

Determining the Age of Olive Trees through Morphometric Methods

Hairi ISMAILI

Agricultural University of Tirana,
 Albania Gene Bank, Str. Siri Kodra 1020 Tirana, Albania
 Email: hairiismaili@yahoo.fr; hismaili@ubt.edu.al

Zaim VESHAI

National Institute of Fruit Trees,
 Departamenti iullirit, Shamogjin, Vlora Albania
 Email: zaimveshaj@ubt.edu.al

Abstract – Olive groves in Albania make up 20 % of the surface encompassing several centennial trees. The history of their domestication represents a mixture of the mediterranean basin with the interference of wild and partially wild olives. Morphological and statistical indices were modelled during the period of 2013-2014 to estimate the growth rhythms of the trunk and the neck in order to determine the age of the trees. Two cultivars “Kaninjot” and “U.Bardhe” were chosen randomly in three plots of 50 trees each. They were examined for morphometry. Annual thickening was caused by the cambium of the Neck (N) and trunk (T). The results showed that circumferential growth increases simultaneously with the age as per order of groups ($P_1 < P_2 < P_3$), whereas annual thickening decreases simultaneously with aging ($P_1 > P_2 > P_3$). As of lognormal statistics estimates average annual thickening of the neck during the ontogenetic cycle of the “Kaninjot” cv is 6.123 mm, whereas of “U.Bardhe” 4.222 mm. The neck of the trunk is considered the main regenerative immortal organ and analysis on its morphometry enables estimation of high levels of accuracy.

Keywords – Statistical Indice, Olive, Lognormal, Morphometry, Thickening.

I. INTRODUCTION

Several molecular studies about “Kaninjot” and “U.Bardhe” cvs have emphasized the autochthonous origin and genetic variety with the varieties of the neighbour countries [1 ; 2]. Spontaneity of oleasters and wild olives in the ionian area allows for the assumption of the origin this species has even in Albania [3]. Domestication of the olive has gone through a hard period and it is impossible to be determined accurately for all mediterranean countries [4 ; 5]. In Albania, the olive is considered a « myth » considering the economic and ecological importance that it has [4 ;5]. in the meantime this tree is one of the best biological indicators of the mediterranean climate in this country [6 ; 7; 8]. There are around 15 thousand hectares of old olives in our country, whose age is impossible to be identified for sure: Several dendrological attempts have evidenced the difficulties of this method because the olive tree contains cavities, irregular evergreen trunk and unidentifiable growth rings [3]. In general age evaluations have been connected to religious mythology, history of ancient cities, castle building etc, but not on scientific elements. This research has put in practice for the first time, some morphological indices and statistical models to evaluate the growth of the trunk and the neck, as well as the age of the tree. As the neck is the main regenerating organ, analysis on its morphology enables a higher level of accuracy in determining the age.

II. MATERIALS AND METHODS

Study Area: 6 olive plots of “Kaninjot” and “Ulli Bardhe” cvs were chosen during 2013-2014. Their age had been identified and certified based on documents and historical data. 3 plots were chosen randomly per each cultivar containing 50 trees, with an area of 4 km² i.e. 300 trees for both varieties.

A. Experiment I. “Kaninjot” cv (Kan):

Plot 1, 50 trees at the age of 50 in Shamogjin, Vlora

Plot 2, 50 trees at the age of 130 in Trevllazer, Vlora

Plot 3, 50 trees at the age of 300 in Kanine, Vlora.

B. Experiment II. “Ulli i Bardhe” cv (UB)

Plot 1: 50 trees at the age of 50 in Linze, Tirana

Plot 2: 50 trees at the age of 130 in Tufine

Plot 3: 50 trees at the age of 300 in the area “Ndën rrepet” in Kruja.

Research indices; each tree underwent measurement procedures about: (i) Circumference of the neck and trunk (cm) *Fig-1 and 2* (ii) Circumference of the trunk in (cm), at the height of 60 cm from the neck, *Fig-1 and 2* (iii) trunk height in cm, measured from the neck to the part where skeletal branches emerge. (iv) Nr of branches differentiated above the neck.

Statistical analysis: a total of 300 trees were used for the statistical analysis. Descriptive statistics was calculated within and among three plots, with univariate, F-test for the distinctions among trees. Variability was tested for each character with welch's test tukey-kramer. Statistics estimates by lognormal, weibull, loglogistic and frechet has calculated the dynamics of neck and trunk thickening during the ontogenetic cycle of the tree. [9 ; 10].

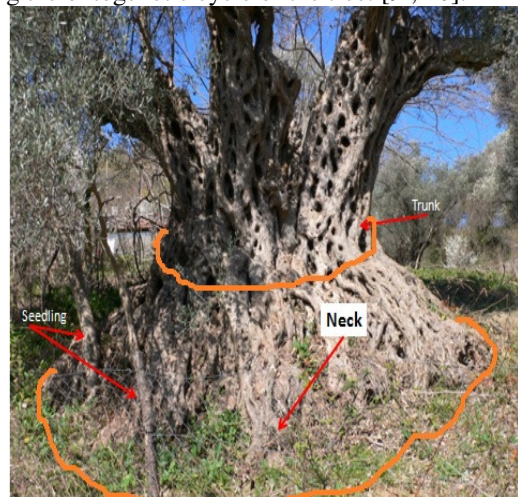


Fig.1. Presentation of the trunk and neck olive trees of “Kaninjot” variety,

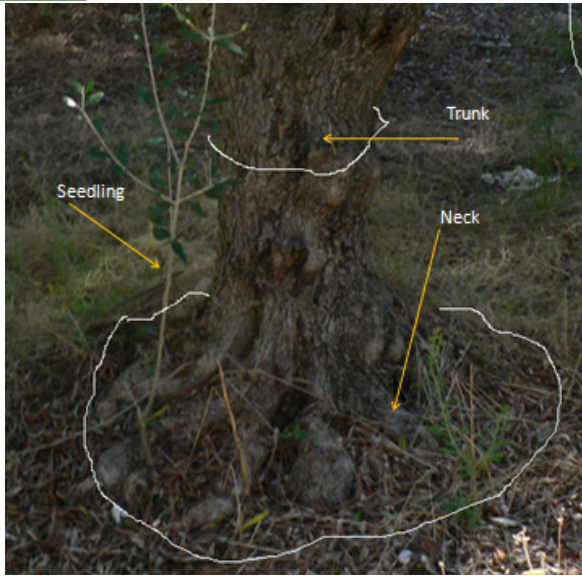


Fig.2. Presentation of the trunk and neck olive trees of “U.Bardhe” variety

III. RESULTS AND DISCUSSIONS

The neck and the trunk are covered by a superphelloderm stratum 15-25 mm thick. The cambium or the tree functions throughout the whole year, from spring to autumn and its function are to thicken the neck and the trunk. The heart of the trunk has mechanical function and is made up of dead cells, rich in resin, tannin, mineral matter such as: calcium carbonate, silicon carbonate etc of protective function. In case one of these matters lacks the trunk creates cavities [11; 12].

Biometrics of the neck: The neck is volumetric, made up of lumps and numerous ovules which deform the outer surface considerably. The Neck’s circumference had different values statistically caused by the influence of age, *Table-1*. Circumference differences were small and

unproved within the trees of each group, *Isd. 1.2311*, while there was a great variation among Plots varying from $Cvs=9.3-45.8$. Analysis of mean squares of the plot displays proved differences, which serves as proof that thickening has been simultaneous with the age. *Dendogram-3* displays that thickening caused by cambium is dynamic and has changed depending on age. In “Kaninjot” cv after 50 years the neck has circumference of 2.16m, and thickness 4.28cm/year/tree. On the other hand in the 130-year-old tree; the neck has reached 3.42m, whereas the values of thickness 2.57cm/year/tree. When Kaninjot cv turns 300 years old circumference of the neck increases up to 4.45 m/tree, but its annual thickening rhythms were lower than the other groups (1.44cm/year/tree) which are ranked as follows: $(P_1 > P_2 > P_3)$.

“U.Bardhe” cv after 50 years has a circumference of 0.96m, grown through annual thickening 1.93cm/year/tree, when the tree is 130 years old the neck reaches 2.48m, enabled through thickening 1.88cm/year/tree. In 300-year-old-trees circumference of the neck increases up to 4.23 m/tree, but annual rhythms of thickening were lower 1.37cm/year/tree, ranking as follows: $(P_1 > P_2 > P_3)$. Obviously differentiation between the new and old wood that thickens the neck displays two contradictory features: (i) because growth in thickness occurs progressively and simultaneously with aging ranking as follows $(P_1 < P_2 < P_3)$ whereas (ii) annual thickness decreases progressively $(P_1 > P_2 > P_3)$. The average number of the differentiated branches over the neck displayed increasing density simultaneously with aging. Respectively “Kaninjot” and “U.Bardhe” cvs at the age of 50; 0.32 and 0.56 branches/neck; at the age of 130 only 2.4 and 3.3 branches; at the age of 300, 7.8 and 12.3 branches. Density of branches in the neck served as an index for the physiological state, especially the degree of amortization at the aerial part. [11].

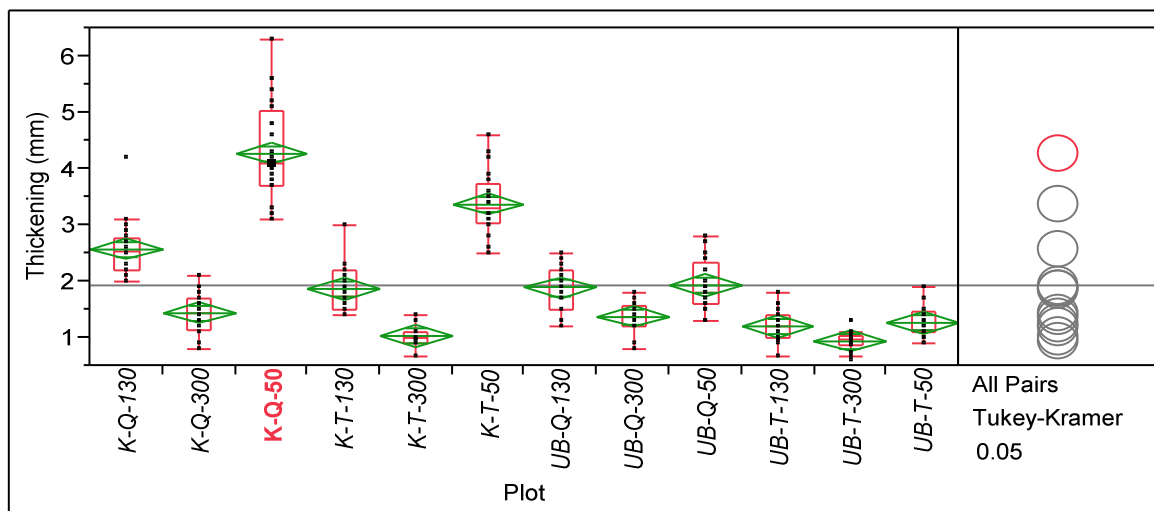


Fig.3. The variance analysis, for twelve plots in two varieties (K=Kaninjot and UB=Ulli Bardhe) of Thickening by Plot (Means Comparisons for all pairs using Tukey-Kramer, alpha 0.05). The changes in the variance of the Thickening values have been expressed through plots which result:

Table 1: The data of variance analysis, means and std deviations, for twelve plots in two varieties (Kan=Kaninjot; UB=U.Bardhe) of Thickening and Circumference of trunk and neck

Plot	Mean Circumference	Mean Annual Thickening	Score Mean	(Mean-Mean 0)/Std0	Prob > F Thickening	Prob>ChiSq Thickening	CV Circumf	CV Thickening
Kan/Neck/130	342.9 ±65.3 b	2.57±0.49 c	0.7638	3.635	0.0054*	<.0001*	26	25.5
Kan/Neck/300	445.2±105 a	1.44±0.35 ef	-0.3199	-1.522	0.0102*	<.0001*	42	18.2
Kan/Neck/50	216.7±41 ef	4.28±0.88 a	1.6721	7.958	0.0033*	<.0001*	16	45.8
Kan/Trunk/130	245.4±55 de	1.86±0.41 de	0.2178	1.037	0.0016*	<.0001*	22	21.3
Kan/Trunk/300	307.2±57 bc	1.03±0.18 fg	-1.0632	-5.060	0.0122*	<.0001*	23	9.3
Kan/Trunk/50	169.9±27 f	3.38±0.55 b	1.2125	5.771	0.0041*	<.0001*	11	28.6
UB/Neck/130	248±50 cde	1.88±0.38 de	0.2405	1.144	0.0144*	<.0001*	20	19.7
UB/Neck/300	423.2±81.6 a	1.37±0.27 fg	-0.3945	-1.877	0.0079*	<.0001*	32	14
UB/Neck/50	96.9±20.9 g	1.93±0.42 d	0.2860	1.361	0.0071*	<.0001*	8.4	21.8
UB/Trunk/130	159.7±35.5 f	1.20±0.26 fg	-0.6987	-3.325	0.0133*	<.0001*	14	13.5
UB/Trunk/300	285±57 bcd	0.94±0.18 g	-1.3443	-6.398	0.0101*	<.0001*	23	9.4
UB/Trunk/50	63.8±14.5 g	1.26 ±0.29 fg	-0.5722	-2.723	0.0133*	<.0001*	6	15.1

Levels not connected by same letter are significantly different. Means, comparisons for all pairs using tukey HSD, $q^* 3.202$, $\alpha 0.05$ Prob>F <.0001*

Biometrics of the trunk: The morphological changes of the trunk while aging are similar to the changes of the neck, but there are changes considering the appearance. “Kaninjot” cv had different circumference among different age groups (P_1 , P_2 and P_3) respectively: 1.69, 2.45 and 3.07m, and average annual thickening 3.38, 1.86 and 1.03cm/year/tree, whereas “U.Bardhe” cv had different dimensions depending on the age. The trees in P_1 , had trunk circumference 0.64m and thickness 1.26cm/year/tree; the trees in P_2 , 1.39m and thickness 1.20cm/year/tree, whereas trees in P_3 had circumference of 2.85m and thickness 0.94cm/year/tree. Thus wood differentiation (Cambium) increases trunk circumference simultaneously with growing, increasing ranking progressively as follows ($P_1 < P_2 < P_3$), whereas intensity of annual thickening has moved towards the opposite direction, ranking as follows ($P_1 > P_2 > P_3$). Trunk heights had different results within groups and among groups, respectively for “Kaninjot” cv: 0.93m, 1.37m and 2.12m, whereas for UB cv 1.15m, 1.45 and 1.78m. High trunks displayed lower values of 12% of circumference.

Morphometry of the Neck and the Trunk: the neck thickens, grows old and is renewed systematically, but it never dies. The trunk might die, but prior to that, the neck renews one or several substitute trunks, as the neck is an immortal organ of the tree, it is the renewing organ. Circumference of the neck is greater than circumference of the trunk and the ratio between the varieties is (*Kan-1:07 and UB-1:0.66*). When the tree ages it differentiates several branches at the circumferential area of the neck, it substitutes the trunk and in this way the tree is constantly renewed, it never dies because of growing old [11].

Discriminate power values calculated for the neck is 91.2% while for trunk 63.2% of the total variance of trees, and confirmed the discriminates between the neck and the trunk.

The significant variables contributing to the discrimination between plots and varieties, are “anatomical neck” and “anatomical trunk”, two strongly correlated variables, *Table-1*. The correlation is not strong between thickening annual of trunk and neck ($r=0.16$), ie IF the neck is normal dynamic of thickening, these are not

normal values for trunk. In this correlation has influenced varieties, climate, technology etc [13].

Morphometric correlation of the growth logarithm: Orthogonal analysis of regression in *figure 4*, represents the correlation between the circumference (X) and annual cambial thickening (Y), their ratios and functional probabilities simultaneously. It has been proved that whenever there is a change in the neck circumference (NC) and trunk circumference (TC) there is a change in the annual value of thickening mm/year/tree. Through morphometric data of the period under study we have predicted an assumption model for the future of the life of the tree, through the formula; $E(y_i) = mx_i + b$. The hypothesis were analyzed and displayed in *Table 2 and figure 4*, and were based on the value of F, $F = \frac{x}{y}$ which

resulted $F^* \geq P=0.05$. Assumption for the correlations among C, N and annual thickening, were based on two components x and y and have observed the variation of Y (thickening) in any case. Morphometry variance of N and T, and probability of variation is $0.46 > P=0.05$, thus proving the hypothesis as probability is higher. Annual thickening was caused by cambium of the neck (N) and the trunk (T) which were statistically accepted. Referring to $\alpha=0.05$, factual difference (fd) was lower than the limit difference (ld) ($fd < ld$), $ld=2$ (region of acceptance) proving that cambium growth is the cause of neck (N) and trunk (T) expansion, *table 1*. Following the ontogenetic cycle the hypothesis for age calculation was supposed as related to morphometry of the neck (N) according to the logarithm of annual thickening, as of the formula;

$$Y = \ln(A \cdot B^{mx})$$

In *figure-4*, Logarithm of annual thickening consistently displays a decline; up to pause (*0.001mm*). In “Kaninjot” cv this occurs after 2000 years and in “U.Bardhe” after 2800 years. Continuing hypothesis; Orthogonal life regression by statistics estimates of lognormal, weibull, loglogistic and frechet of thickening has calculated the percentiles of the x^2 distribution, and entry is $X^2(A; V)$ were $P\{x^2(v) \leq x^2(A; v)\} = A$. the x axis are the values from probability 0.005 -0.99, while the y axis (y), are the values of varieties [10], *Table-3*.

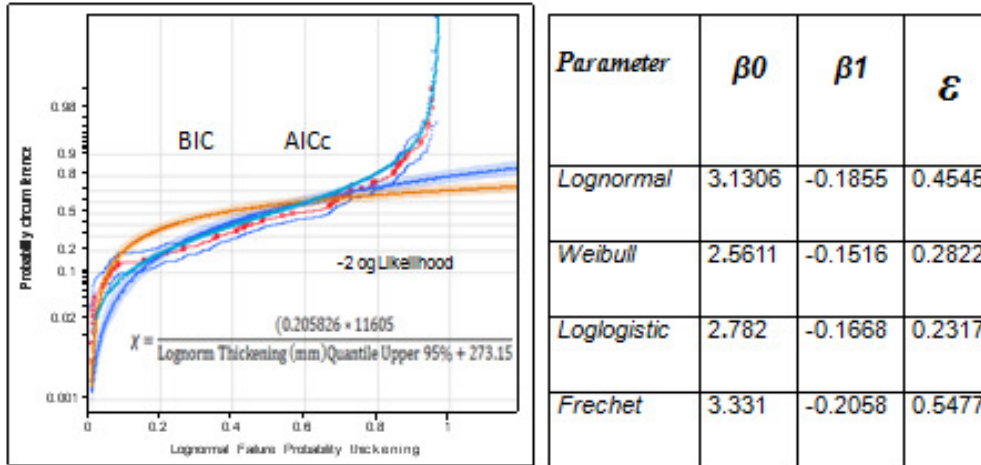


Fig.4. Orthogonal regression of the thickening of neck tested by statistics estimates of lognormal, weibull, loglogistic and frechet, for the annual logarithmic value probability.

Table 3: Selected probability and the logarithmic value of annual thickening olive “Kaninjot” and “U.Bardhe” variety.

Cumulative probability Variety	0.90	0.95	0.975	0.98	0.99	0.995	0.999
Kaninjot-Annual Thickening	6.123	6.229	6.273	6.300	6.372	6.411	6.433
UB- Annual Thickening	4.222	4.289	4.322	4.335	4.348	4.361	4.374

In conclusion: in any case the physical morphometric components are available (A) and the logarithm value of varietal cambial (B) derive by the non linear regression, the age of the olive tree is evaluated as per formula:

$$M = \frac{P}{L}$$

where; P=circumference of the neck (mm) and L= logarithmic value of cambial thickening tested through lognormal statistics, *table-3 and figure-4*. In *table-3*, the logarithmic value of cambial thickening is in correlation with cumulative probability and different from one variety to the other and has genetic character. For the “Kaninjot” cv it is 6.123-6.433mm, whereas for “U Bardhe” cv, 4.222-4.374mm.

IV. CONCLUSION

Morphological indices of the neck and trunk of the tree resulting from statistical analysis have enabled modelling in the current and cultural conditions for the individualization of the profile for the age through biometrical methods. The mechanism of neck and trunk thickening was caused by the activity of cambium per year, at different intervals of the annual cycle and progressively pursuant to the ontogenetic cycle. The neck of the trunk resulted the most regenerative main organ, immortal and analysis on morphometry has provided approximate estimate about age at acceptable levels of accuracy. The logarithmic value of cambial thickening is the essential index which has had a genetic influence, thus it should be analyzed in advance for each variety based on statistical analysis.

REFERENCES

- [1] Belaj, A., Satovic, S., Ismaili, H., Panajoti, Dh., Rallo, L. (2003): RAPD genetic diversity of Albanian olive germoplasm and its relationships with other Mediterranean countries. *Euphytica* 130. 387-395
- [2] Lumaret, R., Ouazzani, N. (2001) *Ancient wild olives in mediterranean forests. Nature* 413, 700. doi:10.1038/35099680
- [3] Ismaili, H., Gixhari, B., Osmani, R. (2013): The diversity of genetic resources In the Albanian olive, *Agriculture and Forestry*, Vol.59. Issue 3: 35-46, 2013, Podgorica.
- [4] Zohary, D., Hopf, M, Weiss E. (2012). *Domestication of plants in the Old World: The origin and spread of cultivated plants in Southwest Asia, Europe, and the Mediterranean basin*. Oxford, UK: Oxford University Press.
- [5] Kaniewski, D., Van Campo, E., Boiy, T., Terral, JF., hadari, B., Besnard, G. (2012): *Primary domestication and early uses of the emblematic olive tree: palaeo botanical, historical and molecular evidences from the middle east*. *Biol. Rev.* 87, 885–899. doi:10.1111/j.1469-185X.2012.00229.x
- [6] Carrión, Y., Ntinou, M., Badal, E. (2010). *Olea europaea L. in the North Mediterranean Basin during the Pleniglacial and the Early-Middle Holocene*. *Q. Sci. Rev.* 29, 952–968. doi:10.1016/j.quascirev.2009.12.015
- [7] Blondel, JJ., Aronson, J., Bodiou, JY., Boeuf, G. (2010). *The Mediterranean region: biological diversity in space and time*. Oxford, UK: Oxford University Press.
- [8] Terral, JF. et al. (2004) *Historical biogeography of olive domestication (Olea europaeaL) as revealed by geometrical morphometry applied to biological and archaeological material*. *J. Biogeogr.* 31, 63–77. doi:10.1046/j.0305-0270.2003.01019.x
- [9] SAS. 2008: *SAS users guide; SAS/STAT, version 2008*. SAS Institute Inc., Cary, N.C.
- [10] Pearson, J., Hartley, (1972). *Biometrika Tables for statisticians, Volume 2, 1972* published by the Cambridge University Press, on behalf of the Biometrika Society.
- [11] Baldini, E., and Scaramuzzi, F. (1955). *Ulteriori indagini sulla validità del metodo bio-statistico nella descrizione e classificazione delle cultivar di olivo*. *Ann. Sper. Agr.* 9:171-186.
- [12] Ismaili, H., Cantini, C., Ianni, G., Lloshi, I. (2012). *Exploration and Selection of the Olive Genotypes* *J.Int.Environmental*



- [13] Alessandri, S., Fiorino, P., (1995). Differenze inter varietali nella morfologia del polline di cultivar di Olea europea Atti del Covegno Oliv. Mediterranea

AUTHOR'S PROFILE



Hairi Ismaili

Has 30 years working for the scientific research in the field of olive. Researcher in the Albania Gene Bank and lecturer at the Crop Production Department of Agricultural University of Tirana. Has published more than 120 scientific articles, 20 books, and has participated in 35 conferences. This

article belongs to the field of his research.