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Combining Dendrometric Parameters and Soil Chemical Properties: An Useful Tool for Valorization of Shrubs in Forests

Brahimi Djamel[1], Rahmouni Abdelkader[2], Youcefi Ahmed[3]

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ABSTRACT

Background: The work was carried out in the arid environment of south-western Algeria using Retama retama (Forssk.) Webb and Berthel. an indicator shrub for forest protection and restoration.

Methods: The experiment was conducted during the period 2024-2025 in university center of Naama, in the arid region of Naâma, Algeria, North Africa.The study of dendrometric parameters such as height, circumference was based on inter-plant measurements, height of the shrubs and circumference of Retama plant. The soil chemical quality was examined by NMR spectroscopy magnetic and diffractometer. The statistical data representation was studied by descending hierarchical classification and correlation using R software.

Result: A height range of 0.2 to 3 m, a crown circumference range from 0.03 m to 13.8 m and an equidistance between 0.2 m and 19.40 m was observed. This study helped to understand the links between dendrometric parameters such as height, circumference and the chemical quality of soil. The chemical analysis of the soil by X-ray fluorescence spectrometry, XRD “X-ray diffractometer” and NMR “nuclear magnetic resonance”,shows that SiO_2 represent 90,83%, Al_2O_3: 7.45%, CaO:1.02%, Fe_2O_3:0.29%, Na_2O and K_2O:0.01%, TiO_2: 0.09%. The significant dendrometric results of the retama shrub demonstrate a significant ability to combat erosion and improve soil chemical quality through the addition of nutrients and organic matter from the associated fauna of the retama shrub. Dendrometrics are a valuable tool for sustainable forest management in arid regions, as they link tree characteristics to soil quality and the protection of the forest ecosystem.

Key words: Agricultural soil, Algeria chemical, Dendrometric, Forest.

Abbreviations: C: Circumference; D: Diameter; DHC: Descending hierarchical classification; NMR: Nuclear magnetic resonance spectroscopy; R: Radius; XRD: X-ray diffractometer.

INTRODUCTION

Large in area and with a remarkable variety of species, the Algerian forest plays a vital ecological role in the maintenance of the Mediterranean ecosystem and in local development, but it is now being eroded, especially in arid areas, due to several factors.

Majority land use changes from the natural forests to commercial agricultural lands, orchards and grazing lands have occurred due to deforestation and land degradation. (Amarjeet *et al.,* 2021).

Rétam is characterized by good adaptability and a tolerant species in the Naâma region, besides low palatability by animals, which qualifies it as one of the best forest resources to be valued in sustainable development and protection programs.

Today, dendrometry is necessary for the natural resources management and for the formulation of governing forest evolution and its production. In order to evaluate the dendrometric parameters and chemical characteristics of the soil, studies were carried out on *Retama retama*; a shrub indicator of the degradation of arid environments in arid regions.

MATERIALS AND METHODS

Study area

The experiment was conducted during the period 2024-2025 in three stations in the arid region of Naâma, Algeria, North Africa It is located in geocoordinates of 33° 47 29.55 N and 0° 1636.31 W, with 5.0% slope, at an altitude of 1058 m msl. This region is spread over 5000 ha, we opted for the random selection of four (04) stations, each is composed of fifty (50) aligned subjects of *Retama.*

[1]Department of Biology, Faculty of Sciences, University of Salhi Ahmed, Naâma, Algeria, Labo : Sustainable Management of Natural Resources in Arid and Semi Arid area, workshop: Biodiversity Valorization and Conservation in Arid and Semi-arid Zone, Naâma 45000, Algeria.

[2]Department of Chemistry, Laboratory of Polymer Chemistry, University of Oran1 Ahmed Benbella, BPN 1524 El’Menouer, 31000 Oran, Algeria.

[3]Department of Agronomy, Faculty of Sciences, University of Salhi Ahmed, Naâma, Algeria.

Corresponding Author: Brahimi Djamel, Department of Biology, Faculty of Sciences, University of Salhi Ahmed, Naâma, Algeria, Labo: Sustainable Management of Natural Resources in Arid and Semi Arid area, workshop: Biodiversity Valorization and Conservation in Arid and Semi-arid Zone, Naâma 45000, Algeria.
Email: brahimi@cuniv-naama.dz
ORCID: https://orcid.org/0000-0002-7115-0343

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According to Koshelev *et al.* (2024), When studying the dynamics of changes in indicators of forest-improved soils and mapping them, the following factors should be taken into account: The age of forest plantations, their height, the position of soils in the relief and the nature of agricultural exploitation.

Dendrometric parameters

The height of shrubs and circumference of *Retama* plants were measured. The circumference of the *Rétama raetam* plants was measured using a 30 m measuring tape and calculated by the mathematical formula:

$$C = \pi \times D \text{ } i.e. \text{ } C = \pi \times 2 \times R$$

C: Circumference.
D: Diameter.
R: Radius.

Soil analyses

In order to know precisely the chemical of soil, the analyses were carried out by: -NMR; nuclear magnetic resonance Spectroscopic: method of exploiting the magnetic characteristics of nuclear molecules; is a technique which exploits the magnetic properties of certain atomic nuclear. It is based on the phenomenon of magnetic resonance 200 MHz. NMR spectrometer with automatic sample changer used in organic chemistry for the determination of chemical structures. This technique is specifically used to study phosphorus (P) in soil, revealing the different chemical forms of P (*e.g.*, organic P, inorganic P) and their relative abundance.

-XRD;Diffractometer: X-ray diffractometers are designed to obtain ultimate quality target radiation diffraction data, combined with ease of use and flexibility to quickly switch to different applications.

The statistical representation of the data was carried out by HDC Hierarchical descending classification and C correlation using the R software.

RESULTS AND DISCUSSION

Dendrometric parameters

Through the dendrometric measurements carried out, station 01 (East) is characterized by a height of the shrubs between 0.2 and 3 meters, a circumference of the crown varies from 0.10 m to 12 m and an equidistance from 0.25 m to 19.40 m. The second station (West) the height is between 0.3 m and 3 m, the crown circumference between 0.03 m and 12 m and the equidistance between 0.25 m and 11.50 m. Regarding station no. 03 (North), the height varies from 0.30 m to 1.80 m, the crown circumference from 0.03 m to 8.30 m and the equidistance from 0.40 m to 13.40 m. The last station (South) is distinguished by a height of 0.40 m to 2 m, a crown circumference of 0.12 m to 13.80 m and an equidistance of 0.70 m to 16.10 m.

Hierarchical descending classification of Rétam subjects

The graphic representation of the hierarchical descending classification (Factorial plan, Hierarchical tree) of the subjects of Rétam (Fig 1), taking into account the quantitative variables: perimeter of the crown, height and the equidistance between plants reveals three classes namely :

Class 1

Groups together subjects that share low values for the variables: Crown perimeter, height and between plants. These are relatively dense formations, made up of small subjects.

Class 2

Composed of subjects characterized by high values for the crown perimeter and height variables and low values for between plants. This population brings together scattered and healthy subjects with significant heights and perimeter.

Class 3

Structured by individuals characterized by high values for the variable between plants. This group includes scattered populations with a significantly low density compared to the other classes.

Correlations data

Correlation of crown height/circumference correlation

When the height is less than 01 meter and the circumference of the crown is less than 05 meters, the distribution of plants is relatively dense, while when the

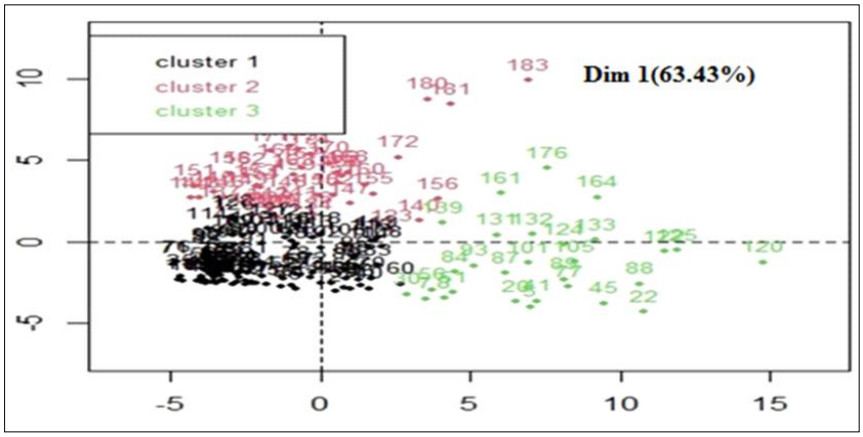


Fig 1: Factorial plan of Retam according to variables (crown perimeter, height and between plants).

height exceeds 01 m and the circumference 5 m, we notice heterogeneity in the distribution of plants. The correlation coefficient which is of the order of 0.79 reflects a good positive linear relationship between the two variables: height and circumference of the crown, given that they present a trend in the same direction.

Correlation of crown circumference/between plants

The regression line as well as the calculated correlation coefficient (r = 0.10) indicate the absence of a linear relationship between the two variables: crown circumference and between plants.

Correlation of Height/between plant correlation

The processing of data relating to the existing relationships between the variables: height, circumference of the crown and between plants shows that the parameter between plants is not really determining in the distribution of subjects and in the values of the other quantitative variables, this may be due to the hardiness of the *Rétam* and their tolerance towards poor or mediocre soil quality, which presents a very important advantage for this species (Fig 2).

Statistical study

Statistical study of height of rétama plants

Height

Population studied

Height of *Rétama* plants. According to Sturges' rule we calculated: classes number N : 1+ (3.3 log N), targeted: k= 1+3.3 log (200). k=9 .2_Extent: E = x max –x min E=3-0.2 therefore E=2.83_ Class interval (size or Amplitude) So: Am= E = 2.8 Am=0.31 (Table 1).

The mode

$$Mo = xi + D1\ am\ D1 + D2$$

Xi = Lower limit of the modal class.
Am = Amplitude of the modal class.
Mo = 0.49.

The model class of the statistical series of height of retama plants in the study area is [0.2, 0.51 [which corresponds to the maximum number 43.

The median divides the statistical series into two equal parts.

Depending on the value of the median in the graph, the two curves of increasing and decreasing cumulative numbers or frequencies.

The intersection point has Fi = 50% as ordinate and corresponds to the median class [1.44,1.75[. Using the R software we calculated the position and distribution parameters Height Min. : 0.200 1st Qu:0.600 Median: 1.000 Average: 1.166 3rd Qu: 1.670 Max. : 3,000 -The model class of the statistical series of plant height of retama in the study area is [0.25,2.35] which corresponds to the maximum number 69. the two curves of increasing and decreasing cumulative numbers or frequencies.

The intersection point has the ordinate Fi = 50% corresponds to the class r of the median [8.65, 10.75 [.Using the R software we calculated the position and distribution parameters between plants (Table 1).

Statistical table of Rétama plant circumference

Population studied: circumference of *Rétama* plants. 1_According to Sturges' rule we calculated: (3.3 log N) + 1 targeted: k= 1+3.3 log(196) k=9 (Table 2) .

The mode

$$Mo = xi + D1\ am\ D1 + D2$$

Xi = Lower limit of the modal class.
Am = Amplitude of the modal class.

The model class of the statistical series of plant height of retama in the study area is [0.03, 0.56 [which corresponds to the maximum number 97 .the two curves of increasing and decreasing cumulative numbers or frequencies. The intersection point has the ordinate Fi = 50% corresponding to the median class [6.15, 1.56].

Significant and high dendrometric values were recorded for the different parameters of the Retama shrub in the study region.

This study shows that the chemical quality of the soil plays an essential role in the improvement of dendrometric parameters, especially on trees and shrubs in arid regions. The shrub indicator of the degradation of forest ecosystems

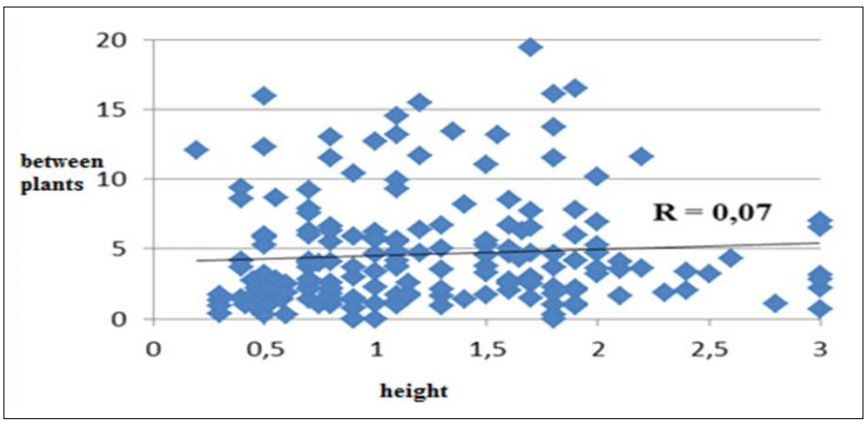


Fig 2 : Correlation between crown height and between plants of subjects *Rétam.*

in Algeria Retama showed resistance and adaptation, facing unfavorable conditions, notably the low quality of the soil with important dendrometric parameters.

With these parameters the impact of the Retama shrub against erosion and desertification is significant given the volume of its root system. Domergue and Pirot (2008) report that certain shrubs reach up to 5 to 8 m high in unfavorable conditions, this adaptation of shrubs in forests plays an essential role in the erosion and restoration of forests (Brittaine *et al*., 2010; Reubens *et al*., 2010).

Chemical stady

The chemical analysis of the soil by X-ray fluorescence spectrometry, shows that SiO_2 is the main element in the chemical composition of the soil with the presence of low amounts of some chemical elements.

Analysis of the soil shows that SiO_2 represent 90,83%, Al_2O_3: 7.45%, CaO:1.02%, Fe_2O_3:0.29%, Na_2O and K_2O:0.01%, TiO_2: 0.09%. Analysis of the soil by the XRD "X-ray diffractometer", NMR "nuclear magnetic resonance" and XRF "X-ray fluorescence spectrometry" confirms that the chemical quality of the soil of these regions is low, SiO_2 is the main element in the chemical composition of the soil with the presence of low amounts of some chemical elements. These results show that the soil in these regions requires natural chemical supplements and additions in order to improve the chemical quality of the soil.

The use of the diffractometer (Fig 3) and the two techniques magnetic nuclear resonance (Fig 4) and spectrometry show that the chemical quality of the soils in the study area is low. These results show that Retama shrubs adapt to chemically poor soils with an abundance of silicon dioxide, aluminum oxide and calcium oxide.

Abdelghani (2020), demonstrated that the nature of the soil in the southwest region of Algeria is calci-magnesian with remarkable salinity. The important limiting factor of agricultural production in arid soils is salinity (Linzhu, 2021).

According to Ewing (2006), The dry climate favors an increase in salinity in arid regions, this situation reduces the development of plants and trees with the exception of resistant species Ons (2018). in a study by Abdennour *et al*. (2021) on soil chemical quality traditional agricultural practices in Africa increase salinity levels.

The use of spectrometry in chemical analysis of soil classifies silicon dioxide with 90.83%, aluminum oxide: 7.45%, calcium oxide: 1.02%, iron oxide: 0 .29%, Sodium oxide and Potassium oxide: 0.01%, Titanium dioxide: 0.09%.

Steven (2013) and Deng (2015) emphasize that the chemical study of the soil is necessary to understand the formation of arid biological soils. Peng (2021), the Algerian forest is largely located in semi-arid and arid regions whose soils are saline and limestone, this situation contributes to the degradation of Algerian forests requiring the introduction of forest species resistant and adaptable to salinity such as retame. Meslier and Diruggiero (2019), confirmed arid soils, require significant organic fertilizers including phosphorus and nitrogen. Lakhwinder *et al*. (2025).

Table 1: Statistical table of height of *Rétama* plants.

Classes	Xi	Eff (ni)	Fi	Fi%	Ei cum	F cum	F C C%	F C D%	ni xi
[0.2 ; 0.51	0.35	43	0.215	21.5	43	0.215	21.5	100	15.05
[0.51 ; 0.82]	0.66	40	0.2	20	83	0.41	41	96.5	26.4
[0.82 ; 1.13]	0.97	33	0.165	16.5	116	0.58	58	94.5	32.175
[1.13 ; 1.44]	1.28	16	0.08	8	132	0.66	66	91	20.12
[1.44 ; 1.75]	1.59	26	0.13	13	158	0.79	79	79	41.47
[1.75 ; 2.06]	1.90	25	0.125	12.5	183	0.915	91	66	47.62
[2.06 ; 2.37]	2.21	6	0.03	3	189	0.945	94.5	58	13.29
[2.37 ; 2.68]	2.52	4	0.02	2	193	0.965	96.5	41	10.1
[2.68 ; 03]	2.84	7	0.035	3.5	200	1	100	21.5	19.88
Total		200		1		100		226.11	

Table 2: Statistical table of Rétama plant circumference.

Classes	Xi	Eff (ni)	Fi	Fi%	Ei cum	F cum	F C C%	F C D%	ni xi
[0.03 ; 1.56]	0.795	97	0.485	48.5	97	0.485	48.5	100	77.115
[1.56 ; 3.09]	2.325	29	0.145	14.5	126	0.63	63	99.5	67.425
[3.09 ; 4.62]	3.855	29	0.145	14.5	155	0.775	77.5	97	11.795
[4.62 ; 6.15]	5.385	17	0.085	8.5	172	0.86	86	96.5	91.545
[6.15 ; 7.68]	6.915	14	0.07	7	186	0.93	93	93	96,81
[7.68 ; 9.21]	8.445	7	0.035	3.5	193	0.965	96.5	86	59.115
[9.21 ; 10.74]	9.975	1	0.005	0.5	194	0.97	97	77.5	9,975
[10.74 ; 12.27]	11.505	5	0.025	2.5	199	0.995	99.5	63	57.525
[2.68 ; 03]	2.84	1	0.005	0.5	200	1	100	48.5	2.84
Total		200	1	100					474.145

showed that application of Zn; $ZnSO_4$ to soil at 20 kg/ha + 0.5% with foliar spray of Zn (0.5%) at flowering initiation and pod formation phases attributed significant increase in growth and yield attributes of mung bean. The percentage increase in yield was 14.6% and 15.0%.

According to Christopher (2015) the chemical elements of the rich soil are essential for the natural development of plants and trees. calcium (Ca) Ca^{2+} Phosphorus (P) and are essential for plant development and in the composition of adenosine and triphosphate (Mcgrath, 2014).

In arid regions, remarkable accumulation of calcium carbonate, gypsum or silica by arid soils (Skujins, 1991). According to Huan (2020), nutrients are considered indicators of soil fertility.

The dendrometry of the Algerian forest is also threatened by certain natural species such as insect pests, these species including locusts, processionary caterpillars and wood-eating beetles affecting the health of trees and shrubs. Taibi (2018) and Brahimi (2019) highlight the abundance of insect pests in Algerian forests causing significant damage. The chemical quality of soils can be influenced by the use of phytosanitary products, Constanza *et al*. (2021), emphasized that chemicals have harmful consequences on soils. According to Debjani *et al.* (2018), The indiscriminate use of synthetic chemicals led to development of resistance in plants which has necessitated utilization of higher concentrations, with the consequent rise in toxicity in food products. In ecosystem plants are surrounded by various enemies which defend themselves by producing secondary metabolites like terpenes, phenols and nitrogen and sulphur compounds.

Agricultural practices such as fertilization and tillage influence soil chemical properties and nutrient dynamics throughout the soil profile (Das *et al.,* 2020). The soil microbial biomass is fundamental to maintaining soil functions because it represents the main source of soil enzymes that regulate transformation processes of elements in soils, and it has been suggested as possible indicator of soil environment quality (Sahoo *et al*. 2019).

According to Brahimi *et al.* (2021), arid zones in North Africa are characterized by arid ecosystems and fragile soils caused by wind erosion.

Based on its morphological characteristics and strong nitrogen fixation power, the forest shrub retama plays an

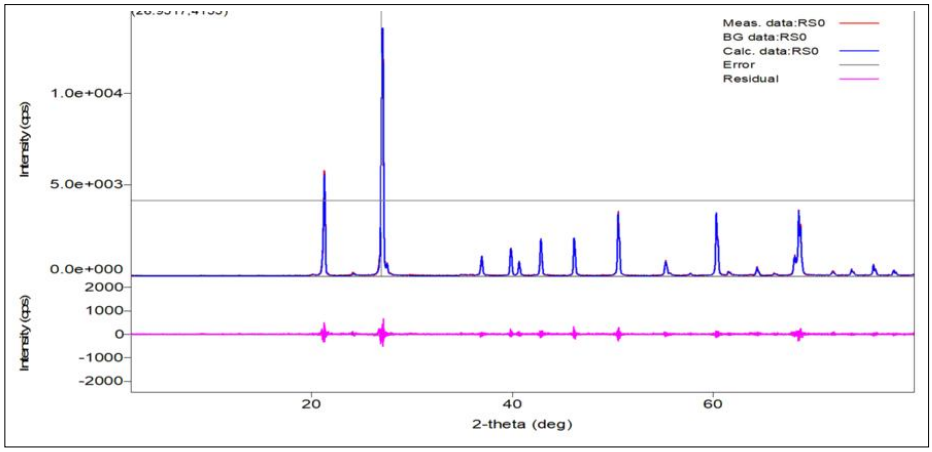


Fig 3: Chemical analysis of the soil by X-ray diffractometer XRD.

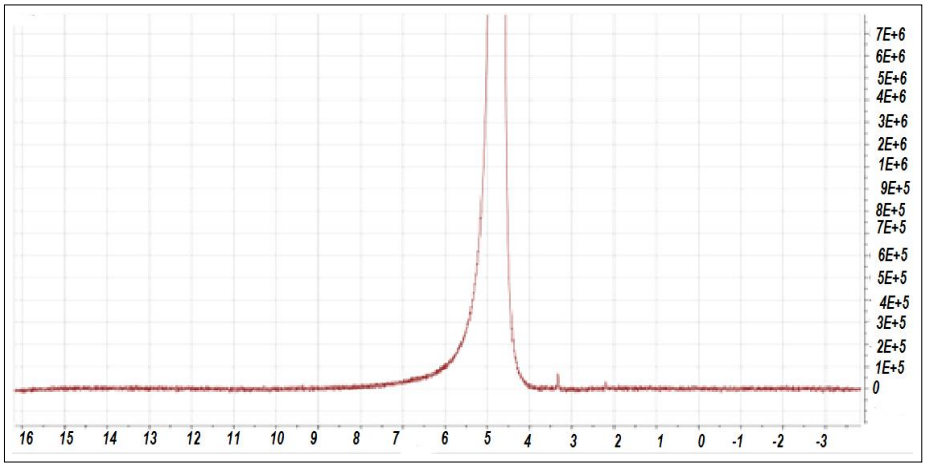


Fig 4: Chemical analysis of the soil by nuclear magnetic resonance NMR.

important role in faunal diversity because it attracts insects; arthropods; invertebrates which participate in the process of chemical transformation of nutrients and recycling of organic matter as well as in the microbial activity of the soil. Nutrition of plants has a substantial impact on the predisposition of plants to insect-pests. Regulated and balanced crop fertilization can be helpful in altering host plant susceptibility to sucking insect-pests (Vinay, 2017).

The aridity and desertification of ecosystems in North African regions provides favorable conditions for harmful insects and forms of adaptation for several plant species (Brahimi *et al*., 2020). Biological control agents (BCAs), including entomopathogenic bacteria and fungi, provide sustainable alternatives for pest management. The effectiveness of these methods depends on understanding the underlying mechanisms and optimizing application conditions (Mahesh *et al.,* 2024).

The physicochemical properties and the microbial population of the soil varied according to the use of forest land and plantation land.

Sandeep *et al.* (2021), showed that Soil physicochemical properties and microbial population also varied with land use, while physicochemical properties and microbial population were generally improved in *Kharif* compared to *Rabi*.

During this work, we recorded a very good state of health of retama; it is a pest-resistant shrub, in case of phytopathogenic diseases we suggest a combined chemical and biological treatment to protect the trees. It is therefore necessary to reduce the use of insecticides. The prospect of integrating chemical and fungal insecticides in combination offers a promising strategy to reduce environmental impacts as part of an integrated pest management approach (Ankit, 2025).

Soil physical analysis

A Comparative study between two sites soil physical analysis shows an improvement in the physical characteristics of soils planted with retama shrubs compared to other forest species. The fines content and fineness modulus vary between 1 and 1.33, while the sand equivalent is reduced to 45% with an absolute density of 2.59.

These results confirm the ecological role of retama shrubs and their important dendrometric characteristics in improving the physical quality of fragile soils.

CONCLUSION

The main objective of this study is to combine dendrometry of the retama indicator shrub with soil chemical analysis to protect forests.

This study demonstrates excellent morphological and physiological adaptation of the retama indicator shrub to arid soils and a significant correlation between dendrometry and soil chemistry results in the ability of retama to rehabilitate degraded forests and improve the chemical quality of arid soils.

The soil chemical analysis confirms the importance of integrating the retama indicator shrub into degraded North African forests for forest system development, improving the chemical quality and productivity of arid soils.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completenessof the information provided, but do not acceptany liability for any director in directlosses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal Care and Handling Techniques were approved by the University of Animal Care Committee.

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Conflict of interest

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