RESILIENCE ASPECTS OF WOODY PLANT SPECIES AT THE PASSAGE OF FIRE: CASE OF *QUERCUS COCCIFERA* IN TLEMCEN MOUNTAINS (ALGERIA)

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ABSTRACT

Rafa, A., Berrichi, M. & Haddad, A. (2020). Resilience aspects of woody plant species at the passage of fire: case of Quercus coccifera in Tlemcen Mountains (Algeria). *Lebanese Science Journal,* 21(2), 119-128.

In this study, on the aspects of the resilience of woody species to the passage of fire, we wanted to test the alveolar specificity represented by the size of the pores of the secondary xylem of the root system in Quercus coccifera L., Pore size assessment is based on measuring 100 pores in cross sections, from the roots of 10 shrubs. The aim of this study is to explain how the roots can maintain their vitality after passing a fire and thus guarantee regeneration. In addition to the vigor of the root system of this species, the release of pyrolysis gases and the propagation of heat by conduction are provided by the porosity of the material. The results show that the pores are qualified as "fine" in the initial wood with an average diameter of 83.35 µm. In final wood, they are "very thin" with 42.30 µm in diameter. The absence of oxygen and the less porous structure delay the combustion cycle of the root system, the roots distant from the surface are thus protected from proliferation by heat conduction and thus guarantee regeneration.

Keywords: *Quercus coccifera* L., pyrolysis, secondary xylem of the root, Tlemcen, Algérie.

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INTRODUCTION

The summer period seems to be becoming critical for vegetation in the Mediterranean, the recurrence and incidence of fires have increased considerably in recent decades (Hoff & Rambal, 2000; Maheras, 2002; Berrichi et *al*., 2016).

In the Mediterranean ecosystem exposed to recurrent fires, plants have developed resilience traits (Trabaud, 1994; Pausas et al., 2004; Keeley et al., 2011). In terms of pyrology, according to Trabaud (1990); Naveh (1975); Bond & Keeley (2005) pyrophytes are plants that resist fire by various mechanisms: (I) for some, vegetative growth or the propagation of seeds which are stimulated by the fire (Trabaud, 1995; Pfab & Witkowski, 1999; Burrows et al., 2008). These are the active pyrophytes. (II) for the others, they resist fire by various characteristics: (i) the thick bark of the cork oak (Catry et al., 2012; Gheffar & Dehane, 2017); (ii) poor flammability due to the high level of mineral matter in, (Kennouche et al., 2013; Candelier et al., 2016); (iv) the existence of underground regeneration organs in the various geophytes. They constitute the passive pyrophytes.

Through these mechanisms of resistance (Naveh, 1975; Barbero et al., 1990; trabaud, 1994) unanimously grant the diversity of Mediterranean vegetation to the action of fire. Two hypotheses can act individually or collectively on the resistance mechanism of active pyrophytes. The first is a positive feedback from certain plants which find in the increase in temperature following low intensity fires a stimulation of physiological activity (Pausas & Keeley, 2017). These activities include the development of roots, suckers or stumps. The second hypothesis tries to explain the maintenance of the root system protected from the action of fire.

The second hypothesis constitutes the main objective of this research. Its aim requires the combination of knowledge between the phenomenon of combustion and the anatomical characteristics of wood related to the conductive elements to predict hypotheses on the maintenance of the regenerative capacities of this material protected from the action of fire.

According Bland (1991); Yang et al., (2003) and Reszka (2008) the process of burning plants takes place as follows:

(i) Dehydration: under the action of a heat source, the wood cells lose their water, until only the cell walls retain moisture (30%). The loss of water contained in the walls causes their deformation and modifies the migration of the first gaseous products of pyrolysis. This action occurs up to a temperature of 250 ° C.

(ii) Pyrolysis: Under the action of heat, the complex molecules of organic compounds break down into gaseous molecules, which, if they had just ignited, would burn permanently. The proportions of flammable gases produced depend on the conditions under which the pryloyse takes place: **(a)** the diffusion of gases inside the solid particles produced by the deformation of the cell walls; **(b)** the dissociation temperature of the molecules. At low temperatures, combustion takes place slowly. When the temperature becomes important, pyrolysis generates flames. The temperature of pyrolysis occurs between 250 and 800 ° C.

(iii) Gas phase pre-combustion reactions: on contact with oxygen in air, gaseous products ignite.

(iv) Combustion of the carbonaceous residue: begins to appear at the end of pyrolysis when the gas flow becomes insufficient to prevent oxygen from diffusing to the solid.

The proportion of flammable gases produced depends on the temperature and pressure conditions caused by the deformation of the cell walls and the environment in which the pyrolysis takes place. In the absence of oxygen, the heat of combustion of the root system propagates slowly by conduction and the temperature of dissociation of molecules for the release of gaseous liquids is low. According to Jang et al., (2018) progression of hot air in the mass of the wood is through the pores of the vessels. The pressure caused by the deformation of the cell walls is linked to the alveolar structure. The alveolar structure and more especially the porosity of certain species defenated by the ratio of the surface occupied by the alveoli (vessels and trachaeids) compared to the mass of the wood affect wood drying (Stayton & Hart, 1965; Hill & Papadopoulos, 2001; Forsstrom, 2004).

The effects of fire on regeneration result from the transfer of heat from combustion to root tissue (Michaletz & Johnson, 2007). They can manifest directly as the death of fine roots or cause necrosis of the cambium and phloem of the roots of the upper layers of the soil which can occur during deep or surface fires, where the organic soil burns for hours or days can lead to soil heating and root mortality (Ryan & Frandsen, 1991; Swezy & Agee, 1991; Smirnova et al., 2008). Oaks develop a deep rooting system that branches out from the main root. Over time, the taproot recedes and is replaced by many large lateral roots which form the lateral root system. From the lateral roots develop the fine root system responsible for the absorption of nutrients and moisture from the soil (Barbero et al., 1990; Trabaud, 1994).

In this research, we try to find and through a histological study of the secondary xylem of roots of the Q. c*occifera* .L an answer to the circulation of hot air in the mass of the wood and to the maintenance of the regeneration organs sheltered from the action of fire.

Study area and presentation of the species

Study area and presentation of the species. The total forest area in Tlemcen (north-western Algeria) reaches to 209, 230 hectares, 22.30% of the whole Wilaya’s total area (Letreuch- Belarouci et al., 2009). Fagaceae are the main family of dicotyledonous angiosperms, covering 46% of the forest area. Oaks (Quercus spp.) are mainly confined in the mountainous areas. When Q. ilex and Q. suber cover the vast expanses, Q. faginea is recorded only in the South-west, when certain conditions of topography (cool valleys), exposure (North-east) and coolness are gathered. Q. coccifera is a shrub associated with Q. ilex and Q. suber (Berrichi & Bouazzaoui, 2015).

Q. coccifera L., is a Mediterranean shrub species, which covers more than two million hectars (Trabaud, 1990). The typical areas where Q. *coccifera* grows are characterized by full light, shallow limestone soils and semi-dry to humid Mediterranean climate (Constantino & Tsiouvaras, 1987; Sabaté et al., 1990; Dureau et al., 2003).

In the study area, Q. coccifera is an evergreen deciduous shrub can reach 4 m high elliptically shaped with a globular crown (Figure 1a). The spinous leaves are leathery with different characteristics such as: shiny green light (Figure 1b). Its bark (Figure 1c) is smooth, with age it axially split and gray clear of color. Moreover, the acorns of yearly maturity (Figure 1d) are slightly enclosed in a cup. Morphologically Q. coccifera of the Mountains of Tlemcen differs from the other oaks by its leaves (Figure e1 & Figure e2) that have the same brightness on two faces.

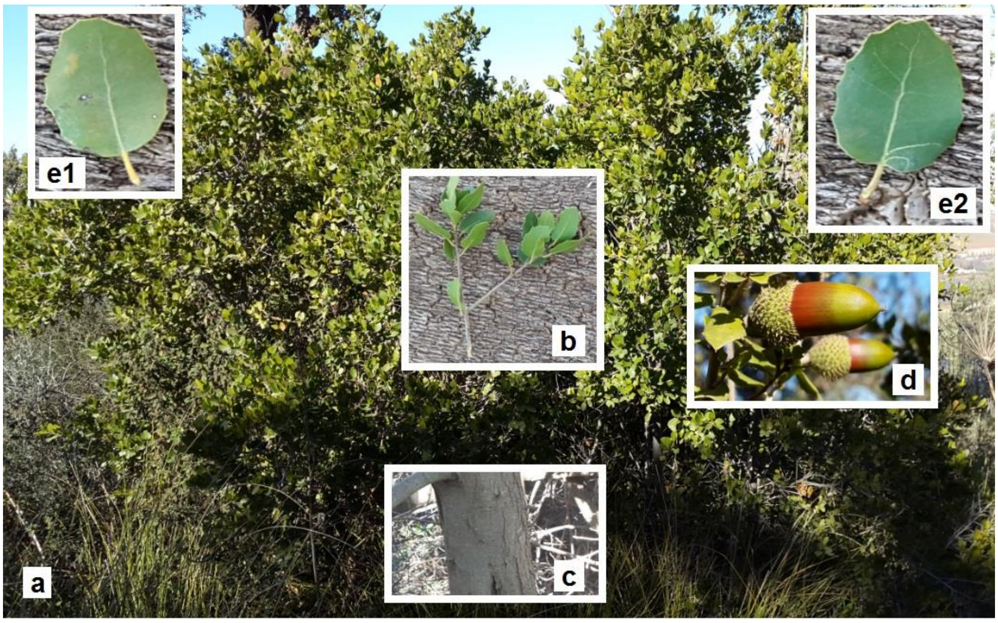

Figure 1. General Aspects of *Quercus coccifera* L.in the Mountains of Tlemcen.
(a: general look**; b**: branch and acorn with cup; **c**: bark; **d**: acorn with cup; **e1&e2**: both sides of the leaf)

MATERIAL AND METHODS

For wood microscopy, we have selected randomly ten aged roots from five shrubs. From the best microscopic cross sections prepared according to a defined protocol by (Normand, 1998), we have also realized 100 measures each sample on the early wood and latewood vessels .Besides, 50 measures on the number of vessels per mm^2.

In the wood cross section structure description, we attempt to describe and quantify some microscopically elements. In fact, we are interested only to describe and quantify the characters of the vessels. The technical equipment necessary for microscopic wood measurements consists of a sliding microtome, a microscope and eyepiece micrometer.

The *Q. coccifera* L., wood used for the present study come from the Zarief forest, located in the state forest of the Tlemcen Mountains. On the other hand, The Zarief forest is situated in an altitude of 900 -1100 m, with 600 mm annual rainfall and with an low average temperature of 2 ° C (January), to a maximum mean temperature of 31 ° C (August), and the relative humidity of 50% during the summer months.

According to the previous researches, flora of Zariefet forest is composed by the following species: *Quercus suber* L., *Quercus coccifera* L., *Erica arborea* L., *Myrtus communis* L., *Arbutus unedo* L., *Cistus triflorus* (L'herit.), *Erica scoparia* L., *Calicotome spinosa* L., *Ampelodesma mauritanica* (Dur et Schinz.), *Viburnum tinus* L., *Cistus ladaniferus* L., *Asparagus acutifolius* L., *Lavandula stoechas* L), *Fumana thymifolia* L., *Teucrium polium* L., *Rubia longifolia* L.

RESULTS AND DISCUSSIONS

Describe characters of wood microscopy

The cross section of Q. coccifera wood (Figure 2) argues that annual growth layers are less apparent and indistinct, the outline is sinuous.

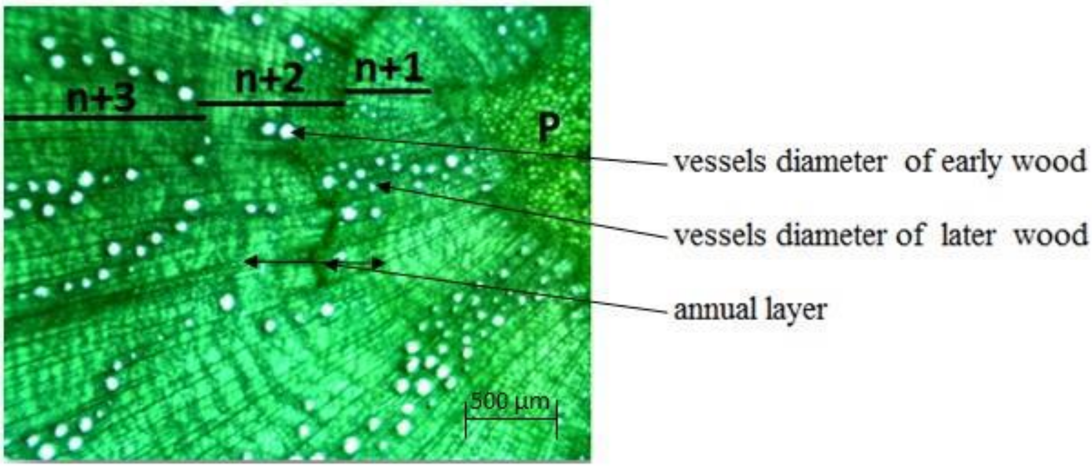

Figure 2. Cross-section of secondary xylem of roots in Q. *coccifera.*
(**P**: pith; **n1**: first year; **n2**: second year; **n3**: third year)

As a result, we can say that; the reason of the sinuous outline of the layer is associated with juvenility. Age and environmental conditions reduce the sinuosity (Huber, 1993; Mellerowicz & Sundberg, 2008). The pores are such "semi-porous" with oval or round shapes. The early wood has two to three row isolated pores. The pores of the later wood are aligned of 1-2 radial lines. The parenchyma is of apotracheal type with isolated and dispersed cellules, sometimes disposed in chainlets and the paratracheal parenchyma in confluent bands and circumvasculare.

Quantifying characters of wood microscopy

From the previous anatomical measurements of our samples, we have calculated: First, the mean (position parameter), Second, the standard deviation and the coefficient of variation (dispersion parameter). The coefficient of variation is used to quantify the standard deviation from the mean. So, the variation can affect the average (Dagnellie, 1988). The results are posted in Table 1.

Table 1. Some microscopically elements of Kermes oak (*Q. coccifera* L) of secondary xylem of roots in Tlemcen area.

Measured parameters	$\bar{X}$	σ	CV %
vessels diameter of early wood (µm)	84,35	11,81	14
vessels diameter of later wood (µm)	42,3	7,12	16,8
number of vessels per unit area (/mm ^{2})	29,69	4,7	15,9

X: arithmetical mean; ***σ*:** standard deviation; **%:** coefficient of variation.

Table 1 determines the mean vessels diameter of early wood are 83, 35 µm. Therefore, the wood of the *Q. coccifera* L. Belongs to the pores category "purposes greatness", 90% of the measurements are located in this class. Mean vessels diameter of later wood is of 42.30 µm is qualified as “very thin size», 89 % of the measurements are located in this class. The mean number of vessels per mm ^{2} are 30, and qualified as "Many”, 100 % of the measurements are located in this class. So, according to the previous statistics the results of *Q. coccifera* compared to other microscopic element of the oaks wood of Tlemcen area (Figure 3) and also show the smaller diameters of vessels in early wood are registered at the Kermes oak. The lowest difference between the diameters of vessels in early wood and vessels in later wood also characterized the *Q. coccifera* wood. The greatest number of vessels per unit area is also a characteristic of *Q. coccifera* L., The vessels size of *Q. coccifera* L., can be the reason of this distinction in the microscopic elements, and in its regard.

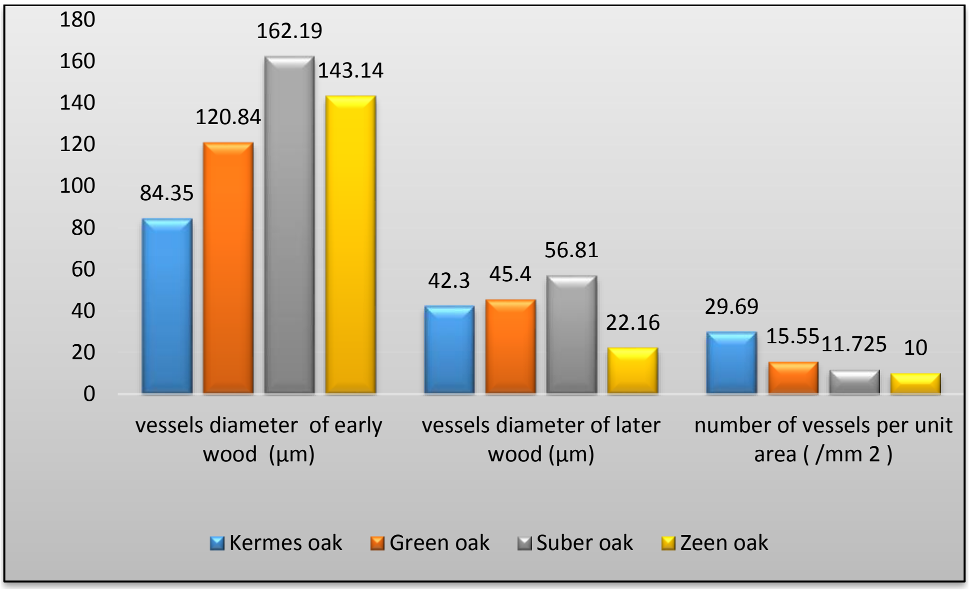

Figure 3. Microscopic element of the oaks (*Quercus* spp.) of secondary xylem of roots.

The results show that the resilience of wood to the passage of fire is linked to the importance of the dimensions of the vessels and their frequency. To this end, the results give an average diameter of the vessels of 63 µm in the case of Q.coccifera L.,which is the smallest in this series of diameters tested in other oaks in the Tlemcen region, which are respectively 83 µm, 109 µm and 82 µm for Q.ilex, Q.suber and Q.faginea. In Q.coccifera L. The vessels are small and more frequent per unit area. In less porous woods, it is more difficult for decomposition gases to reach the surface of the piece of wood due to the preservation of the dimensional stability of their cell walls (Jang & Kang, 2019). According to Xie et al., (2002), high hygroscopicity related to high porosity causes poor durability, poor heat resistance and easy degradation. As a result, less porous woods ignite harder and radiate less heat for longer. According to Xie et al., (2002), high hygroscopicity related to high porosity causes poor durability, poor heat resistance and easy degradation. As a result, less porous woods ignite harder and radiate less heat for longer. According to Moghtaderi & Fletcher (1988) and Meesri & Moghtaderi (2002), a less porous structure delays the combustion cycle of wood. Less porous woods ignite more easily and give off less intense heat for a longer time (Xie et al., 2002; Zahreddine et al., 2007). The results also show that the frequency of the vessels does not act on the resilience (Xie et al., 2002; Zahreddine et al., 2007). The figure shows that Q. coccifera has the highest frequency of vessels. Hence, we can say that the size of the vessel which is responsible for the release of gases from pyrolysis under the effect of deformation of cell walls.

CONCLUSION

Oaks are passive pyrophytes which resist the effect of fire thanks to various mechanisms or particularities such as the presence of thick bark or poor combustibility. This study attempted to explain the poor combustibility of Quercus coccifera through the alveolar appearance of its pores. They are very small sizes "fine" in the initial wood "83.35 µm" and "very fine" with 42.30 µm in summer wood. This pore size can inhibit the deformation of cell walls upon exposure to a heat source and therefore impede the movement of pyrolysis gas migration. This alveolar aspect must be associated with the deep and branched root system of oaks. The roots close to the surface can by the microstructure of their secondary xylem escape the effect of fire, nevertheless those of the depth and in our opinion remain intact because of their distance from the heat source and the bad conduction offered by the high density of the wood of Quercus coccifera.

Q *coccifera* L., is a shrub that characterizes the garrigue of the low mountains where the slopes are rocky in the region of the Tlemcen Mountains. Its capacity to resist and to regrow vigorously after a fire offers it ecological services in the management of watersheds, conservation and soil formation. This type of training provided at the interface between the forest and the city of Tlemcen also offers a certain security to the population in terms of the prevention of floods, landslides and other avalanches.

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