TETRACLINIS ARTICULATA REGENERATION (THE THUYA OF THE MAGHREB) AND ITS RESISTANCE TO HUMAN CAUSED DETERIORATIONS: CASE OF FIRE

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Tetraclinis Articulata (The Thuya of the Maghreb) is one of the threatened species, in its ecological area where it is endemic, not only under pressure of animal and human effects, but especially fire, currently, this formation knows an alarming regression although it has the ability to regenerate very often quickly, so it plays an important role preserving the vegetable covertures in the semi-arid areas.
The purpose of this work is to check the regeneration of Thuya through dendrometric characteristics: annual increase of height and diameter, this will allow us to know more about this vegetable formation bringing to light all its potentialities in the eco-development of spaces and to emphasize the degraded and marginalized zones.
The results obtained in the three facies will prove the resistant aspect of Thuya against alternations such as fire meanwhile it's imperatively advised to fight against all risks of regression of this vegetable formation.

Keywords: increase, dendrometry, phyto-ecology, facies, forest of Tenira (west of Algeria)

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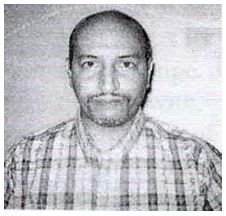

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Introduction

Thuya covers about 143,000 hectare [1], this is one of the rare species in Algeria, and it is going to disappear because this useful rustic forest which needs to be given more care is permanently harmed, (cutting – degradation, fire) [2], its resistant aspect makes it one of the most important and dense species which needs more effective studies.
A wide field of Thuya still dominates the national forest of Tenira which is situated in the mountains of Dhaya. Its superficies counted about 16630 hectare [3] while it

is now only 8800 hectares. The degradation of forest ecosystems is a problem that worries all searchers in general and ecologists in particular.

The main cause of this degradation is the antropozoogene pressure: many searchers such as [4-6], [7-9] were interested in studying the causes of the forest ecosystem degradation, both [10] and [11] studies were established in western Algeria.

Fire keeps its dominating pressure with a destructive impact on the Tetraclinaie, which is the only vestige of the Thuya species, it's a warning diminution in which Thuya formations are dealing with.

The danger of fire is a notion resulting of the combined action of many factors; we can mention the most important factors responsible of the wide sensitivity of Algerian forests:

− The length of the dry season of summer.
− Structure and nature of the vegetation.
− Frequency of the stormy dry winds
− Uneven relieves.
− Eroded ground which is often over-passing.
− Terrorism taking the forests as a refuge in the1990, especially in Tenira.

Fire is an important factor that affects the vegetation because of its high frequency; many authors agreed that the successive regression of vegetation is due to it, however, it is necessary to follow the evolution of this vegetation for a period of time either controlling it with an experimental devices or in nature where the vegetation came under fire but in both cases, the exact date of when fire happened must be known [12].

According to him – [12] – the evolution may be done within four ways:

− Checking the different steps of the previous vegetation remaining to a long time.
− The gaps that became more overt than they was before the fire, associated to decreased proportion of ligneous vegetables.
− Instant checking the previous vegetation with no transition.
− Progressive evolution to different vegetations

Presentation of the studied area

Climate and soil

The forest of Tenira is 16 km south of Sidi Bel Abbes, 12 km from Teghalimet and 9 km from Boukhanifis; it is crossed by the national road No. 13 linking Sidi Bel Abbès to Telagh.

The forest lies on the secondary Jurassic, relieves are bad enough and formed of porous calcareous layers giving the ground a superficial aspect, the forest lies on superficial enclaved soil between emerged rocks. The superior horizons are constituted of a mixture of sand and calcareous pebbles. The local climate has been realized through two meteorological stations; of Sidi Bel Abbès and of Teghalimet (Table 1).

According to [13] the forest of Tenira has a superior semi-arid bio-climate [14].

Table 1

Climatic data of the studied area

Station	Altitude, m	Rainfall, mm	M – m, °C	Q_2
Sidi Bel Abbès	476	395	33.2 – 1.9	43.2
Teghalimet	650	334	34 – 1	34.8
Tenira				
PH	840	468	30.6 – 2.8	57.7
PB	628	393	32.1 – 3.6	47.2

PH: It's the most high point of area.
PB: It's the most low point of area.
M: The avearge of maximals temperature of the hot month.
m: The avearge of minimals temperature of the cold month.

Vegetation

The forest consisted on a populating of young and old timber-trees of *Pinus halepentis* Mill and *Tetraclinis* A*rticulata* Wahl before the fire took place, in under-stages with an average covering of 20 % as a dense high copse. Thuya formed in the particular stationary conditions, pure formations with some vestiges of forest. *Quercus Rotundifolia L.*, it was third in position with a rate of covering of 10 %. The secondary species were especially dominated by *Quercus Coccifere L.*, *Phillyrea media L.* and *Pistacia Lentiscus L.*

Tetraclinis articulata reached in this forest the treelike stage with an under-wood characteristic of this formation with three different facies:

The first one to *Rosmarinus tourneforti L.*
The second to *Ampelodesma mauritanica L.*
The third to *Stipa tenacissima L.*

In spite of a quasi-permanent animal and human pressure, the Thuya formed a plant grouping and dominated the pine of Alep relegating it to secondary specie.

Tetraclinis articulata is present essentially in the form of copse in under-wood of *Pinus Halepensis* in such conditions the Thuya vegetates and this is what explains its strong density [15].

Tetraclinis articulata presents three facies:

* Ampelodesma when the ground is deep, slightly muddy, in the north and in depressions.
* Rosmarinus when the ground is of type rendzine, strong presence of limestone in the south.
* Stipa in the most extreme conditions [16].

Identification of Tetraclinis articulata

Monographic quality of Tetraclinis articulata

The Thuya of North Africa (*Tetraclinis articulata Vahl.*) has been defined by (Vahl, 1979) under the name of Thuya articulata, it is one of the spermaphyte gymnosperme branches, belonging to coniferous family [17].

The botanic characters as given by [3] are: the Thuya of Maghreb (North Africa) is resinous with a light foliage,

(see Fig. 1) when it's still young plant, its port is pyramidal, leaves are reduced to two opposed scales, fruits are like a cubic cone, can be opened by four valves in hot conditions, giving away six seeds, the longevity of Thuya can exceed 400 years, it's reproduction is generally done with rejects or sowing [18].

The Thuya of North Africa is an endemic essence of the southern occidental Mediterranean sea [17, 19], in particular in the Maghreb countries where its density floats from the east to the west [2].

However [20] consider that Thuya in North Africa covers a surface of million hectares, all the searches that studied this specie: [1, 2, 3, 16, 19, 21-26], and others have agreed that Thuya does not require edaphic factors, it is indifferent to the chemical nature of the substratum, can be found in poorest and dries soils, meanwhile it seems that it prefers more calcareous and deep soils.

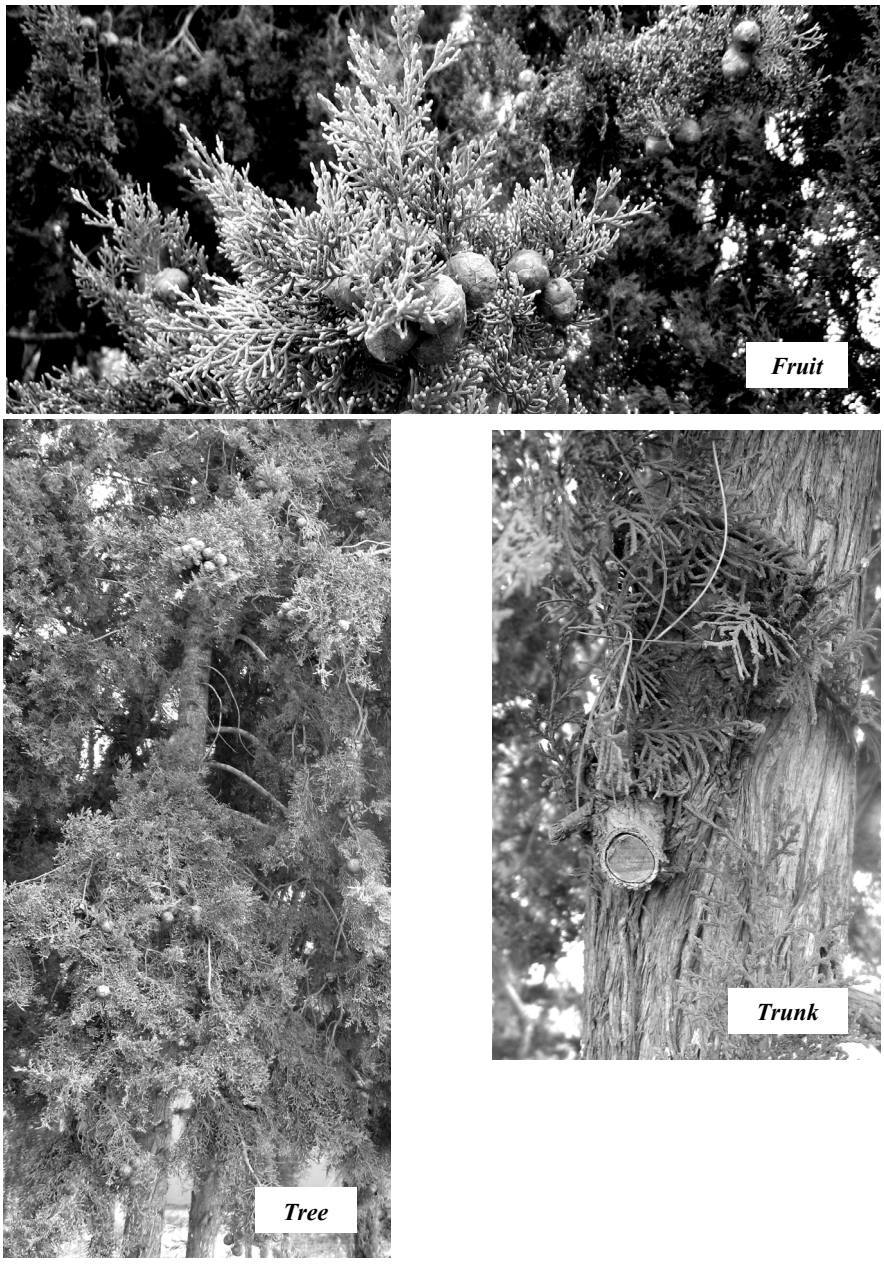

Fig. 1. *Picture of different parts of Thuya three (Tetraclinis articulata)*

It is doted with a faculty of adaptation to different types of bio-climates, hot semi-arid in particular, temperate or sub-humid and cool [24], it supports the drought and hot weather conditions but not cool humid weather. Adapted to extreme conditions, the Thuya of the Maghreb can develop on an annual pluviometric slice of 300 mm, an annual average temperature of 15.2 °C and a minimal temperature of 2 °C, average of the temperatures of the warmest month (M) is 32.5 °C [15], [25-27].

Dendrometric characteristics

Thuya is present, as underlined previously, whether in the form of copse or of timber-tree. Exceptionally, the following dendrometric parameters (density averages, height, diameter and volume) for every type of formation and for every facies give an outline onto these populating. Small squares m^2 among 3 types of formation informing about the dendrometric characteristics of the formations of vegetable as showed in Table 2 [23].

Table 2

Dendrometric characteristic of the Thuya formations

Evaluated parameters	Copse				Timber-tree			
	F1	F2	F3	Average	F1	F2	F3	Average
Density	1680	1120	510	1100	320	210	130	220
Height in cm	2.60	2.10	1.60	2.10	3.70	2.90	2.30	2.90
Diameter in cm	10	8	6	8	21	16	11	16
Volume in cm	34.20	11.80	2.30	16.10	12.20	2.80	18.60	17.30

F1: Facies of Ampelodesma; F2: Facies of Rosmarinus; F3: Facies of Stipa.

These averages of dendrometric data constitute ecological indicators and inform about the dynamism, the potentialities and the development of this plant grouping threatened in its three facies before the fire destroys them. The obtained results constitute a reference in western Algeria where no work is carried on.

Phyto-ecologic Statements

The floral characterizations of these three facies were recapitulated through three representative average statements of the floral composition of this grouping. The phyto-ecologic description of the forest of Tenira confirms these statements of vegetations for the same period [24] (Table 3).

Table 3

Phyto-ecologic average of facies

Facies	Ampelodesma			Rosmarinus			Stipa		
Constant species	1	2	3	1	2	3	1	2	3
Quercus coccifera	2.1	1.1	2.1	1.1	+	+			
Phillyrea angustifolia	2.2	2.1	2.1	2.1	1.1	1.1	+		
Pistacia lentiscus	+	1.1	1.1	1.1	2.1	2.2	1.1	2.2	2.2
Cytusus triflorus	+	+	+						
Cistus villosus	1.1	+	1.1	1.1	1.1	2.2	2.1	2.1	2.2
Vhamaerops humi	+		+	+	1.1	+	2.1	1.1	1.1
Juniperus osycedrus				+	1.1	+	+	1.1	1.1
Differential species									
Stipa tenacissima	+	1.1	+	+	2.1	1.1	2.1	3.2	2.2
Arbutus unedo	1.1	+	1. 1						
Genista quadriflora					+	1.1			
Ampelodesma	2.2	2.1	2. 2	1.1	1.1	+			
Mauritanicum	+			+	1.1	+	+	2.1	1.1
Globularia alypum	+		+	1.12.2	2.1	2.2	1.1	+	2.1
Rosmarinus tournefortii									
Campaign species									
Astragalus lusitanicus									+
Asphodelus		+					1.1	+	2.1
Microcarpus				+	+		1.1	1.1	
Elichrysum stoechas	1.1	+	1.1						
Helanthemum	+	1.1	+						
Halimifoliums									

Materials and methods

The objective of this work is follow the dynamism of *Tetraclinis atriculata* after the 1991 fire that affected most of our forests (the case of Tenira forest in this study), this dynamism needs a long period of time to obtain satisfactory results, concerning the regeneration, development and their comparison with other neighbourhood species.

As we have seen previously, the Tetraclinetum is affected with human and animal alterations, it became more fragile after being affected by fire in 1991, due to terrorism who took the forest as a refuge.

This vital plant grouping for a perpetuity of the vegetable cover in semi-arid conditions, its capacities of rejecting and to colonize space every time it is destroyed needs to be protected.

The work will be methodologically based on observing Thuya in the forests of Tenira (western Algeria) after it was destroyed by fire and to know its behaviour, these observations will be taken in a period of 15 years along, with a periodicity of 5 years in which we will determine the number of stalks, as well as the height and diameter of two formations which are (timber-tree and copse) and then of three identified facies: F1, F2, F3, then we will determine the annual increase of height and diameter taking into account their age.

The observations of 15 years from 1991 to 2006 took place some months after the fire of 1991, with a periodicity of 5 years, which means three measures concerning:

– The number of copses by hectare.
– The number of stalks by copse by hectare.
– The average diameter of stalks.
– The height averages stalks.

Obtained results

Three years after fire took place, Thuya started rejecting and colonizing destroyed spaces, after some floral sorts of its procession The dendrometric parameters measured after five years on small squares of 100 m^2 and those measured after ten years and fifteen years began to give refusals and to colonize the space as shown in Table 4, 5 and 6 respectively. Table 7 constitutes the global result of our study, and then we have to underline annual growth average in height, and in diameter of this specie.

Table 4

Dendrometric parameter 5 years after fire on small squares of 100 m^2

Evaluated parameters	Copse				Timber-tree			
	F1	F2	F3	Average	F1	F2	F3	Average
Number of copse	530	460	290	426	310	260	160	243
Number of stalks of copse	2120	1380	870	1456	1550	1300	960	1270
Height average of stalks in cm	55	48	37	46. 6	83	76	65	74.6
Diameter average of stalks in cm	2.8	2.1	1.8	2.2	4.3	3.5	2.2	3.3
Annual growth average in height	11.0	9.6	7.0	9.3	16.6	15.2	13.0	14.9
Annual growth average in diameter	0.5	0.4	0.30	0.4	0.8	0.7	0.4	0.6

F1: Facies of Ampelodesma; F2: Facies of Rosmarinus; F3: Facies of Stipa.

Table 5

Measure of dendrometric parameters ten years after fire done on the same small squares of 100 m^2

Evaluated parameters	Copse				Timber-tree			
	F1	F2	F3	Average	F1	F2	F3	Average
Number of copse	510	430	270	403	290	230	140	220
Number of stalks of copse	2550	1290	1620	1820	1740	1150	840	1343
Height average of stalks in cm	112	103	81	98.6	178	157	137	157.3
Diameter average of stalks in cm	4.9	4.6	4.1	4.5	5.1	4.9	4.3	4.7
Annual growth average in height	11.2	10.3	0.8	9.8	17.8	15.7	13.7	15.7
Annual growth average in diameter	0.49	0.46	0.41	0.45	0.51	0.49	0.43	0.4

Table 6

Dendrometric parameter 15 years after fire

Evaluated parameters	Copse				Timber-tree			
	F1	F2	F3	Average	F1	F2	F3	Average
Number of copse	510	420	250	393	280	230	120	210
Number of stalks of copse	2040	1260	1000	1433	840	920	480	746
Height average of stalks in cm	162	145	98	135	251	237	214	234
Diameter average of stalks in cm	6.7	6.2	5.8	6.2	7.3	6.8	6.1	6.7
Annual growth average in height	10.8	9.6	6.5	9.0	16.7	15.8	14.3	15.0
Annual growth average in diameter	0.4	0.4	0.3	0.45	0.4	0.4	0.4	0.4

Table 7

Annual growth average in height and in diameter

Growth average in cm	Under copse			Under timber-tree		
Age, years	5	10	15	5	10	15
Height	9.3	9.8	9.0	14.9	15.7	15.0
Diameter	0.4	0.45	0.45	0.6	0.4	0.4

The obtained results over a relatively short period are interesting and allow appreciating the evolution of Thuya after fire destroyed the formation of copse and forest. The data obtained by stuffed and by type of formation help to better understand the dynamics of this plant grouping.

Synthesis and interpretation of the results

Five years after fire, the regeneration is strongly present but the dominant sort is not *Tetraclinis articulata*, because its increase in height is weak compared with the other sorts affected by the fire as Phillyrea, Pistacia, Cistus.

The annual average increase both in height and in diameter remains considerable compared with other species often used in reforestations.

The forest where Thuya was destroyed by fire presents a lower regeneration than that of the copse which is 15 %.

Ten years after fire, the registered differences are constant and the average increases both in height and in diameter remain rather stable. The same observations would be made on the results obtained 15 years after fire.

15 years after fire of the copse of Thuya, stalks stemming from refusal among 1433 present an average height of 135 cm and an average diameter of 6.2 cm while in forest, the averages are sharply superior, the height is 234 cm while the diameter is 6.7 cm and the number of stalks is 746. The growth in height and in diameter remains superior to 30 % in the results obtained in the destroyed copse.

The annual average growth in height and in diameter of all Thuya facies is recapitulated in the Table 7.

The growth in height remains sharply superior for the developing forest after fire. They are 9 cm for the copse and 15 cm for the young forest. The density or the number of stalk by hectare constitutes a determining parameter in the growth average especially in height.

The growth remains relatively stable for the diameter no matter what conditions of the destroyed vegetable formation are.

The increases both in height and in diameter and under three fancies and type of formation (copse or timber-tree) affected by fire remain slightly lower than those of other species considered as fast growing in semi-arid floor and which remain widely used in Algeria. In this range we can mention *Pinus Halepensis* Mill. *Quercus ilex L, Pinus pinaster L*.

Comparison with other species

After fire, growth in height and in diameter are respectively estimated at 9.3 cm and 0.4 cm: for the pine of Alep (the most used specie in reforestation and afforestation and repopulation) under bioclimatic semi-arid conditions, the floor the average increases in height and in diameter and is estimated for the first one between 14 and 18 cm and for the second between 1 and 2 cm.

Analyzing the development in height and in diameter of the *Pinus halepinsis* of 13-year-old in the green dam [28], advance an annual average growth of 0.2 cm in diameter and 17 cm in height.

Conclusion

The fire does not seem to modify in any important way the floral composition the vegetable training formations of *Tetraclinis articulata*. It is competed by species with strong power of covering as *Pistacia lentiscus*, *Quercus coccifera*, *Phillyrea angustifolia*, *Rosmarinus tourneforti*, Thuya, with its small domination of space starts again slowly but certainly its colonizing area. Thuya, after fire develops and to reconstitute its plant grouping in all climatic, edaphic, and antropozoogene pressure conditions.

The results of growth in height and in diameter obtained under three facies of Thuya confirm the resistance of this specie to changes in general and fires in particular. Annual growth average in height and in diameter oscillates respectively between 9.3 and 15.7 cm for the first parameter and between 0.4 and 0.6 cm for the second.

The hasty condemnation of which Thuya was the subject, imputed to its very slow growth, seems to be wondering by comparing the results obtained after fire to other species. The difference is not important, the faculty of refusal and resistance of Thuya often militates in favour of this relegated specie giving a second plan in all repopulations and reforestations.

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