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Production Potential of *Thymus atlanticus* (Ball) Roussine in the Eastern High Atlas of Morocco

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Abstract:

Aromatic and medicinal plants are a rich source of substances that are beneficial to human health. At a socio-economic level, the exploitation of medicinal plants constitutes an important income for the local populations. However, the use of these plants in recent decades has put a lot of pressure on these resources, and many species suffer from over-use without taking into account the existing potential. *Thymus atlanticus* is an aromatic and medicinal shrub endemic to Morocco. It's rare and has a very limited geographical area. In this study, we determine the status of *T. atlanticus* and evaluate the biomass production potential of this spontaneous species in 2021. The results show that the density of *T. atlanticus* does not exceed 235 plants per 100 m^2, with a recovery rate of 19.92 %. Whereas the biomass dry matter was only 67.3 ± 1.22 kg/ha. The yield of *T. atlanticus* essential oil was 1.78 % (w/w). From these results, it appears that *T. atlanticus* cannot be exploited in this state. It needs to be rehabilitated, and protected. These results can help to better restore and manage the steppe at *T. atlanticus* in the future.

Keywords: *Thymus atlanticus*; Essential oil; Aromatic and medicinal plants; Biomass production

1. Introduction

In Africa, medicinal plants are valuable resources for the majority of rural populations, where they are used by more than 80 % of this population for their health care (Jiofack et al., 2010; Mpondo et al., 2012). Morocco, by virtue of its geographical location, constitutes a completely original natural setting, offering a complete range of Mediterranean bio-climates favoring a rich and varied flora with a very marked endemic plant (Ghanmi et al., 2011). It is one of the Mediterranean countries with a long medical tradition and traditional know-how based on medicinal plants (Scherer et al., 2005). The ecosystems of Morocco offer a total of 382 species of aromatic and medicinal plants. Among this set of plants, there are 364 medicinal species, 29 cultivated and 335 spontaneous (Aafi et al., 2011). Morocco is one of the world's exporters of aromatic and medicinal plants. More than 90 % of the national production is based on the collection of spontaneous plants, the main ones being thyme, rosemary, carob, and laurel sauce (Zrira, 2017). At another socio-economic level, the exploitation of aromatic and medicinal plants constitutes an important income for the local populations. Harvesting medicinal and aromatic plants is a socioeconomic strategy to diversify agricultural production while still providing jobs for local people. This activity gives about 500000 working days for a total income of 2.27 million dollars to the local community and creates additional cash for rural communities (Taleb, 2013). However, the use of aromatic and medicinal plants in recent decades has put a lot of pressure on these resources, and many species suffer from over-harvesting without taking into account the existing potential.

T. atlanticus is an endemic and rare plant in Morocco found in high mountains on drained limestone soils. *T. atlanticus* is an aromatic and medicinal plant characterized by its anti-inflammatory, anticoagulant and antioxidant effects (Hmidani et al., 2019; Khouya et al., 2020) among others.

The exploitation of aromatic and medicinal plant in Morocco suffers from a lack of precise knowledge regarding

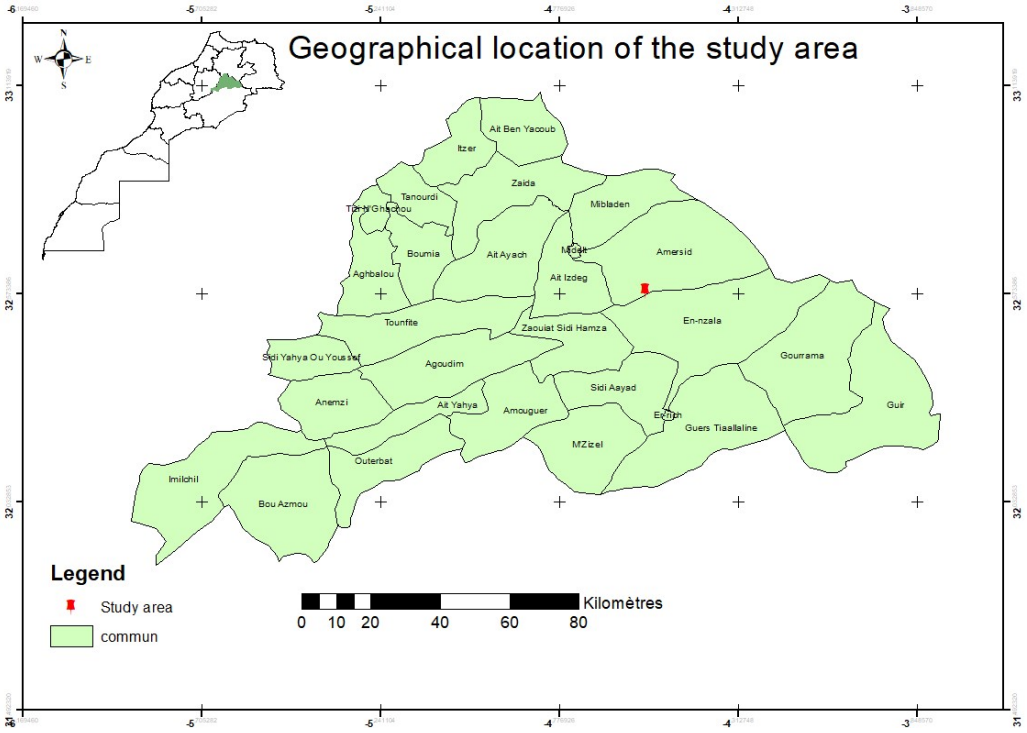

Figure 1. The geographical location of the study area.

the existing potentialities. Also, it is far from rational. Overgrazing, overexploitation and other anthropogenic threats increasingly threaten the presence of this species. The objective of our work was to determine the status of *T. atlanticus* and to evaluate the phytomass production potential of this species.

2. Materials and methods

2.1 Study area

The study area concerned by our work is located at the level of the Moroccan Eastern High Atlas situated in the region of Draâ Tafilelt, Midelt province with coordinates (32.57922251; −4.55283492 and altitude 2070 m) where *T. atlanticus* is found in the wild (Figure 1). The choice of this site is based on the presence and dominance of *T. atlanticus*, which is our desired plant. The study site is characterized by the characteristics presented in Table 1.

2.2 Climate data

Rainfall and temperature data for the study area are taken from https://power.larc.nasa.gov. Figure 2 presents the embrothermic curve of Tizi n'Telghemt site. It shows that the drought at the study site level is 4 months. The study area is characterized by a semiarid climate with an average temperature of 14.64 °C and minimum temperatures of 4.57 °C recorded in January, and maximum temperatures of 26.52 °C recorded in July with annual precipitation of around 361.44 mm.

Table 1. Characteristics of study site.

site	Tizin'Telghemt
date of observation	25/05/2021
altitude	2070 m
coordinats	32.57922251; -4.55283492
topography	slope
slope	30 and 45 %
lithology	marly limestones
pedology	limestone
geology	toarcian
stone load	medium
bare soil (%)	60 %
grazing intensity	intense
exploitation	rare
rangeland quality	degraded

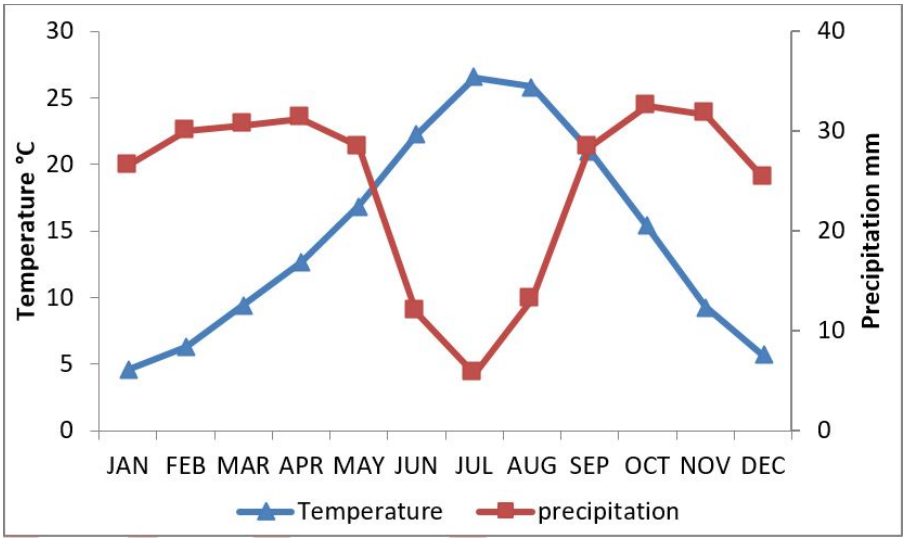

Figure 2. Embrothermic curve of Tizi n'Telghemt site.

2.3 Methodology

The phytomass was estimated by weighing a quantity of *T. atlanticus* cut and dried in the laboratory oven. The phytomass of *T. atlanticus* was assessed using the direct method of cutting vegetation to the ground. A 1 m^2 quadrant was cut, transported and dried to estimate the dry mass. The weight often concerns the aerial part of the plant expressed in dry matter after drying. Results of 1 m^2 were converted into hectare to obtain phytomass in the total area of site.

We deliberately chose a minimum area of 100 m^2. Sampling was conducted in *T. atlanticus* dominated steppe from an elevation 2000 m in one location.

During the survey, five plots of (10×10 m) were randomly constructed. Different traits like density, young plants and recovery of *T. atlanticus* were investigated. Data were represented as mean and standard deviation (SD).

$$\text{Density} = \frac{\text{Total number of individuals of a } \textit{T. atlanticus} \text{ in all quadrates}}{\text{Total number of quadrates}}$$

2.4 Extraction of essential oils

The plant materials were dried in shade. Then, 60 g of the dried plant materials was subjected to hydro-distillation in 500 mL of distilled water for 4 h using a Clevenger-type apparatus. The essential oil was separated, and then, the oil yield was calculated.

3. Results

Table 2 shows the estimated the ecological parameters of *T. atlanticus* at the Tizi n'Telghemt site. The surface of the steppe of *T. atlanticus* was 24 ha, so it occupies a very limited space. The recovery of *T. atlanticus* at Tizi n'Telghemt site was 19.29 %. So, it has undergone strong degradation by grazing. The results show that the density of *T. atlanticus* was 235 ± 46.94 plants $/100\,m^2$, and that the number of young plants does not exceed 40.27 ± 18 plants $/100\,m^2$. So, the majority of plants were old; the generation was rare in a way that *T. atlanticus* in its site may disappear over time.

The results showed that the amount of dry matter was only 67.3 ± 1.22 kg/ha. Likewise, dry leaf mass does not exceed 28.52 ± 0.51 kg/ha. Concerning the yield of essential oils of *T. atlanticus*, it was 1.78 % (w/w). According to these results; this site cannot be exploited because the amount of plant material that can be collected is limited.

4. Discussion

This area is known for its heavy grazing, which is the main cause of degradation of this pastoral ecosystem. However, the amount of dry matter of *T. atlanticus* at Ourika site does not exceed 37.60 kg/ha; it is less abundant in comparison to other thymes such as *T. pallidus* (327.55 kg/ha) and *T. satureioides* (235.83 kg/ha) (Arhinful, 2017).

Table 2. Ecological records, phytomass and essential oils of *T. atlanticus*.

Traits	Unit	Values
area	ha	24
recovery	%	19.29 %
density	plants /100 m^2	235±46.94
young plants	plants /100 m^2	40.27±18
yield of essential oil	%	1.78 %
dry matter	kg/ha	67.3±1.22
dry leaf mass	kg/ha	28.52±0.51

The yield of essential oils of *Thymus atlanticus* was 1.78 % (w/w). Similarly, (Nafis et al., 2021) showed that aerial parts of *T. atlanticus* gave an essential oil yield of 1.41 %, based on dry matter (v/w). In another study, the *T. riatarum* yield was 0.26 %(Fadli et al., 2014). The same *T. maroccanus* and *T. broussonetii* yielded 1.38 % and 1.2 % EOs, respectively (Fadli et al., 2012). Also, the yield of *T. bleicherianus* was 1.75 % (Aafi et al., 2011).

Exploiting of aromatic and medicinal plant potential has emerged as a crucial and promising sector for the country. The economic analysis showed that the quantities exported are on average 6.805 tons of essential oils and various extracts for a value of 18.31 million dollors whereas Moroccan imports represent only 1.523 tons for a value of 2.86 million dollors. In addition to essential oils, the aromatic and medicinal plants sector exports about 100 tons of dried herbs for a total value of about 8.32 million dollors (Aafi et al., 2011). Despite these numbers, the exploitation of aromatic plants in Morocco is done in an uncontrolled manner, which negatively affects the natural resources of these plants.

5. Conclusion

T. atlanticus is one of endangered species. The *T. atlanticus* steppe is in a state of degradation due to climate change and overgrazing. The results showed a low quantity of *T. atlanticus* in this site. Therefore, this steppe needs rehabilitation and protection. This study provides information on the state of the *T. atlanticus* steppe to allow better management and protection of the species' resources.

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Ethical Approval
This manuscript does not report on or involve the use of any animal or human data or tissue. So the ethical approval does not applicable.

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Authors Contributions
All authors contributed equally in performing and preparing the paper.

Availability of Data and Materials
There is no presented experimental data in the manuscript.

Conflict of Interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this.

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