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STUDY OF CORRELATIONS AMONG VEGETATIVE GROWTH, FRUIT AND OIL SYNTHESIS IN THE OLIVE

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Abstract

This study treats interdependence of vegetative growth of olive, oil synthesis and growth of the fruit to three olea europaea variety. Analysis was based on statistical modeling for Bivariate analysis for Statistics Estimates, according Diagnostics and multivariate correlation matrix analysis, for the flowering period of olive maturity. Percentage of olive oil was characteristic varietal and expressed great variability inter varietal. (*lsd 1.233 q=0.05*). The dynamic of oil formation have been the same sense with the growth of fruit. ($R^2=0.933$). The polp of fruit has increased in correlation with weight. ($r^2=0.881$). Fruit weight has fluctuated from 1.1 to 3.6g. The fruit growth was 11- 22 mlg/day, oil 3.7-6 mlg/day and vegetative growth 0.9-2.4 mm/day. Frutis after bonding have increased with velocity and vegetative growth is medium. In the phase of sclerification of endocarp; fruit growth, vegetative growyh and olive oil synthesis are inhibited. After this time, increase the volume of cells of pericarp, is done intensive synthesis of oil; decrease in maximum vegetative growth. Percentage of olive oil at the time where the fruit has the maximum weight constitute the biological value of the variety. After this moment is reduced fruit weight ($r^2=312$), while the percentage of oil increases as a consequence of dehydration of the fruit. Vegetative growth is interrupted.

Keyword: *olea europaea; vegetative growth; pericarp; percentage;olive oil; dehydration.*

Introduction

The climate influences vegetative growth, efflorescence, the growth of fruit and the chemical components of the olive fruit (*Villiam H. K. 1994*). The temperature is of great importance because the varieties differentiate the organs based on thermal valences. The variety is important for fruit characteristics, dimensions, the ratio pulp - endocarp, etc. The formation and growth of olive fruit requires a long time and fluctuates according to the varieties from 130-210 days. During the dynamics of growth the fruit competes with vegetative growth for water and food elements. The olive differentiates a considerable amount of flowers, but their fruiting and the progress of grains up to the period of ripeness are very few or zero. This disorder has been the object of a range of different researches, which have found several aspects of compatibility and sterility, (*Cimato A. et all. 1986*) while others for flower biology, the quality of the pollen, nutritional state etc. (*Martin G. et all. 1994*). From this point of view we have studied the physiological correlations that occur within the sprig, as an organ that holds and grows flowers, fruit and vegetation to define the relations and reciprocal influences.

Materials and Methods.

Efflorescence, flowering, fruit growth and vegetative growth have been monitored in one-year-sprigs which have differentiated crowns. The study was carried out in three years and its object was the interconnection of these phenomena within the sprig in three autochthonous variety (Kaninjot, Himara and Pulazeqin). 200 flowering sprigs scattered in the 4 areas of the horizon were chosen in 5 trees of each variety. Vegetative growth was measured monthly (mm), the number of crowns (Nc), the number of flowers (Nf). Physiological dropping was evaluated in June, followed by the monthly evaluation of the dynamic of fruit weight growth, fruit dropping and vegetative growth. The monitoring of biological processes was accompanied with statistical modelling for testing variability (alpha=0.05). Bivariate analysis for statistic estimates has analyzed the correlation limits among the main indices and the amount of reciprocal influence. The degree of influence on the variability of independent factors and the importance of the relations according to eigenvalue and eigenvectors was determined with PCA correlation.


Photo-1 and 2. This olive sprig differentiates crowns and flowers, develops the vegetative growth, linking and increases fruit, simultaneously forms the fruit oil.

Results and Discussion

The varieties were characterized for their thermal constants (Kt= t-tº). Their biological processes are developed on their basis. Kaninjot cv for the differentiation, growth and ripeness for needs 2600ºC, Σ(t-tº), Himara cv. 2600ºC and Pulazeqin 2270 ºC (*Koppen W. 1923*). The sprigs have shown considerable polymorphism within one variety as well as among the varieties, which was caused by the activity of the buds, flowering and oil synthesis. The sprigs are one year old and are the biological basis for the flowering induction and the formation of carbon hydrates ($C_6H_{12}O_6$) (*Tombesi A. et all.1986*) (*Boulouha B. 1994*). (*Photo-1 and 2*)

In March the buds of each sprig have differentiated crowns in the armpit of the leaves, whereas the bud of the top has a vegetative sprig. Small fruits appear immediately after flowering and fertilization, a part of whose has dropped for physiological causes, incomplete fertilization by the high temperatures and lack of nutrition, (*El Khavaga AS 2007*). The quantity of the dropped flowers has been different and depended on the variety (*HSD. lsd.1.1311, q=0.05*) Kaninjot cv. 37.8%, Himara cv. 45.1% and Pulazeqin cv. 45.3%. After physiological dropping fruit development has undergone three important stages: (i) in June-July, the fruit undergoes intensive growth and endocarp is formed due to rapid cell division. (ii) In August growth has been stopped because the embryo is developed and endocarp is sclerified. (iii) In September the fruit re-starts to grow, forms the pulp by increasing in volume the endocarp cells. (*Photo-1 and 2*)

Fruit growth, vegetative growth and the formation of oil were created during a different active period of time. Σ(t-t°), while the biological processes were in unity and contradiction. Pulazeqin cv has a shorter biological period (2270°C), whereas Kaninjot and Himara cv display no differences (2600ºC)

Vegetative growth, flowering and fructification. Vegetative growth and fructification were developed following the active period, *tukey-kramer lsd 1.78. q=0.05*, (*Tab-1)*. As it can be seen, vegetative growth was developed from March to December and displayed obvious oscillations. After the differentiation of the top of the bud (vegetative) the sprigs grew rapidly and they decreased the rhythm of the fruiting period of time. Vegetative growth was dominant at two different moments: In the period March - May, and after endocarp sclerification in September. In general, vegetative growth and fruit growth are in contradiction during their development cycle (*Villemur P et. All. 1978*). This is expressed with a negative correlation coefficient (r^2= -0.706), and the coefficient of variation for three varieties cv=7.5%. Whereas vegetative growth with flourishing, have a strong connection and without negative impacts, value of correlation coefficient positive r^2=0.864 and varietal variation coefficient, cv=5.9%.

Table-1, Data on analysis of variance of cv. Kaninjot, Himara and Pulazeqin for fruit growth, vegetative growth, % oil by Month.

Month	Kan. Fruit growth (g)	Him. Fruit growth (g)	PZeq. Fruit growth (g)	Kan. Veg. Growth (mm)	Him. Veg. Growth (mm)	PZeq Veg. Growth. (mm)	Kan. Oil. (%)	Him.Oil. (%)	PZeq Oil (%)	Kan. LF. (%)	Him .LF. (%)	PZ. LF. (%)
3	0	0	0	34	26	13	0	0	0	0	0	0
4	0	0	0	49	39	33	0	0	0	100	100	100
5	0	0	0	118	77	66	0	0	0	100	100	100
6	0	0	0	82	16	39	0	0	0	37,8	45	45
7	0,84 **f**	0,55 **e**	0,6 b	6	4	5	2,1 **c**	1,2 c	1,3 g	1,57	8,1	8,1
8	1,66 **e**	0,81 de	0,94 e	2	3	4	3,8 **c**	2,7 c	2,9 f	1,48	6,3	6,3
9	2,13 **cd**	1,19 cd	1,24 d	33	23	18	9,6 bc	7,1 bc	7,3 e	1,47	6,1	6,1
10	2,71 **b**	1,33abc	1,88 c	6	4	2	16,4 abc	12,5 abc	14,6 d	1,44	5,4	5,4
11	3,21 a	1,51 ab	2,12 b	1	2	2	23,8 ab	16,6 ab	17,1 c	1,43	4,9	4,9
12	3,82 **b**	1,69 a	1,88 a	1	1	1	26,1 a	17,5 ab	18,3 b	1,34	4,1	4,1
1	3,34 **c**	1,24 ab	1,37 f	0	0	0	29,4 a	19,4abc	21,6 a	1,04	2,8	2,8
2	2,78 **d**	1,1 bc	1,14 c	5	4	2	35,3 ab	21,3 a	22,3 a	0,67	0,8	0,8

Levels not connected by same letter significantly different

I.e, vegetative growth, flowering and fruit growth in the three varieties has been in unity from bud differentiation up to flowering, (r^2=0.888), (*Figure-3*). Later they follow contradictorily, detrimental to vegetative growth (r^2= 0.234), the first stage of fruit growth up to endocarp sclerification, followed by pulp formation (increase of the volume of the pericarp cells), fruiting begins to strengthen again (r^2=0.445) and this unity resists up to the beginning of October, where oil formation becomes active, and fruiting becomes weak, detrimental to vegetative growth up to fruit ripeness, (*r^2=0.123*). In table-1, vegetative growth during the period April – May is dominant and it had growth of 2.78 mm/day, later it was slowed down following the period June – August 0.59mm/day. It regained dominant position in September (1.1mm/day) and it was later characterized for minimal growth up to December (0.04mm/day). It is obvious that following the active period the growth values were different, verified by the value of the coefficient of variation. (cv=39%).

In this analysis, the relation between growth and fructification started during the period of bud differentiation (*first stage of fructification*), and continues up to the stage of fruit ripeness. In several phenophases these processes have been in disproportion and have created unfavourable situations because of nutritional rivalry.

Fruit growth and oil synthesis. The analysis proved strong interdependence among the number of fruiting, vegetation and oil percentage. When the coefficient of correlation fluctuated between the values (r^2=0.812-0.913), the quantity of the oil increased parallel with the increase of fruit weight. This progress went up to a certain limit, after which fruit weight begins to decrease whereas oil percentage increases. (*Figura-3*). Fruit in the trees after the optimal date of the moment of joining of weight with the corresponding percentage of the oil, have decreased in weight and some oxidation phenomena have increased their acidity and the unreal oil percentage. Oil percentage at the moment of meeting point constitutes the varietal biological value. After this moment fruit weight is reduced, whereas oil percentage is increased as a consequence of fruit dehydration. The correlation coefficient between the percentage of oil and the average fruit weight after their moment of joining is negative (r^2= -0.233), while cv=3.2%.

Finally the bio-physiological sprig processes and the correlations between fruit growth, the quantity of the oil and vegetative growth are shown via the ratio V=Nf/S. i.e. oil quantity (O) serves the number of fruit (Nf) and leaf surface (Sl).

The quantity of oil being a product of metabolism i.e. a genetic feature, has shown great inter- varietal variability (*lsd 1.233 q=0.05*), because the Kaninjot cv had 26.1% oil, Himara 17.5% oil, and Pulazeqin 17.1% oil. The process of oil formation within the fruit has been in strong correlation with fruit growth (r^2= 0.860), but it has been in contradiction with the vegetative growth of the sprig (r^2= -0.612), (***SAS User guide. 2008***).

Three periods have resulted interesting for each variety: (i) from fruiting up to endocarp sclerfication; the fruit undergoes intensive growth but a low oil synthesis, (ii) growth of fruit pulp up to ripeness, accompanied by maximal oil synthesis and increase of fruit weight. In *Figure-3*, The fruit pulp has increased in correlation with its weight (r^2=0.881). (iii) When the fruit gains maximal weight each variety has a characteristic quantity of oil. After this moment fruit weight is reduced whereas oil percentage is increased as a result of fruit dehydration was expressed by the correlation coefficient value (r^2= -0.233) and cv=3.2%, (*Soltani A. 2007*)..

As it can be seen in Tab-1 and *Figure-2,* in the 1st stage, the fruit have grown 8-12mlg/day, oil 1-3 mlg/day and vegetative growth 1-1,1 mm/day. Whereas in the 2nd stage, fruit growth 8- 12mlg/day, oil 1-3 mlg/day and vegetative growth 1-1,1 mm/day. In the third stage oil is increased to 12 mlg/day, whereas the fruit loses weight progressively -12 mlg/day.

In the three varieties the fruit have grown intensively detrimental to vegetative growth. Later with endocarp sclerification, fruit growth and vegetative growth were inhibited. Whereas with pulp growth even fruit grow a lot until they gain maximal weight being accompanied by minimal vegetative growth 0.2mm/day and maximal oil synthesis 8mlg/day**.** Whereas in the third stage vegetative growth becomes zero and the fruit dehydrates water, thus losing weight, while oil percentage has increased as a result of dry matter increase.

Statistical importance of the correlation of processes. Finally, the biological processes occurring in the sprigs as well as the correlation within the fruit for growth, oil formation and vegetative growth are shown via the ratio V=Nf/S. The largest the leaf surface of the sprig the biggest is the assimilation activity and the power of growth. The relation between vegetative growth and fructification in each variety have evidenced several biological ratios: vegetative growth – crown differentiation. Vegetative growth - efflorescence/fruiting, vegetative growth –endocarp sclerification, vegetative growth – pulp/fruit ripeness. The number of fruit at ripe for each variety in percentage has been different and this was an individual varietal characteristic.

The number of fruit at ripe displayed differences among the varieties because the Pulazeqin cv and Himara had a higher fruit percentage at the period of ripeness 4.9% and

4.1%, whereas Kaninjot cv 1.34%. Thus although each variety has differentiated a large quantity of flowers, their fruiting and the number of grains at ripe are considerably low.

The PCA analysis has distinguished the importance that the factors had in correlations for each variety, and it has found positive links among them. Eight independent factors possess, as it can be seen in eigenvalue (*figure-2),* 99% of the whole variability. But four factors are more important because they possess 86%. In the eigenvectors analysis of PC1 there are 76% of the possessing capacity referring to 3 vectors of the value PC above 0.3. The varieties with the independent variables are found in the axis of x, 77% whereas the difference between the axis y and z, i.e. the importance of the analysed factors is strongly interdependent with the varieties and between each other.

Prin. Components / Factor Analysis

Principal Components

EigenValue:	9.2998	1.7753	0.3950
Percent:	77.4982	14.7940	3.2914
CumPercent:	77.4982	92.2922	95.5835
Eigenvectors:			
Kan-Fruit (g)	0.30424	0.24809	0.13766
Him-Fruit (g)	0.30097	0.19047	0.29200
PZ-Fruit (g)	0.29230	0.18893	0.39855
Kan-RV (mm)	-0.29277	0.19054	-0.39592
Him-RV (mm)	-0.28201	0.25274	-0.19877
Pz-RV (mm)	-0.29945	0.23578	-0.21353
Kan-O (%)	0.27621	0.35136	-0.33082
Him-O (%)	0.28291	0.35182	-0.24962
PZ-O (%)	0.28317	0.34918	-0.24113
Kan-LF (%)	-0.27910	0.35524	0.26979
Him-LF (%)	-0.28243	0.33897	0.30720
PZ-LF (%)	-0.28692	0.31695	0.31310

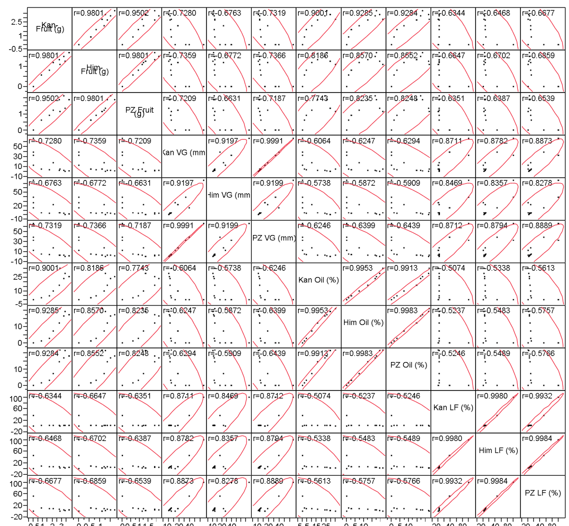

Figura - 2 Data for Principal Components Factor Analysis for three varieties: Kaninjot (Kan), Himara (Him), dhe Pulazeqin (PZ)

Figura-3 The correlations are estimated by Pairwise method in Multivariate Correlations Scatterplot Matrix the main indicators for cv. Kaninjot, Himara and Pulazeqin.

The bivariate analysis - correlation parwoise, has analyzed the level of double relations and has defined the importance and the sense of the relation between the factors and the cultivars.

The mentioned considerations were proved through analysis of the variance which resulted in a lower value at F in the minimal limit of importance (5%). Vegetative growth, oil formation and fruit growth are important factors, they rank in PC1 and have a coefficient of correlation 0.8-0.92. In this case they grow the sprigs as a biological basis for the year in succession, fruit and fruit growth, and form oil in quantity and quality. Each sprig has maintained 4-13 fruit, and fruit weight in the sprigs has fluctuated from 12-36 grams.

In diagram 4 and 5, indicates with Statistics Model Comparisons according to Diagnostics -2Loglikelihood*, and parametric estimate; weibull α and Weibull β (figura-5)* have proved the correlation and the impact for each variety with oil synthesis process, vegetative growth and fruit growth, the link of flowers and fruits, and their performance until matyrity. After biological matyrity reduced fruit weght associated with not real increase te percentage of oil. *Average oil = -14.69933 + 18.692539*Average Fruit + 3.0176342*(Average Fruit 1.13917)^2 - 7.3626403*(Average Fruit-1.13917)^3.*

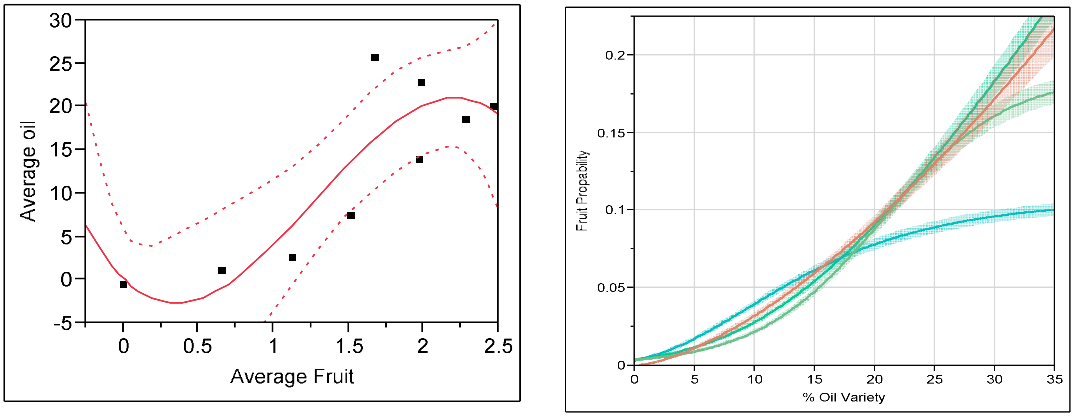

Figura -4 and 5. Bivariate normal ellipse Fit of Average Fruit By Average oil, P=0.05, for three olive variety, Kaninjot, Himara and Pulazeqin.

While elaborating the analysis, when we say that Fruit Growt,h has strong connectin with Oil Synthesis in fruit, are accepted for the level of a = 0.05, we must understand that this acceptance is statistically important for a=0.05 and t***f <tk***. (t>2). r^2= 0.821-0.900.

In the flowering phenophase and until the fruit matures, the ***value*** tf>tk, 2.2092>2. This proves the hypothesis that vegetative Growth influences on the flower fertility, oil synthesis and fruit growth. the result is statistically unimportant for a level of the value tf<tk.

Conclusions

Three olive varieties have different individuality, have specific relations with the environment, have different thermal constant, consequently, different behaviour for biological processes, above all for fertility and oil synthesis in fruits.

The biological processes occurring in the sprigs as well as the correlation within the fruit for growth, oil formation and vegetative growth are shown with typical values of interdependence.

During the vegetative cycle, each variety ha demonstrated different values of the relations with positive or negative inpacts.

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