in papermaking industries. This is because juvenile wood is characterized by less pronounced latewood, shorter cells, larger microfibrillar angles, and lower crystallinity and cellulose content in comparison to mature wood, that is produced later. Enviromental factors such as altitude influence cambial growth both by affecting the formation of leaf primodria and expanded leaves (Kozlowski, 1971). Usually, fast growth becomes synonymous with lower density, lower stiffness and higher juvenile wood proportion (Geoffrey *et al*., 2002). Wood quality characteristics depend on the intended products and are usually defined by relative wood density, ring width, microfibril angle, fiber length, knot size and distribution, spiral grain angle and chemical composition (Ministry of Forests of Canada, 1999). From this fact it is understandable that fast growing trees, as well as young tree stems, have mainly juvenile wood and make different pulp from mature wood. For example, juvenile wood requires more energy than mature wood to refine (Hatton and Johal, 1993). Recognition of juvenile wood rate production in trees makes it possible to

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evaluate the exploitation age for chemical and papermaking purposes. With respect to tree species, the amount of juvenile wood varies among different trees. Dadswell (1958) found that the number of years taken to reach constant cell length varies from species to species and is, to some degree, related to the life span of the tree. He states that cell length increases in the first 12-15 years in Pinus radiata, and in Eucalyptus gigantea cell length may increase within 20 years. When fiber length reaches its maximum value, it can be considered as juvenile wood border (Tsoumis, 1969; Dadswell, 1958). Latitude and altitude in an unspecified interaction of mean temperature and available moisture, also have major effects on variability in wood properties within species and, therefore, could have an impact on juvenile wood rate production as well (Panshin and de Zeeuw, 1980). Determination of the juvenile wood border was examined using the Shiokura formula, I (%) = $(T_{n+1} - T_n) / T_{n.}100$, where I (%) is the increasing rate of fiber length as a perentage, $T_{n+1}$ and $T_n$ are fiber lengths at the (n+1)th and the n-th ring position from pith (Chen and Wang, 1996). Growing conditions, such as competition within the stand or soil fertility, can cause major differences in the magnitude and cell length of juvenile wood in trees as well as latitude and altitude (Panshin and de Zeeuw, 1980). For Japonese larch (*Larix leptopis*), Koga *et al*. (1983) state that the site class plays a significant role in determining the width of juvenile wood as does stand density. It is important to recognize that juvenile wood is different wood, not necessarily a poor wood. It is very suitable for example, for thermomechanical pulp or chemical-thermomechanical pulp. It is useful for producing newspaper, some tissues, and high quality writing paper, among others. Usually, juvenile wood affects pulp quality when it makes up more than 20% of the furnish (Zobel and Buijtenen, 1984). The aim of this study was to investigate the effect of intermediate and high altitude on the fiber length, juvenile wood border and exploitation age of beech tree (*Fagus orientalis* L.), when the stem comprises 20% juvenile wood.

## MATERIALS AND METHODS

From the point of altitude view, of the Caspian forest is divided into three parts: lowland (from sea level to altitude of 500m), intermediate altitude (501-100m), and high altitude (1001-1500 m). This study was focused on the intermediate and high altitudes of the Caspian forest located in Sari region in northern Iran. Selected sample trees had no signs of disease or insect damage, as well as any other abnormalities, such as root buttress and eccentricity. Normally, trees, that are less than 20m in height do not show buttress or butt flare. This is more prominent in beech trees, which are native to temperate climates. It is worth mentioning that the buttress phenomenon is accompanied by annual ring disruption. Precipitation in high and intermediate altitudes is nearly the same and, available data showed, mean annual rainfall is about 590mm and temperature 17.1 ºC. Three trees were cut from each of the altitudes mentioned, and 2cm thick discs were separated from the 1% and 75% tree heights. The discs were smoothed with a plane, so that the annual rings became clearly visible for further measurements. Two diagonal and parallel lines were drawn on each disc at 2cm distances and, then, wood strips were cut out in which a wood sliver for each annual ring was prepared. Wood slivers were subjected to maceration, using acetic acid and hydrogen peroxide in equal proportion at 60ºC and 48 hours in an oven. From sample trees, with different age categories, 50 annual rings from the lower point (1% tree height), and 35 from the upper point (75% tree height) of each tree stem were taken, in order for comparison measurements to be performed at both altitudes in similar positions. Fibers of individual rings were prepared and stained with 1%water soluble safranin, then fixed on slides. Thirty randomly selected fibers from the lower and upper heights of the trees (1% and 75%tree height) at both altitudes were measured by light microscope. Whether three or two heights were taken along a tree stem was basically dependent on tree height, namely, when tree height exceeds 20m, three heights must be taken otherwise, two heights are enough (Bhatt and Dhamodaran 1989). In this study all the sample tree heights were lower than 20m, therefore two sample heights at 1% and 75% tree height have been taken. In order to obtain the mean fiber length in the stem, the values were weighted using the following formula L= $D_sf_1+D_tf_2$ / $D_s+D_t$, where $D_s$ and $D_t$ are the disc volume at the 1% and 75% height levels respectively. $f_1$ and $f_2$ are the fiber length values for the discs (Bhat and Dhamodaran, 1989). Fiber length varies rapidly from pith to bark and, when reaches its maximum, is considered as juvenile wood border (Tsoumis, 1969). The concept of the exploitation age on the basis of 20% juvenile wood is based on the chemical conversion of wood used in papermaking industries. While a tree is in the early stage of growth, it contains 100% juvenile wood. As a tree becomes older, fibers slowly reach their maximum size, and from the maximum point onwards mature wood is the product. Mature wood increases continuously as a part of the stem while a tree is in the stand, meanwhile the juvenile wood portion does not changed. Consequently, by increasing the mature wood portion, juvenile wood is reduced as a whole in the stem. On the other hand, fiber refining is extremely important to papermaking industries in which fiber shortening is one of the three major factors, that occurs during refining. According to Zobel and Buijtenen (1989), the juvenile and mature wood ratio 0f 20:80 percent in the stem is suitable for papermaking purposes. Therefore, in respect of this result, the exploitation age can be calculated in the stem. The time when the stem reaches 20% juvenile wood is considered as the exploitation age or harvesting time for chemical conversion and papermaking purposes. By increasing the amount of mature wood in the stem, the percentage of juvenile wood is reduced. From the exploitation age of the assumed tree on the basis of 20% juvenile wood we can obtain the actual juvenile wood percentage in each tree, which is convenient for papermaking processes. Volume between the 1% and 75% tree heights were calculated using a truncated cone formula {$V = h/2(S_1+S_2)$}. A statistical comparison between fiber length and exploitation age was conducted, using the t-test statistical method.

## RESULTS

Fiber lengths in the lower and upper heights of the stem of all sample trees at intermediate altitude are shown in Table1. Fiber lengths at the two heights mentioned vary in a generally similar trend from pith to bark. The fiber length values of the first and second annual rings began from less than one millimeter, while, in the third ring they exceeded one millimeter. The mean fiber length value of the lower height of individual stems was greater than the upper height at intermediate elevation (Table1). With respect to the juvenile wood portion of the stems, the mean fiber lengths of juvenile and mature wood were calculated separately as 1.20 and 1.46mm at lower heights, and 1.16, 1.31mm at the upper height of the stems at intermediate altitude (Table1). Similar measurements were carried out on the fiber lengths of juvenile and mature wood of the two stem heights mentioned at high altitude, and were found to be 1.22 and 1.48mm at the lower height and 1.3 and 1.4mm at the upper height of the stem as well (Table2). Fiber from the bottom to the top of the tree stems has showed little increase in length, and this can be attributed to short tree height in all sample trees which were less than 20m. Meanwhile fiber length in the whole stem at intermediate and high altitudes was determined using the stem formula, which were found to be 1.31 and 1.38 mm. This

**Table1**. Mean fiber length in 1% and 75% heights of beech tree (*Fagus orientalis* L.) at intermediate altitude in the Caspian forest- Sari region.

| | Fiber Length (mm) | | | Fiber Length (mm) | | |
|---|---|---|---|---|---|---|
| Ring No. | 1 % | | | 75 % | | |
| | Tree No.1 | Tree No.2 | Tree No.3 | Tree No.1 | Tree No.2 | Tree No.3 |
| 1 | 0.839 | 0.967 | 0.821 | 0.836 | 0.816 | 0.954 |
| 2 | 0.88 | 0.969 | 0.948 | 0.845 | 0.959 | 1.061 |
| 3 | 0.954 | 1.048 | 0.984 | 0.890 | 1.044 | 1.073 |
| 4 | 1.030 | 1.185 | 1.034 | 0.9 | 1.108 | 1.095 |
| 5 | 1.037 | 1.219 | 1.134 | 0.948 | 1.173 | 1.132 |
| 6 | 1.095 | 1.259 | 1.188 | 0.952 | 1.274 | 1.152 |
| 7 | 1.102 | 1.219 | 1.3 | 0.994 | 1.286 | 1.167 |
| 8 | 1.156 | 1.316 | 1.381 | 1.066 | 1.290 | 1.222 |
| 9 | 1.166 | 1.406 | 1.411 | 1.011 | 1.241 | 1.259 |
| 10 | 1.143 | 1.488 | 1.253 | 1.036 | 1.282 | 1.240 |
| 11 | 1.198 | 1.435 | 1.313 | 1.032 | 1.200 | 1.284 |
| 12 | 1.284 | 1.472 | 1.365 | 1.019 | 1.240 | 1.353 |
| 13 | 1.214 | 1.508 | 1.35 | 1.039 | 1.264 | 1.359 |
| 14 | 1.342 | 1.489 | 1.358 | 1.060 | 1.200 | 1.379 |
| 15 | 1.328 | 1.453 | 1.472 | 1.071 | 1.216 | 1.26 |
| 16 | 1.227 | 1.478 | 1.506 | 1.150 | 1.278 | 1.27 |
| 17 | 1.267 | 1.498 | 1.494 | 1.133 | 1.345 | 1.301 |
| 18 | 1.213 | 1.425 | 1.479 | 1.194 | 1.350 | 1.314 |
| 19 | 1.226 | 1.496 | 1.457 | 1.112 | 1.380 | 1.339 |
| 20 | 1.200 | 1.507 | 1.482 | 1.224 | 1.298 | 1.331 |
| 21 | 1.190 | 1.472 | 1.495 | 1.132 | 1.373 | 1.298 |
| 22 | 1.215 | 1.481 | 1.502 | 1.180 | 1.387 | 1.355 |
| 23 | 1.180 | 1.46 | 1.518 | 1.170 | 1.370 | 1.337 |
| 24 | 1.206 | 1.497 | 1.563 | 1.106 | 1.425 | 1.364 |
| 25 | 1.188 | 1.513 | 1.564 | 1.116 | 1.455 | 1.434 |
| 26 | 1.198 | 1.559 | 1.530 | 1.176 | 1.358 | 1.426 |
| 27 | 1.201 | 1.559 | 1.593 | 1.179 | 1.375 | 1.402 |
| 28 | 1.199 | 1.530 | 1.581 | 1.167 | 1.394 | 1.429 |
| 29 | 1.212 | 1.490 | 1.574 | 1.167 | 1.356 | 1.465 |
| 30 | 1.206 | 1.504 | 1.584 | 1.170 | 1.301 | 1.466 |
| 31 | 1.210 | 1.550 | 1.443 | 1.167 | 1.364 | 1.475 |
| 32 | 1.265 | 1.350 | 1.440 | 1.143 | 1.300 | 1.475 |
| 33 | 1.300 | 1.56 | 1.363 | 1.152 | 1.427 | 1.406 |
| 34 | 1.245 | 1.57 | 1.472 | 1.131 | 1.281 | 1.435 |
| 35 | 1.195 | 1.52 | 1.494 | 1.175 | 1.283 | 1.499 |
| 36 | 1.210 | 1.507 | 1.412 | | | |
| 37 | 1.190 | 1.507 | 1.566 | | | |
| 38 | 1.200 | 1.54 | 1.528 | | | |
| 39 | 1.227 | 1.58 | 1.551 | | | |
| 40 | 1.296 | 1.538 | 1.559 | | | |
| 41 | 1.370 | 1.56 | 1.534 | | | |
| 42 | 1.364 | 1.57 | 1.544 | | | |
| 43 | 1.338 | 1.5 | 1.604 | | | |
| 44 | 1.273 | 1.577 | 1.582 | | | |
| 45 | 1.369 | 1.574 | 1.624 | | | |
| 46 | 1.355 | 1.542 | 1.520 | | | |
| 47 | 1.267 | 1.553 | 1.588 | | | |
| 48 | 1.303 | 1.498 | 1.649 | | | |
| 49 | 1.215 | 1.501 | 1.650 | | | |
| 50 | 1.364 | 1.494 | 1.670 | | | |
| Sum | 60.45 | 72.69 | 72.03 | 37.84 | 44.69 | 45.85 |
| Mean | 1.20 | 1.45 | 1.44 | 1.08 | 1.27 | 1.31 |
| Std,dev. | 0.112 | 0.1494 | 0.1877 | 0.1051 | 0.1326 | 0.1354 |
| C V % | 9.3 | 10.3 | 13 | 9.73 | 10.44 | 10.33 |

**Table 2**. Mean fiber length in 1% and 750% heights of beech tree (*Fagus orientalis* L.) at high altitude in the Caspian forest- Sari region.

| | Fiber Length (mm) | | | Fiber Length (mm) | | |
|---|---|---|---|---|---|---|
| Ring No. | 1 % | | | 75 % | | |
| | Tree No.1 | Tree No.2 | Tree No.3 | Tree No.1 | Tree No.2 | Tree No.3 |
| 1 | 0.803 | 0.867 | 0.905 | 0.989 | 0.951 | 0.99 |
| 2 | 0.850 | 0.947 | 0.855 | 1.180 | 1.007 | 1.185 |
| 3 | 1.015 | 0.959 | 1.010 | 1.181 | 1.013 | 1.181 |
| 4 | 1.050 | 1.067 | 1.060 | 1.247 | 1.115 | 1.25 |
| 5 | 1.061 | 1.147 | 1.065 | 1.370 | 1.132 | 1.375 |
| 6 | 1.207 | 1.121 | 1.205 | 1.407 | 1.137 | 1.408 |
| 7 | 1.241 | 1.157 | 1.248 | 1.437 | 1.146 | 1.439 |
| 8 | 1.139 | 1.296 | 1.140 | 1.494 | 1.157 | 1.49 |
| 9 | 1.241 | 1.37 | 1.241 | 1.472 | 1.182 | 1.47 |
| 10 | 1.183 | 1.288 | 1.185 | 1.445 | 1.152 | 1.44 |
| 11 | 1.281 | 1.369 | 1.28 | 1.478 | 1.159 | 1.479 |
| 12 | 1.375 | 1.420 | 1.380 | 1.517 | 1.206 | 1.498 |
| 13 | 1.440 | 1.452 | 1.442 | 1.499 | 1.199 | 1.499 |
| 14 | 1.388 | 1.443 | 1.389 | 1.505 | 1.252 | 1.5 |
| 15 | 1.401 | 1.451 | 1.400 | 1.408 | 1.179 | 1.41 |
| 16 | 1.427 | 1.425 | 1.427 | 1.480 | 1.249 | 1.4 |
| 17 | 1.427 | 1.406 | 1.427 | 1.583 | 1.220 | 1.48 |
| 18 | 1.522 | 1.539 | 1.521 | 1.570 | 1.254 | 1.52 |
| 19 | 1.520 | 1.520 | 1.520 | 1.541 | 1.240 | 1.545 |
| 20 | 1.454 | 1.495 | 1.450 | 1.461 | 1.255 | 1.500 |
| 21 | 1.491 | 1.517 | 1.491 | 1.439 | 1.225 | 1.440 |
| 22 | 1.485 | 1.505 | 1.475 | 1.498 | 1.215 | 1.490 |
| 23 | 1.506 | 1.471 | 1.510 | 1.447 | 1.240 | 1.440 |
| 24 | 1.422 | 1.449 | 1.420 | 1.542 | 1.239 | 1.500 |
| 25 | 1.492 | 1.548 | 1.490 | 1.475 | 1.235 | 1.475 |
| 26 | 1.450 | 1.586 | 1.430 | 1.548 | 1.323 | 1.454 |
| 27 | 1.498 | 1.585 | 1.490 | 1.544 | 1.250 | 1.550 |
| 28 | 1.444 | 1.486 | 1.450 | 1.516 | 1.265 | 1.527 |
| 29 | 1.461 | 1.506 | 1.359 | 1.572 | 1.260 | 1.445 |
| 30 | 1.428 | 1.450 | 1.420 | 1.520 | 1.330 | 1.450 |
| 31 | 1.431 | 1.420 | 1.425 | 1.465 | 1.320 | 1.460 |
| 32 | 1.366 | 1.400 | 1.410 | 1.465 | 1.360 | 1.500 |
| 33 | 1.434 | 1.450 | 1.438 | 1.535 | 1.380 | 1.540 |
| 34 | 1.495 | 1.407 | 1.495 | 1.532 | 1.323 | 1.535 |
| 35 | 1.383 | 1.401 | 1.390 | 1.566 | 1.300 | 1.545 |
| 36 | 1.565 | 1.499 | 1.510 | | | |
| 37 | 1.531 | 1.500 | 1.530 | | | |
| 38 | 1.556 | 1.480 | 1.550 | | | |
| 39 | 1.530 | 1.465 | 1.530 | | | |
| 40 | 1.543 | 1.464 | 1.540 | | | |
| 41 | 1.449 | 1.497 | 1.490 | | | |
| 42 | 1.539 | 1.442 | 1.540 | | | |
| 43 | 1.471 | 1.479 | 1.471 | | | |
| 44 | 1.490 | 1.530 | 1.495 | | | |
| 45 | 1.448 | 1.520 | 1.450 | | | |
| 46 | 1.503 | 1.550 | 1.510 | | | |
| 47 | 1.558 | 1.555 | 1.560 | | | |
| 48 | 1.589 | 1.560 | 1.550 | | | |
| 49 | 1.531 | 1.560 | 1.530 | | | |
| 50 | 1.589 | 1.570 | 1.540 | | | |
| Sum | 69.7 | 70.59 | 69.64 | 50.93 | 42.43 | 50.41 |
| Mean | 1.39 | 1.410 | 1.39 | 1.45 | 1.20 | 1.44 |
| Std,dev. | 0.1824 | 0.1703 | 0.1735 | 0.1266 | 0.094 | 0.1185 |

finding was close to the value 1.28mm that Panshin and Zeeuw (1980) found for American beech wood *(Fagus grandifolia L).* However, the location of sample trees was not identified in Panshin's is findings. In addition, altitude in this study has had no impact on the result. The percentage in rate of juvenile wood the stem plays an important role in determining the exploitation age that and from year to year, and mainly depended on environmental conditions in which rings are being shaped (Figures. 1 and 2). Mean ring width of the lower and upper heights of the stem at intermediate altitude was smaller (1.82 and 2.95mm), than at high altitude (2.97and 3.37mm). Despite the close mean fiber length and other data obtained from different sample trees at the two altitudes,

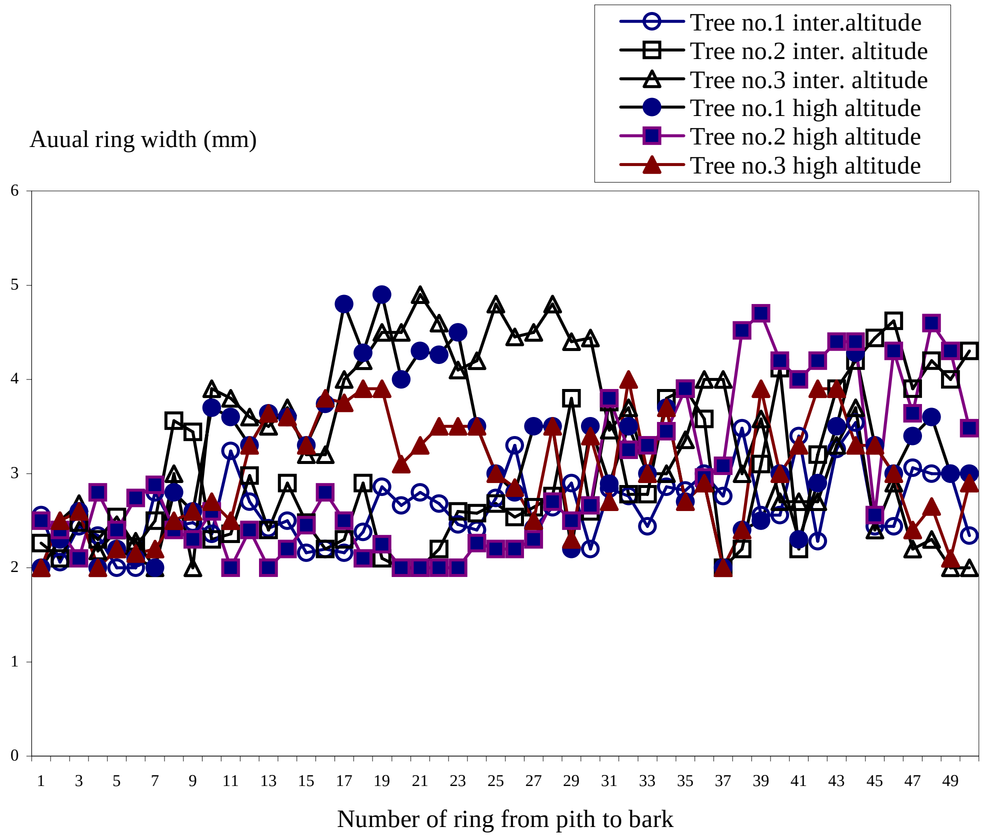


**Figure 1**. Annual ring width of 1% beech tree height at intermediate and high altitudes in the Caspian forest.

is mainly dependent on the size of ring width and, secondly, on the number of annual rings of which the juvenile wood is comprised. Thus, the number of annual rings, that the lower and upper height of the stem contained were 14 and 22 rings at the intermediate elevation, and 18 and 16 rings at the high elevation, respectively (Table2). Annual ring widths varied from pith to bark statistical comparisons were performed for confidential interpretation Fiber length in different sample trees, at the two previously mentioned stem heights at high altitude, showed a greater length value by comparison to intermediate altitude, which can be seen in Tables 2. In the first and second annual rings of the stems at high altitude, some fibers less than and some others more than

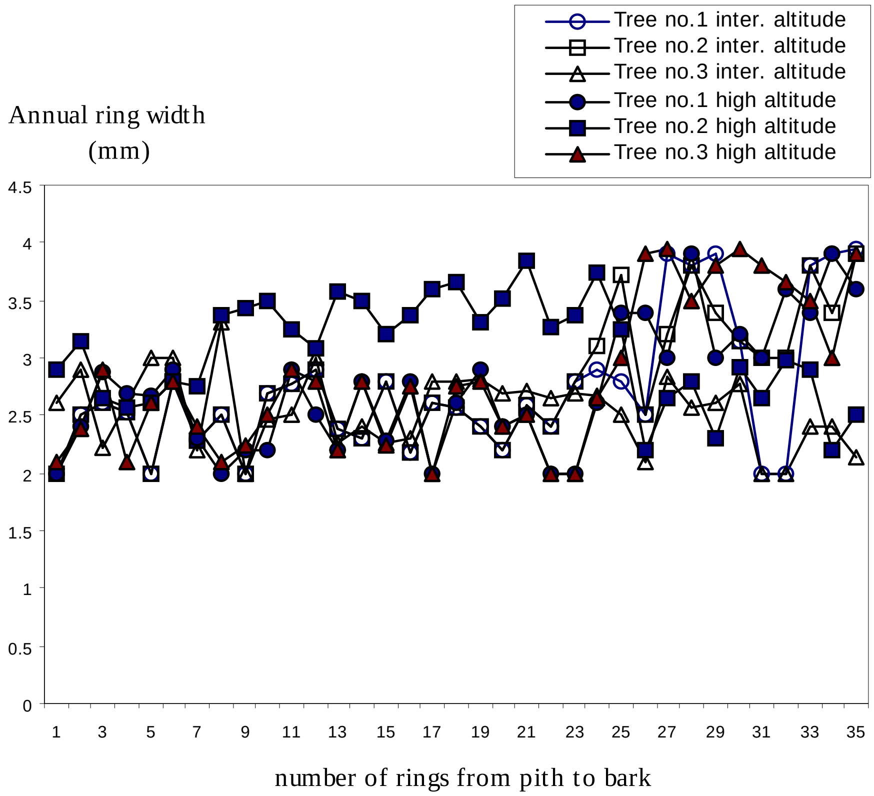


**Figure 2.** Annual ring width of the 75% beech tree height at intermediate and high altitudes in the Caspian forest

one millimeter length were found. This value showed the larger trend of fiber length at high altitude. Despite the finding of larger fiber length at high altitude, t-test comparison did not show significant differences at the 1% level at both altitudes (Table 6). Mean juvenile wood was determined using the number of juvenile wood rings and the mean ring width of the juvenile wood portion in the stem was found to be 7.3% in the stems at intermediate altitude (Table 3), and 8.75% at high altitude (Table 4). Exploitation age, which was derived on the basis of 20% juvenile wood in the stems, at intermediate and high altitudes contained 28 and 32 annual rings respectively (Table 5). As noted before, tree for paper making purposes must have 20% juvenile wood in the stem, which depends on the rate of juvenile wood in individual tree stems. It is obvious that exploitation age is also affected by the rate of juvenile wood production, namely the years a tree needs reach juvenile wood border and mean ring width as well. 4Therefore, the exploitation ages at both altitudes were similar and the statistical t-test showed that no significant differences were found between them at the 1% level (Table 6).

## CONCLUSION

With regard to the result, fiber length at both altitudes and both points (upper and lower) of the stem vary in a similar manner from pith to bark. A sharp increase in fiber length was seen at high altitude in juvenile wood portions, from pith to juvenile wood

**Table 3**. Percentage of juvenile wood, exploitation age and diameter based on 20% juvenile wood in the stems at intermediate altitude.

| Charateristics of tree fature | | | | | Tree height | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1% | | | | | 75% | | | | |
| Number of sample trees | Location name | Tree height (m) | Juvenile wood in whole stem (%) | Exploitation age with 20% juvenile wood in the stem (year) | Diameter (cm) | Number of annual rings (age) | Juvenile wood border (year) | Diameter of juvenile wood (cm) | Tree diameter based on 20% juvenile wood (cm) | Diameter (cm) | Number of annual rings (age) | Juvenile wood border (year) | Diameter of juvenile wood (cm) | Tree diameter based on 20% juvenile wood (cm) |
| 1 | Shakooh | 15 | 4.76 | 28 | 35 | 61 | 14 | 6.30 | 16.72 | 27 | 47 | 22 | 7.4 | 12.4 |
| 2 | ginka | 16 | 4.02 | 24 | 40 | 65 | 13 | 6.32 | 17.40 | 26 | 48 | 22 | 7.3 | 11.8 |
| 3 | Resket | 13 | 13.1 | 32 | 44 | 52 | 16 | 13.18 | 34.40 | 16 | 35 | 23 | 10. | 12.8 |
| Mean | | 15 | 7.3 | 28 | 40 | 59 | 14 | 8.60 | 22.84 | 23 | 43 | 22 | 8.5 | 12.4 |

border in all trees, but this trend was milder at intermediate altitude, which means a fairly good postcambial growth of fibers at the former altitude. Although, this result could not be taken as an important factor, it does have an on juvenile wood rate production as well as the exploitation age, which is important to forest harvesting for papermaking purposes. Although the results showed that raising altitude to about 500m above the sea level resulted in a better wood structure in beech trees, this difference still could not be taken account of, as a significant difference in between. On the other hand, with respect to the evidence of the results, larger values belonged to high altitude, and so it can be predicted that increasing the elevation to above 500m could improve beech wood fiber length. Narrow ring width and variations in it from year to year should have a negative effect on fiber length variation. In fact, seriously low precipitation, a high temperature and human interference, taken together, might cause narrow ring width in the stem. A small percentage of juvenile wood makes for an earlier exploitation age in the stem, which can be taken as a positive factor in tree harvesting for papermaking purposes. However, on the other hand, shorter fiber length in the stem can be seen as a negative point. Although, wider annual rings at high altitude have not accounted for significant difference, they show us better measurements as a whole. Even though a difference in altitude of about 500m could not seriously affect fiber length or juvenile wood rate production in Iranian beech trees of Caspian forests, given the larger values at high altitude, it seems that elevation should play a positive role with beech trees when the difference is greater than 500m.

**Table 4**. Percentage of juvenile wood, exploitation age and diameter based on 20% juvenile wood the stems at high altitude.

| Charateristics of trees fature | | | | | Tree height | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1% | | | | | 75% | | | | |
| Number of sample trees | | Tree height (m) | Juvenile wood in whole stem (%) | Exploitation age with 20% juvenile wood in the stem (year) | Diameter (cm) | Number of annual rings (age) | Juvenile wood border (year) | Diameter of juvenile wood (cm) | Tree diameter based on 20% juvenile wood (cm) | Diameter (cm) | Number of annual rings (age) | Juvenile wood border (year) | Diameter of juvenile wood (cm) | Tree diameter based on 20% juvenile wood (cm) |
| 1 | Gharoon Sara | 16.7 | 9.35 | 32 | 39.6 | 56 | 18 | 12.3 | 26.8 | 20.9 | 37 | 17 | 7.0 | 14.0 |
| 2 | Resket | 18.0 | 7.33 | 34 | 43.0 | 74 | 18 | 7.0 | 25.8 | 20.4 | 34 | 18 | 12.0 | 14.6 |
| 3 | Resket | 14.0 | 9.57 | 30 | 37.7 | 54 | 18 | 12.5 | 25.8 | 19.5 | 37 | 14 | 6.0 | 12.6 |
| Mean | | 16.2 | 8.75 | 32 | 40.1 | 61 | 18 | 10.6 | 26.1 | 20.3 | 36 | 16 | 8.3 | 13.7 |

**Table 5**. Mean fiber length in 1% and 75% tree hights at intermediate and high altitudes, and tree exploitation age.

| Tree No . | Fiber length | | | | | |
|---|---|---|---|---|---|---|
| | Intermediate altitude | | Exploitation age in tree (year) | High altitude | | Exploitation age in tree (year) |
| | 1 % | 75% | | 1% | 75% | |
| Tree no1. | 1.20 | 1.08 | 28 | 1.39 | 1.45 | 32 |
| Tree no2. | 1.45 | 1.27 | 24 | 1.41 | 1.20 | 34 |
| Tree no3. | 1.44 | 1.31 | 32 | 1.39 | 1.44 | 30 |
| Sum | 4.09 | 3.66 | 84 | 4.19 | 4.09 | 96 |
| Mean | 1.36 | 1.22 | 28 | 1.39 | 1.36 | 32 |

**Table 6.** Statistical comparison of fiber length and exploitation age at intermediate and high altitudes, using t-test method.

| Sources of Variation | Df. | $SS_A$ | $SS_B$ | S | t | $t_t$ |
|---|---|---|---|---|---|---|
| Fiber length of 1% tree height | 4 | 0.039 | 0.0003 | 0.009 | 0.389 | 4.604 ns |
| Fiber length of 75% tree height | 4 | 0.029 | 0.039 | 0.017 | 1.346 | 4.604 ns |
| Exploitation age | 4 | 32 | 8 | 10 | 2.50 | 4.604 ns |

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# تاثیررویشگاه بر تشکیل جوان چوب و طول الیاف، مطالعه موردی راش ایران

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## چکیده

میانگین طول الیاف در سه درخت راش ( *Fagus orientalis L.* ) در دو ارتفاع تنه ( ۱ و ۷۵ درصد ) در ارتفاع میان بند ( از ۵۰۰ تا ۱۰۰۰ متر ارتفاع از سطح دریا ) در جنگلهای خزری منطقه ساری بترتیب ۱/۳۶ و ۱/۲۲میلیمتر بدست آمد که بسیار نزدیک به مقدار بدست آمده برای سه درخت در ارتفاع بالابند ( از ۱۰۰۰ تا ۱۵۰۰ متر) به مقدار ۱/۳۹ و ۱/۳۶ میلیمتر بود. میانگین طول الیاف در تنه با استفاده از فرمول الیاف در تنه برای ارتفاع میان بند و بالابند بترتیب ۱/۳۱ و ۱/۳۸ میلیمتر حاصل گردید که نیز بسیار بهم نزدیک بودند. جوان چوب در تنه در ارتفاع میان بند شامل ۱۷ حلقه رویش سالیانه بود که ۷/۳٪ حجمی تنه را بخود اختصاص میداد ولی برای ارتفاع بالابند ۱۸ حلقه و ۸/۷۵٪ حجمی تنه را در بر می‌گرفت. دلیل بیشتر بودن در صد جوان چوب در ارتفاع بالا بند تا حدودی به پهن‌تر بودن حلقه رویش سالیانه مربوط

می‌شود. میانگین پهنای حلقه سالیانه در پائین و بالای تنه در ارتفاع میان بند بترتیب ۱/۸۲ و ۲/۹۵ میلیمتر بدست آمد در حالیکه برای ارتفاع بالا بند ۲/۹۷ و ۳/۳۷ میلیمتر بود. علیرغم ارقام بدست آمده مقایسه بکمک روش آماری t ، ( t-test ) نشان داد که بین میانگین طول الیاف دو نقطه در دو حد ارتفاعی در سطح ۱٪ اختلاف معنی‌داری وجود ندارد. سن بهره‌برداری که کاملا" به مقدار جوان چوب در تنه بستگی پیدا میکرد در ارتفاع بالا بند بیشتر از ارتفاع میان بند بود اما مقایسه آماری در سطح ۱٪ اختلاف معنی داری را بین آنها نشان نداد. بنابراین در جنگلهای خزری اختلاف ارتفاع در حدود ۵۰۰ متر نتواسته است تأثیری بر طول الیاف ، سن بهره‌برداری و مرز جوان چوب باقی گذارد.