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Mineralogy and quality of the cork according to the to the brushwood status in the oak cork forest of M'Sila (North-West of Algeria)

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ABSTRACT

Cork is the bark of the cork oak (*Quercus suber* L.), it is a renewable product of a sustained value, and it is biodegradable and recyclable. Its use is diversified and its global demand is highly prized. The perfect knowledge of its various components allows better management of the species in the forest and in industry since it is marketed according to its visual quality. The present word studies the mineral composition of cork from 60 trees from two different natural environments, one is scrubby and the other is not scrubbed. The quality of the cork on the sample trees and the quality indices were estimated by the coveless. Analysis of variance of the mineral composition revealed that phosphorus and magnesium are attached to the underwood condition. On the other hand, only the potassium content significantly contributes to the cork quality classification and in lesser degrees the phosphorus. The growth complexity of the species and its genetic variability strengthen its great adaptation regardless of the vegetative conditions of the environment.

1. Introduction

The relationship between forest tree growth and biotic and abiotic factors is complex, based on soil fertility and stand responses to abundance or scarcity (Plamondon, 2009).

The nutrients needed for forest growth are not unlimited. In fact, since the beginning of the post-glacial period, soils have constantly evolved and developed according to the mineralogy of the soft deposits, the climate, the vegetation that developed there, and the disturbances that have occurred (Duschesne and Houle, 2009).

Indeed, forests can only have good health if their environment is rich in nutrients. Ebenmayer (1976), in assessing annual litter inputs and their effects on tree growth, demonstrated that a large proportion of the nutrients taken from the soil annually by the tree, returned to the litter annual.

Other inputs come from precipitation and alteration reactions and chemical changes in rocks where nutrients such as calcium (Ca), magnesium (Mg) and potassium (K) are available for tree growth (Bray and Gorham, 1964; Marschner, 1994).

The cork oak is part of the forest trees that interact with their natural environments by drawing from the soils the mineral elements necessary for its radial and suberous growth. Cork is a renewable product, the result of the geochemical cycle of nutrients in forests that accumulate in cork tissue (Pereira, 2007).
During the process of cork formation, disturbances in forests affect growth, color, texture, density and frequency of porosity. These alterations define cork quality and can limit these applications because they are considered defects (Molinas and Oliva, 1990).

The assessment of this visual quality rests solely on the professional experience of the operator. This method of classification therefore requires a long experience and remains rather subjective compared to the recent technology like the coveless. This constraint of subjectivity has had a negative impact on the exact estimate of the price of cork at the place of production and on the markets (Dehane, 2012).
Indeed, industrialists would like to better control their supply and therefore know the factors that favor the production of quality cork, tree and stand parameters, environmental parameters, management parameters and better still, to find objective criteria for measurement of quality that can be easily quantified (Courtois and Masson, 1999a).

The only parameter in relation to the management mode of the cork oaks, and the known effects on quality, concerns the condition of the underwood that surrounds the cork oak. According to Bossuet (1988), too high a density of cork oak would lead to strong competition between trees, a weak vegetative state with a small increase in wood and cork, and poor cork quality.

Studies that have addressed the effect of cork technology (quality) and undergrowth on its mineral composition are absent. The only available studies deal with the problems between the mineral composition of

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cork and the mineral composition of cork oak leaves in relation to the production and quality of cork (Orgeas and Bonin, 1996; Courtois and Masson, 1999b).

The aim of this work is to elucidate part of the relationship between the quality of cork and its mineral composition of 60 samples from two vegetative situations in the M'Sila forest: cork oak trees that are strongly scrubbed and others strictly no-brushwood.

2. Materials and Methods

2.1. Stydy area

This work is carried out in the oak cork forest of M'Sila. This forest is located in the north-western of Algeria (Wilaya of Oran) (Fig.1). The climate is Mediterranean with a semi-arid variant. The average annual temperature varies from 15 to 25 ° C and the annual rainfall does not exceed 400 mm.

Since 2016 this cork oak forests has been linked by a network of permanent plots, including 75 plots in the canton of Park-M'Sila and 75 plots in the Canton of Cheikh Ben Khalifa. This grid of plots allows following the evolution of the trees according to several descriptors in particular the health status of the trees, the growth of wood and cork, etc.

We randomly selected 6 circular plots of 20m radius. These units are characterized exhaustively by a description of topography, vegetation and dendrometric measurements.

The 3 plots P1, P2 and P3 (Park-M'Sila) are covered by sclerophyllous evergreen forest, Mediterranean pine woods, maquis and scrubs. These three plots together form a brushwood area.

The three plots of Cheikh Ben khalifa: P4, P5 and P6 are very open stands composed only of very frugal grasses and a small proportion of legumes. These three plots form no-brushwood area.

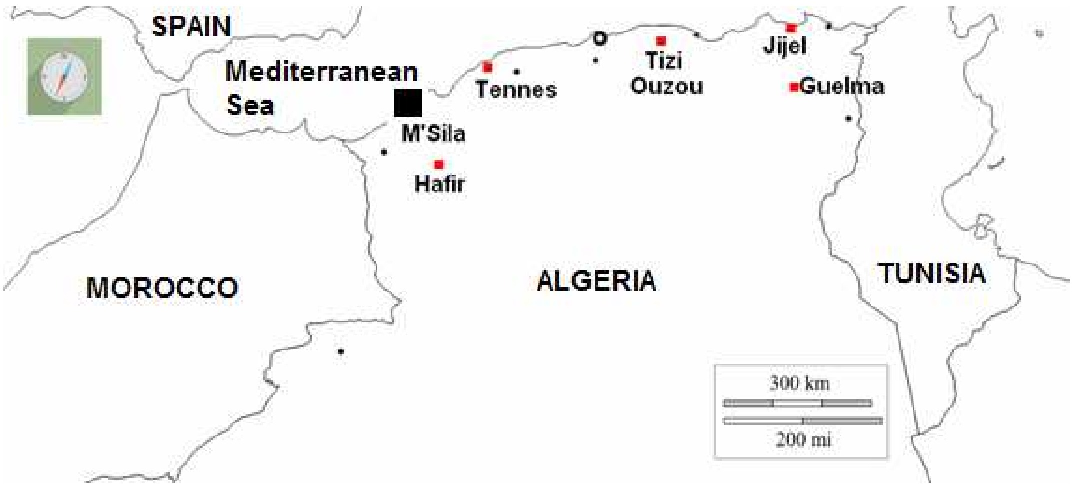

Figure 1- Geographical position of the M'Sila forest in the north of Algeria

2.2. Sampling methods

During the summer season, 10 cork oaks in production were randomly selected in each plot. Various characteristics of the trees are measured at 1.30m from the soil: diameter and height of the tree, canopy diameter, height of debarking, thickness of the cork.

The cork quality of the sample trees of the two areas was estimated by the coveless CQ05, according to the IPROCOR method (2006). The operator probes the bark of each tree 5 times over an area of interest of 10cm ×10cm at 1.30m from the soil. The coveless instantly displays and memorizes the appearance of the cork and its thickness. Each 100 cm^2 of cork tested is carefully removed from the tree without injuring the cork mother. The ten (10) calas forming the plot are numbered and stored in a plastic bag for further laboratory measurements. In the laboratory, the 60 samples from the two areas were dried in the open air for two weeks to reduce moisture.

The chronological order adopted for studying the effect of scrubbing on certain technological and mineralogical aspects of the cork is as follows:

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1- Technological aspect: all the cork samples were subjected to a careful study of the quality according to the information collected by the coveless. The 60 samples are divided into nine quality classes (IPROCOR, 2006) (Tab.1).

Table 1- Cork quality classes (IPROCOR, 2006)

Quality class	1	2	3	4	5	6	7	8	9
	19 more 6ªmore	15-19 5ªmore	15-19 6ª	13-15 5ªmore	13-15 6ª	11-13 5ªmore	11-13 6ª	11 less 4ªmore	Refuse

Each quality class has a value based on the selling price of cork (Tab.2). A quality index is calculated for a particular cork stand from the percentages of all cork choices and their value. The following quality index was proposed by IPROCOR (2006)

$$\mathbf{IQ = (5/100) \times \Sigma_{i=1\text{-}9} (A_i \times Q_i)}$$

Where:
IQ, is the index quality for cork quality of class *i*,
Q_i, *the* proportion of the volume of material of the given category in to the total volume of production (%).
A_i, the average value in egg /kg of cork from categories 1 to 9 boiled and baled.

The index quality obtained is distributed according to their respective quality classes (Tab.2).

Table 2: Cork index quality (IPROCOR, 2006)

Quality class	1	2	3	4	5	6	7	8	9
	19 more 6ªmore	15-19 5ªmore	15-19 6ª	13-15 5ªmore	13-15 6ª	11-13 5ªmore	11-13 6ª	11 less 4ªmore	Refuse
Index quality	11	19.5	7	19	6.5	12.75	5	12	1.5

In order to obtain an equitable and representative distribution between the nine quality classes, we performed homogenization at three levels A, B, C (Tab.3). A: Good quality, B: Average quality, C: Poor quality.

Table 3- Homogenization of quality classes (Chorana, 2017)

Quality level	A				B				C
Quality class	15-19 5ªmore	13-15 5ªmore	11-13 5ªmore	11 less 4ªmore	19 more 6ªmore	15-19 6ª	11-13 6ª	13-15 6ª	Refuse
Index quality	19,5	19	12.75	12	11	7	5	6,5	1.5

2- Mineralogical aspect: This step was carried out from the homogenization of the samples of the two sectors by quality classes A, B and C. For each quality level, the samples were ground into fine particles after scraping the crust. Each material obtained is preserved in a plastic bag while mentioning again the provenance (plot and tree number), the sector and the quality level.

The different of macro-nutrients content (N, P, K, Ca, Mg) are determined by standard analytical methods (Pinta, 1972; Bonvalet et al., 1986; Powels et al., 1992; Orgeas and Bonin, 1996).

The nitrogen is measured according to the Kjeldahl method and is subjected to S_2HO_4 mineralization. The phosphorus (P) is determined by a colorimetric method. Ca, Mg, are analyzed by atomic absorption spectrometry. Finally, the other macro-elements (K, N) are measured by flame emission spectrometry (in mg/g of dry matter)

2.3. Statistical analysis

A two-way analysis of variance (ANOVA 2) model was applied to test the effect of brushwood and quality on the in the mineral composition data among the duplicates. Two-way ANOVA is a special case of the linear model, being its form: $yijk = \mu + \alpha,j + \beta i, + \gamma ij + \varepsilon ijk$
Where:
yijk = is a matrix of studied variable observations (with row index i, column index j, and repetition index k)
μ = a constant matrix of the overall mean.
$\alpha \cdot j$ = a matrix whose columns are the deviations of each class of quality (A,B,C).
$\beta i \cdot$ = a matrix whose rows are the deviations of each areas (brushwood and no- brushwood).
γij = a matrix of interactions. εijk = a matrix of random disturbances.

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3. Results

The table 4 summarizes the results of the analysis of inorganic content of the cork according the presence or absence of the underwood and the quality of cork.

Table 4- Results of the inorganic content of cork according to the underwood and quality of cork

Underwood status	*Cork quality*	*Statistical*	*P*	*K*	*Ca*	*Mg*	*N*
brushwood	A	Mean	0.031	0.284	0.179	0.024	0.045
		N	16	16	16	16	16
		Standard deviation	0.008	0.083	0.062	0.013	0.016
	B	Mean	0.026	0.211	0.153	0.020	0.044
		N	9	9	9	9	9
		Standard deviation	0.010	0.047	0.049	0.005	0.026
	C	Mean	0.023	0.154	0.153	0.022	0.048
		N	5	5	5	5	5
		Standard deviation	0.008	0.060	0.044	0.009	0.025
	Total	Mean	0.028	0.240	0.167	0.022	0.045
		N	30	30	30	30	30
		Standard deviation	0.009	0.085	0.056	0.010	0.020
No-brushwood	A	Mean	0.021	0.269	0.186	0.044	0.051
		N	18	18	18	18	18
		Standard deviation	0.008	0.079	0.059	0.012	0.018
	B	Mean	0.014	0.143	0.170	0.040	0.030
		N	3	3	3	3	3
		Standard deviation	0.010	0.015	0.078	0.005	0.017
	C	Moyenne	0.014	0.181	0.163	0.040	0.043
		N	9	9	9	9	9
		Standard deviation	0.010	0.063	0.042	0.007	0.024
	Total	Mean	0.018	0.230	0.177	0.042	0.046
		N	30	30	30	30	30
		Standard deviation	0.009	0.085	0.055	0.010	0.020
brushwood + No-brushwood	A	Standard deviation	0.025	0.276	0.182	0.034	0.048
		N	34	34	34	34	34
		Standard deviation	0.010	0.080	0.060	0.016	0.017
	B	Mean	0.023	0.194	0.157	0.025	0.040
		N	12	12	12	12	12
		Standard deviation	0.011	0.051	0.054	0.011	0.024
	C	Mean	0.017	0.171	0.160	0.034	0.045
		N	14	14	14	14	14
		Standard deviation	0.010	0.061	0.042	0.012	0.024
	Total	Mean	0.023	0.235	0.172	0.032	0.046
		N	60	60	60	60	60
		Standard deviation	0.010	0.085	0.055	0.014	0.020

The average of the inorganic content of cork samples contains 0.023% d.m.(P); 0.235% d.m.(K); 0.172% d.m.(Ca); 0.32% d.m.(Mg) and 0.046% d.m. (N) (Tab.4).

The average values of mineral content of cork show differences according to the underwood status and the quality. As an indication, the potassium content ranged from 0.284% d.m. (brushwood, A) to 0.181% d.m. (no-brushwood, C). However, the variations are very small for the nitrogen content, 0.045% d.m. (brushwood, A) and 0.043% d.m. (brushwood, C).

The analysis of variance can better explain the relationship between the underwood status, the quality of the cork and the cork inorganic contents taken into account. Table 5 summarizes the degree of variance and significance of these links.

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Table 5- Results summary of tests between subjects effects of the variables studied (ANOVA)

Variables		*Underwood status*	*Quality*	*Underwood status * Quality*
P	F	13.486	3.633	0.076
	p	0.001**	0.033*	0.927
K	F	0.679	14.445	1.172
	p	0.413	0.000***	0.318
Ca	F	0.424	1,081	0.037
	p	0.518	0.346	0.964
Mg	F	36.274	0.668	0.047
	p	0.000***	0.537	0.954
N	F	0.485	1.053	1.031
	p	0.489	0.356	0.363

(***) $p < 0.001\%$; (**) $p < 0.01\%$; (*) $p < 0.05\%$.

Through the results of Table 5, we observe that the underwood has a limited consequence on the content of the mineral elements of the cork. The only significant relationships are phosphorus and magnesium (p<0.01 and p<0.0001). On the other hand, there is no link between the underwood and cork quality. Only potassium (K) has a direct effect on cork quality (p<0.000). The presence or absence of the underwood around the trees does not seem to have a significant influence on the K content (F= 0.68, p= 0.41). The interaction between the underwood and the quality of cork is absent for potassium (p>0.05).

In the same context, phosphorus (P) is well influenced by the underwood (p<0.001). The quality also appears to be slightly influenced by phosphorus (F = 3.63, p = 0.03). The interaction between the underwood and the quality of the cork is not obvious.

4. Discussion

4.1. Phosphorus (P)

Phosphorus represents 0.1 to 0.5% of plant matter (Ben Mimoun, 2002). It is among the major elements most essential for energy transfers and as a constitutive element of cell membranes and the transmission of hereditary characteristics (nucleic acid) (Pancracio and Laflaquière 2006).

In our study, its content varies from 0.006 to 0.045% d.m. (brushwood plots) and 0.01-0.05% d.m (no-brushwood plots). These results are significantly similar to those of Leonardi (1992), Courtois and Masson (1999b): 0.03-0.04% d.m. It has also proved to be more influenced by the underwood and its presence is linked to the quality of the cork. (Tab.6).

Table 6- Tests of inter-subject effects of the dependent variable "P"

Source	*Type III Sum of squares*	*df*	*Mean square*	*F*	*Sig.*
Corrected model	0,002[a]	5	0,000	5,267	0,001
Intercept	0,019	1	0,019	238,781	0,000
Underwood status	0,001	1	0,001	13,486	**0,001**
Quality	0,001	2	0,000	3,633	**0,033**
Underwood status * Quality	1,200E-005	2	5,998E-006	0,076	0,927
Error	0,004	54	7,922E-005		
Total	0,038	60			
Coorected total	0,006	59			

[a] *R squared = 0,328 (Adjusted R Squared = 0,266)*

Several authors state that the phosphorus cycle in forest ecosystems is virtually closed. This means that the atmospheric inputs or by the parent rock are extremely low, that this element is efficiently recycled by returning litter to the soil (Marschner, 1994; Duschesne and Houle 2009). According to Dommergue (1963), the amount of phosphorus returning to the soil by the litter never exceeds 9 kg ha /year. It is also negatively influenced by drought and decreased water content in the soil (Orgeas and Bonin, 1996).

In the canton of M'Sila, the cork oak stands are constantly enriched with organic matter caused by soil cover (litter, plant debris, underbrush). These intakes maintain high water retention and a much diversified microflora, the action of which facilitates the assimilation of minerals to the trees. According to Dodelin (2007), soil cover enhances the organic status of trees and increases their productivity.

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In the canton of Cheikh Ben Khalifa, overgrazing associated with soil compaction reduces any notion of microclimate and undergrowth. To this is added the important differences between the trees creating a low thermal insulation for the ground. Béreau et al.(2003), argued that the total absence of undergrowth intensifies temperature differences detrimental to natural regeneration and soil microfauna, including the reduction of root mycorrhization. According to Bolan (1991), mycorrhizal trees have a high absorption capacity of soil phosphorus than non-mycorrhizae and therefore act positively on the primary and secondary meristematic activity of trees.

On the other hand, phosphorus acts on the energy balance of the tree by the contribution of cellular constituents (sugars, proteins, nucleic acids), and also provides the structural constituents of the cell walls (cellulose, hemicellulose, lignin and suberin) (Hellali, 2002). Indeed, a cork of good quality is characterized by a good impermeability, elasticity and a good flexibility. According to Pereira (2007), lignin is a major component with the suberin, acting on the structure of the cork in particular the cell walls.

The figure 2 shows that the P content is correlated with the industrial classification of cork (A, B, C). It remains important on the trees of M'Sila than the no-brushwood ones of Cheikh Ben Khalifa (0.028% d.m. vs. 0.018% d.m.).

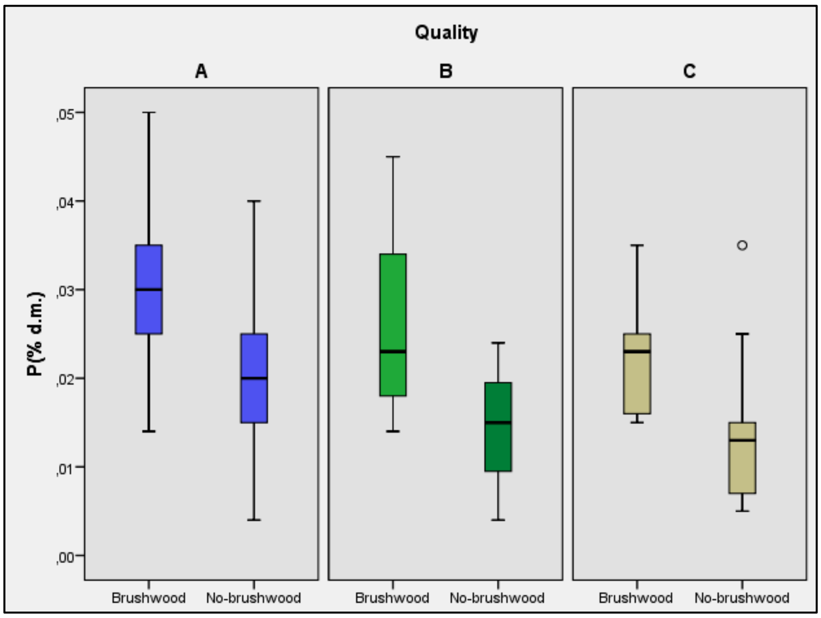

Figure 2- Variations in phosphorus content according to quality classes and underwood status

4.2. Potassium (K)

Potassium is an activator of different enzymes (Ben Mimoun, 2002). It allows increased cellular pressure by regulating the water economy in the plant and reducing evaporation by promoting resistance to drought (Zaid, 2000).

Its content in cork varies from 0.14 to 0.27% d.m (Leonardi, 1992; Courtois and Masson, 1999b). The results show that it varies from 0.09 to 0.45% d.m. It is also found that it is directly linked to the quality of the cork that the underwood status (Tab.7).

Table 7- Tests of inter-subject effects of the dependent variable "K"

Source	*Type III Sum of squares*	*df*	*Mean square*	*F*	*Sig.*
Corrected model	0,149[a]	5	0,030	5,838	0,000
Intercept	1,768	1	1,768	347,102	0,000
Underwood status	0,003	1	0,003	0,679	0,413
Quality	0,147	2	0,074	14,445	**0,000**
Underwood status * Quality	0,012	2	0,006	1,172	0,318
Error	0,275	54	0,005		
Total	3,747	60			
Coorected total	0,424	59			

[a] R squared = 0,351 (Adjusted R Squared = 0,291)

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Potassium is extremely mobile in the plant, the cation most represented in the sapwood sap, and especially the sap of the phloem (Hellali, 2002).

Studies on the mineral nutrition of cork oak revealed that potassium "K" is the only mineral element whose content seems to have a significant influence on the quality of the cork whatever the forest studied (Courtois and Masson, 1999a).Some authors, like Orgeas et al. (1996), place "K" as the general activator of metabolism; it plays a positive role in cell divisions and plant growth phenomena. Martin-Prevel (1978); Orgeas and Bonin (1995), link it to a strong growth in thickness of cork in case of high content. Robert et al. (1996) and Robert (1997) confirm K's leading role in improving the quality of cork by promoting the proper functioning of the phelogen.

On the other hand, Marschner (1994) demonstrated the link between the resistance of cork oak to water stress (by closing the stomata of the leaves) and the high content of this element in the soil. Thus, better water supply would be synonymous with good cork quality. Conversely, low soil K values due to drought would lead to poorer quality of cork and lower tree performance and increased susceptibility to pathogenic diseases and fungi (Hellali, 2002).

By comparing the K component on the cork of brushwood and no-brushwood trees, we note that to be marked on good quality cork (0.28-0.26% d.m.) than poor cork (0.15- 0.18% d.m.) (Fig.3).

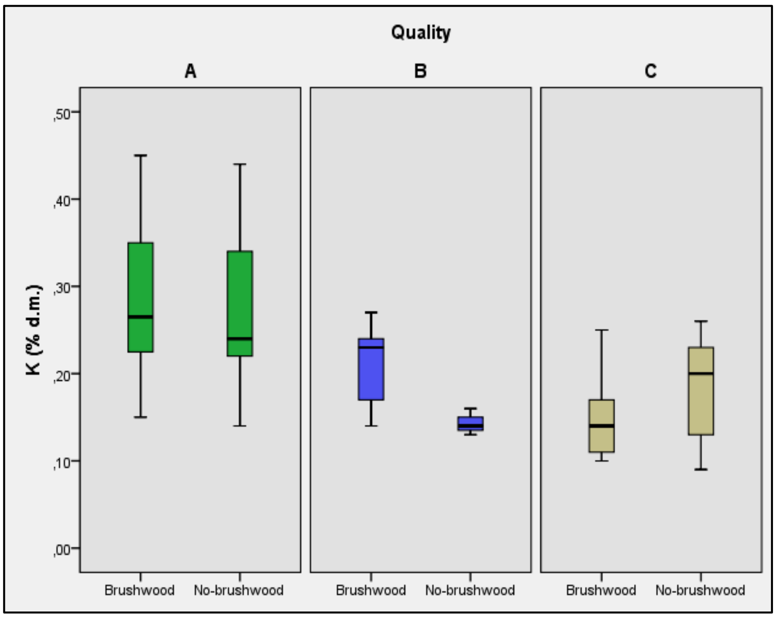

Figure 3- Variations in potassium content according to quality classes and underwood status

5. Conclusion

Characterization of inorganic composition of cork according the status of brushwood and the quality of the cork was performed for the first time in Algeria in the forest of M'Sila. The results indicate that:

- The underwood has a limited effect on the mineral content of the cork. The only significant differences were magnesium and phosphorus.
- In all cork threes samples, potassium was the main mineral component which have an effect on cork quality, followed phosphorus.

The cork oak forests of M'Sila presents two configurations: one in the form of a very dense maquis (Park of M'Sila) and the other very clear similar to a Spanish dehesa (Cheikh Ben Khlifa). In both cases, potassium seems to be the master cation of cork oak metabolism and particularly cork. The quality of the cork comes largely from the potassium content. In particular, the intrinsic characteristics proper to each tree will define the content of this element independently of the conditions of growth.

References

1. Ben Mimoun M., 2002. La gestion de la fertilisation potassique en arboriculture fruitière. INRA-Tunisie, 12p.
2. Béreau M., Louisanna E., De Grandcourt A., 2003. Symbiose mycorhizienne et nutrition minérale. *Rev. For. Fr.* LV: 74-83.

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3. Bolan N. S, 1991.A critical review on the role of mycorhizal fungi in the uptake of phosphorus by plants. *Plant soil*, 134: 189 – 207.
4. Bonvalet A., Ferran J., Cassadas E., 1986. Analyse minérale de tissus végétaux à faible teneur en silice : Proposition d'une technique de minéralisation simplifiée et d'un plan d'organisation de la méthode d'analyse multiélémentaire, *Oléagineux* 41 : 141-151.
5. Bossuet, G., 1988 .Sylviculture du liège et rénovation de la subéraie. *Forêt Méditerranéenne*, X (1) :162-163.
6. Courtois, M. & Masson, P., 1999a.Contribution à l'analyse des facteurs de la qualité du liège brut. *Forêt Méditerranéenne*, XX, n° 2 : 95-102.
7. Courtois and Masson, 1999b.Relations entre la qualité du liège, sa composition minérale et la composition minérale des feuilles du chêne-liège (*Quercus suber* L.). *Ann. For Sc.* 56 : 521-527.
8. Dedelin B., 2007.Les rémanents en foresterie et agriculture : les branches, matériaux d'avenir. Ed. Lavoisier, 400p.
9. Dehane B., 2012.Incidence de l'état sanitaire des arbres du chêne-liège sur les accroissements annuels et la qualité du liège de deux subéraies oranaises: M'Sila (w.Oran) et Zarieffet (w.Tlemcen). Thèse de Doctorat en Foresterie, Université de Tlemcen, 293p.
10. Dommergue Y, 1963. Les cycles biogéochimiques éléments minéraux dans les formations tropicales. *Revue Bois et Forêts des Tropique*, 87: 10-24.
11. Duschesne L., et Houle D., 2009.Les éléments nutritif : un partage entre le sol et les arbres. Avis de recherceh forestière, 15 : 2p.
12. Hellali R., 2002. Role du potassium dans la physiologie de la plante. Institut National Agronomique de Tunisie. Atelier sur la gestion des fertilisations potassiques, acquises et perspectives de la recherche, 7p.
13. IPROCOR, 2006. Metodologia para estimar la claidad del corcho.Documento interno, 30p.
14. Leonardi S., Rapp M., Failla M., Komaromy E., 1992. Biomasse, minéralomasse, productivité et gestion de certains éléments biogènes dans une forêt de Quercus suber L. en Sicile (Italie), *Ecologia Mediterranea* 18 :89-98.
15. Marschner H., 1994 : Mineral nutrition's of higher plants, 2ème Ed., Academic Press, London, 889p.
16. Martin-Prevel, P. 1978.Rôle des éléments minéraux chez les végétaux. *Fruits*, 33(7-8) : 521-529.
17. Molinas M. et Oliva M., 1990 .El suro i les seves classes. L'Estoig (Publicació de L'Arxiui Museu de Palafrugell) 2 : 33-34.
18. Orgeas J., Bonin G., 1996. Variabilité des nutriments foliaires de Quercus suber L. dans différentes situations écologiques dans le massif des Maures (Var, France) et relations avec la production de liège, *Ann. Sci. For.* 53 : 615-624.
19. Pancracio A., Laflaquière M.T. ,2006. biologie et physiologie de la nutrition : la nutrition des plantes. Centre National de Promotion Rurale, 195p.
20. Pauwels J.M., Van Ranst E., Verloo M., Mvondo ZE A., 1992. Manuel de Laboratoire de Pédologie. Méthodes d'analyses de sols et de plantes, équipement, gestion de stocks de verrerie et de produits chimiques. Publications Agricoles - 28. Administration Générale de la Coopération au Développement (AGCD), Bruxelles.
21. Pereira H., 2007. Cork: Biology, Production and Uses. Elsevier, Oxford, UK.329p
22. Plamondon A., 2009. Bassin versants et erosion: application en forêt tropical humide, notes de cours, 3eme Graduation foresterie. Université de Lava, Québec, 287p.

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