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Qualitative Analysis of The Potential Regeneration of Post-Fire Flora in The Ikhelidjen Region (Larba Nath Irathen), Tizi-Ouzou District, Algeria

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Abstract

The last few years, Algeria is renowned for its vulnerability to extensive and destructive wildfires, attributed to highly flammable vegetation and exceptionally favourable with climatic changes. Fire is considered as an ecological force through which plants have developed adaptive mechanisms to endure, regenerate and promote the dissemination of new species. The present study aims to assess the floristic composition regenerated through the year 2022, after the July 2021 fire, which devastated the Ikhelidjen area in the Kabylia region (northern Algeria), characterized by a Mediterranean climate dry cold winter and hot humid summer. The flora survey results revealed the presence of a total richness of 220 individuals with 37 species belonging to 3 classes (Magnoliopsida, Liliopsida and Equisetopsida) spread over 33 genera, 14 families and 14 orders. The rapid flora regeneration was observed within the Asteraceae and Lamiaceae families in a soil presented a low alkaline high organic matter content.

Keywords: Fire, forests, floristic regeneration, plant species, Algeria.

Introduction

The forest is an ecosystem that shelters one of the greatest biological diversities, in terms of ecological and economic resources, which is essential for physical, climatic and social equilibrium. For these reasons, Mediterranean forests represents an important genetic reserves functional diversity specific that should be preserved as much as possible for sustainable management of this biological heritage and its potential resources. Algeria is characterized by a high diverse and fragile forest ecosystem, which is mainly composed of Mediterranean species flora endemic to the Maghreb, that are covering more than five million hectares of preserved forests, where 2.413.090 ha are degraded ones, while the scrubland covers only 1.702.818 ha (or 42% of the total forest formations). These are exposed to many natural risks and mainly to human-induced aggressions through various anthropogenic activities [1, 2].

Forest fires play a fundamental role in Mediterranean ecosystems, with different taxa which are developing adaptive strategies to survive from recurrent fires. Some established observations in Algeria, indicate a remarkable change in the fire regime, over the last decades [3, 4]. This change is attributed to socio-economic and land-use exacerbated by the influence of global temperature rising. In addition, the recurrent use of fire by rural populations, especially at the interfaces between habitat and forest, that contributes significantly to this change [5]. A statistical study retracing the history of fires in Algeria revealed that during the last two decades, the country recorded 42.555 fires, devastating a total forest area of 910.640 hectares, with average of 31.300 hectares a year [6].

The topography of the great Kabylia with hills, mountains and fairly steep slopes in places and forest and pre-forest vegetation occupying the coastline, offers a various of physical conditions that are more or less suitable for fire. In addition, the climate conditions give to this region a dry period of four to five consecutive months, when rainfall is almost non-existent and high temperatures recorded, during the all year [7]. The year of 2021 fire event, in Algeria, is unprecedented in its intensity and severity, particularly in terms of human loss and economic damage. The total area affected is estimated at 100.101 hectares, resulting from a total of 1.631 fires. These fires rank among the most severe in the recent history of the country, leading to a significant human toll of 220 deaths, including civilians and soldiers. The mountainous district of Tizi Ouzou, situated in the Kabylia region, experienced the most significant impact from the fires, resulting in the affliction of approximately 44.000 hectares of forest cover, the loss of several thousand farm animals and the destruction of 1.705 homes [8].

The present study was carried out in order to evaluate the fire effects on the structure of biotic communities and the dynamics of floristic regeneration, after the big fires of August 2021, in the Ikhelidjen mountainous region, of Tizi Ouzou district. This zone is selected as study area, because it was recognized as the most extensively burned region. The aim purpose of the work was to understand how the fire could influence the regeneration of the original vegetation and identify factors that induce the establishment of pyrophyte species.

Materials and methods

The survey was conducted in the Ikhelidjen area which covers 3927 ha, situated within the Larbâa Nath-Irathen region, located at 30 km in the East of Tizi-Ouzou town (36°36'41"N and 4°12'31"E) (**Fig 1**). The study region is characterized by a high rugged topography, is renowned for its rural mountainous character and a Mediterranean climate, characterized by rainy cold winter; from November to March and hot humid summer, started from April to October.

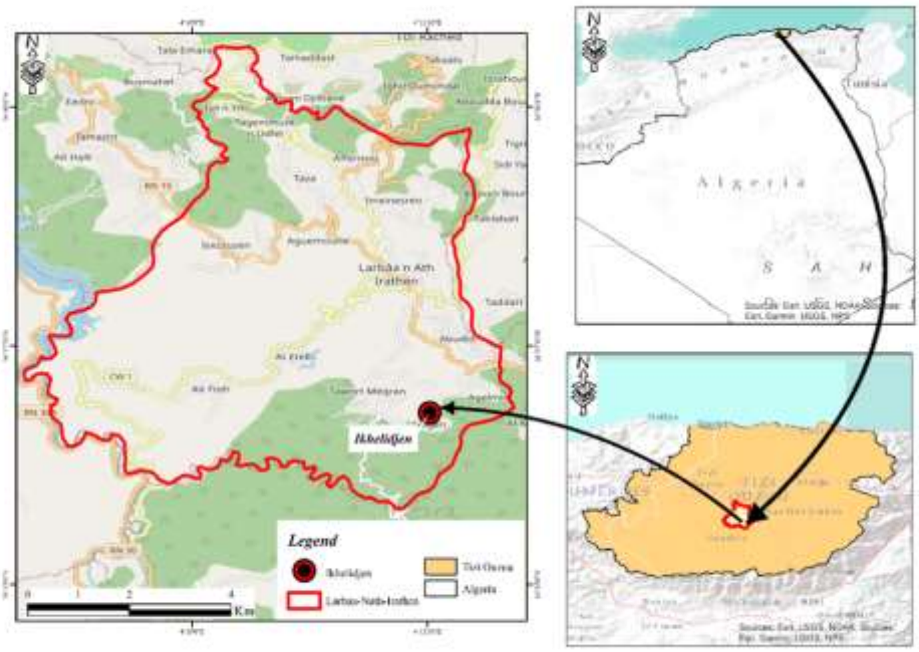

Fig (1): Localization of the study area, Ikhelidjen Tizi Ouzou district (Google Maps, 2022).

This study was investigated to evaluate the fire effects on the flora biodiversity and the physico-chemical soil properties following the fires that ravaged Ikhelidjen in the Larbaa Nath Irathen forest massif. During the flowering season, the spring 2022, one-year post-fire, systematic plant sampling with a measure of some physico-chemical parameters were done. The sampling period was carried out four times a month, from March to June, covering all the study area which was divided into eight (08) plots of equal surface (10x10m) separated from each other with 35m (Wulfsohn, 2010). During the survey all collected fresh (green) plants were put in plastic bags than taken in to the laboratory for identification. Soil samples were taken from the same plot at a depth of 20 cm. The subsequent harvested flora was identified and classified according to [9] and Angiosperms Phylogeny Group IV [10] criteria. The results were subjected to ecological indices and to statistical analysis using the R Statistical Package version (4.1.3). Soil analyzes of different parameters were considered [11], where the pH for each plot was measured, respecting the soil/water ratio which is 1/5. Also, the EC (ds/m) was determined on an aqueous extract of 1/5 of the soil and the granulometry, was carried out using a previous method [12] .

Results

After the fire in Ikhelidjen, the disrupted forest ecosystem begins a new healing survival to join its balance by initiating organization and emergence of a certain flora in order to develop its initial state without human intervention (**Fig 02**). The flora identification studies revealed the presence of various plant species regenerated (*Calicotome spinosa, Galactites tomentosa, Polypogon monspelinesis, Sinapis arvensis, Chrysanthemum myconis, Daphne gnidium, Papaver rhoeas*) consisted predominantly of herbaceous plants. The systematic flora studies confirmed 37 species, belonging 33 genera under 14 orders and 3 classes and 14 families (**Table 1**). The floristic diversity during the initial 10 months post-fire, represented a total richness of

220 individuals, distributed in to 33 genera included 37 species across 3 classes (Magnoliopsida, Liliopsida and Equisetopsida), 14 families and 14 orders.


Fig (2): Aspect of post-fire regeneration of flora species in Ikhelidjen area, after a year of the fire (originals, 2022).

Table 1: Identified plant Species collected from study area, Ikhelidjen during the study period.

Class	Order	Familly	Genera	Species
Magnoliopsida	Astrale	Asteraceae	*Galactites*	*Galactites tomentosa*
			Chcysanthemum	*Chrysanthemum myconis*
			Sonchus	*Sonchus oleraceus*
			Bellis	*Bellis annua*
			Pallenis	*Pllenis spinosa*
			Andryala	*Andryala integrifolia*
			Chicorium	*Chicorium intybus*
			Xanthium	*Xanthium strumarium*
	Myrtale	Thymlaceae	*Daphne*	*Daphne gnidium*
	Geraniale	Oxalidaceae	*Oxalis*	*Oxalis pes-caprae*
		Papaveraceae	*Fumaria*	*Fumaria capreolata*

	Papaver ale			*Fumaria officinalis*
			Papaver	*Papaver rhoeas*
	Caparale	Brassicaceae	*Capsella*	*Capsella bursa-pastoris*
			Sinapis	*Sinapis arvensis*
	Brassicale		*Biscutella*	*Biscutella didyma*
			Raphanus	*Raphanus raphanistrum*
	Lamiale	Boraginaceae	*Echium*	*Echium vulgare*
		Lamiaceae	*Lamium*	*Lamium garganicum subsp longiflorum*
				Lamium album
				Lamium purpureum
	Rosale	Rosaceae	*Rubus*	*Rubus ulmifolius*
			Prunus	*Prunus avium*
	Fagale	Fagaceae	*Quercus*	*Quercus suber*
	Fabale	Fabaceae	*Calicutome*	*Calicotome spinosa*
			Cytisus	*Citysus triflorus*
			Lupinus	*Lupinus angustifolius*
Equisetopsida	Aspiale	Aspiaceae	*Daucus*	*Daucus carota*
			Thapsia	*Thapsia garganica*
	Lamiale	Lamiaceae	*Stachys*	*Stachys ocymastrum*
		Oleaceae	*Olea*	*Olea europaea*
	Poale	Poaceae	*Polypogon*	*Polypogon monspelinesis*
Liliopsida	Liliale	Liliaceae	*Allium*	*Allium triquetrum*
				Allium roseum
			Muscari	*Muscari comosum*
			Asparagus	*Asparagus acutifolius*
3	14	14	33	37

The Asteraceae family was noticed to be the most dominant, with 21.62% belonging Asterale orders that comprising 8 species. This is following with the Brassicaceae, Lamiaceae and Liliaceae families with 10.81% and the abundance of the other families varies between 8.1

and 2.7% (**Fig 3** and **4**). A significant specific richness of harvested species is observed with 31 species at plot 1, with the highest diversification (**Fig 4**).

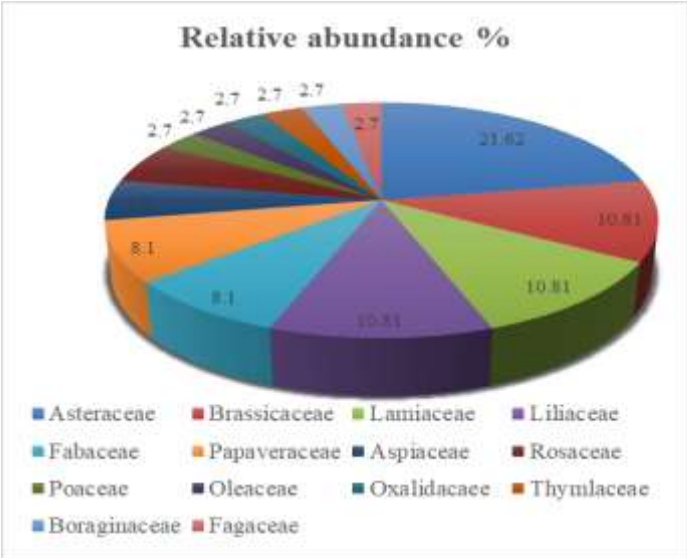

Fig (3): Relative abundance of plant families recorded in the study area.

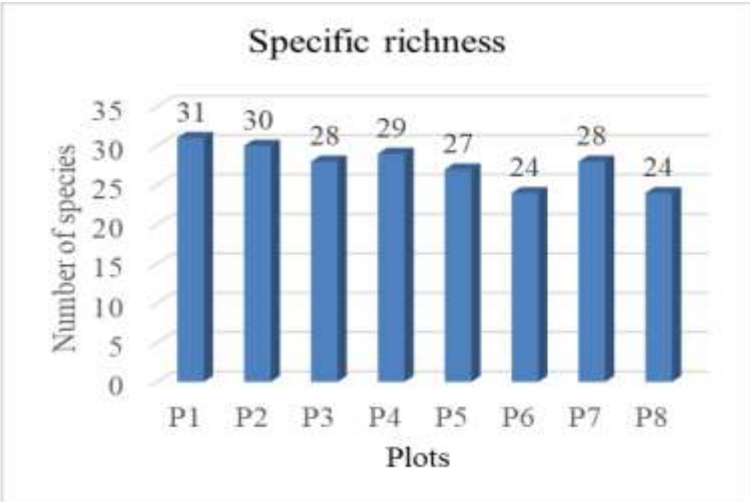

Fig (4): The specific richness of the species collected in Ikhelidjen during the study period.

The Shannon diversity index (H') exhibits a variability, which reflects an average diversity of species and taxa, in Ikhelidjen, reaching a maximum of 3.43 for plot 1 and a minimum of 3.17 for plots 6 and 8 (**Fig 5**). The vegetation reconstitution is faster after fire and depends on the fire's intensity and frequency.

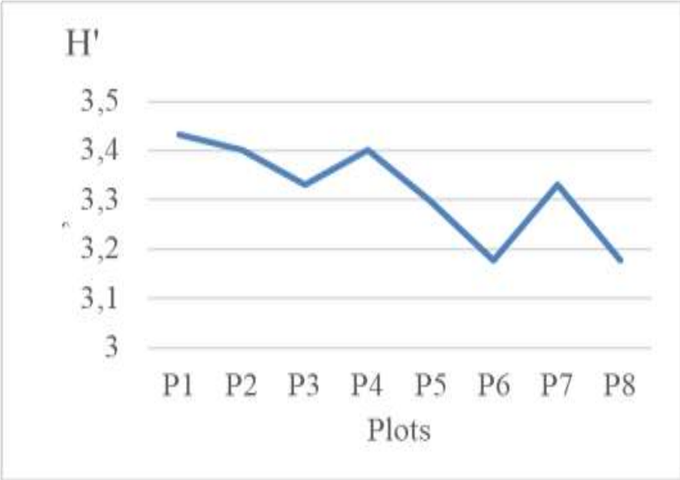

Fig (5): Shannon index (H') of the flora in the study area Ikhelidjen during study period.

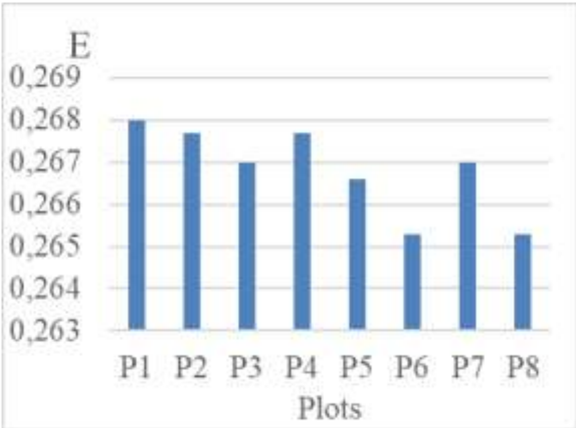

Fig. 6: Equitability of species sampled from the study area, Ikhelidjen during the study period.

The observed equitability (E) is consistently less than 1 for all samples, with a maximum of 0.268 at plot 1 and a minimum of 0.2653 in plots 6 and 8 (Fig. 6). The dominance assessed through the Berger-Parker (BP) index is manifested sequentially by the prevalence of the species *Olea europaea*, *Galactites tomentosa, Calicotome spinosa, Polypogon monspelinesis* and *Sinapis arvensis* (**Fig 7**).

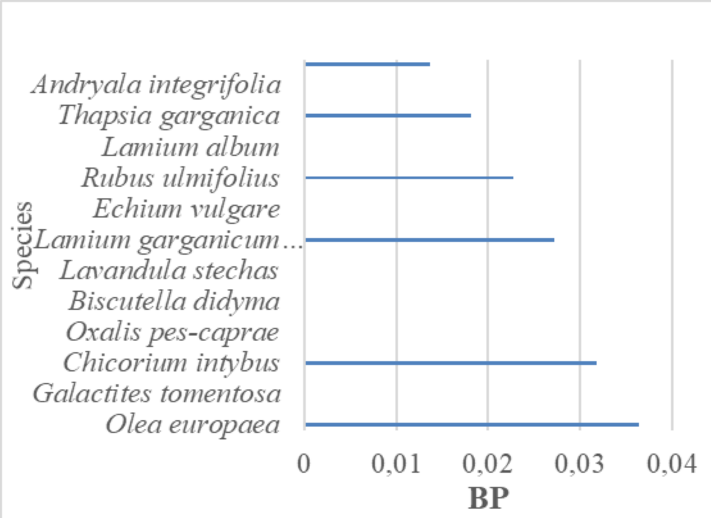

Fig (7): Berger-Parker (BP) dominance of the Ikhelidjen flora, during the study period.

The above ecological analysis is confirmed by the Correspondence Factor Analysis (CFA) (**Fig 8**) when the relationship of the plant species and the plots revealed four affinities between plots and plant species. According to CFA four nuclei were distinguished. The first nucleus with the plots 1 is acknowldged by the species such as: *Chrysanthemum myconis, Chicorium intybus* and *Lamium garganicum subsp longiflorum.* These prefer limestone substrates, as in the case of Ikhelidjen. The second one is the richest in species, regrouping together the plots 6 and 8, where *Allium triquetrum*, *Daucus carota*, *Echium vulgare, Lavaandula stechas* and *Lupinus angustifolius* are the most present. The third nucleus combines the plots 2 and 3 with the species: *Thapsia garganica, Bellis annua, Andryala integrifolia* and *Rubus ulmifolius*. The fourth nuclei form a spot of affinity between plots 4 and 7 with the following species: *Lamium purpureum, Lamium album* and *Capsella bursa-pastoris.* The last one forms a spot of affinity between plots 4 and 7 with the following species: *Lamium purpureum, Lamium album* and *Capsella bursa-pastoris.*

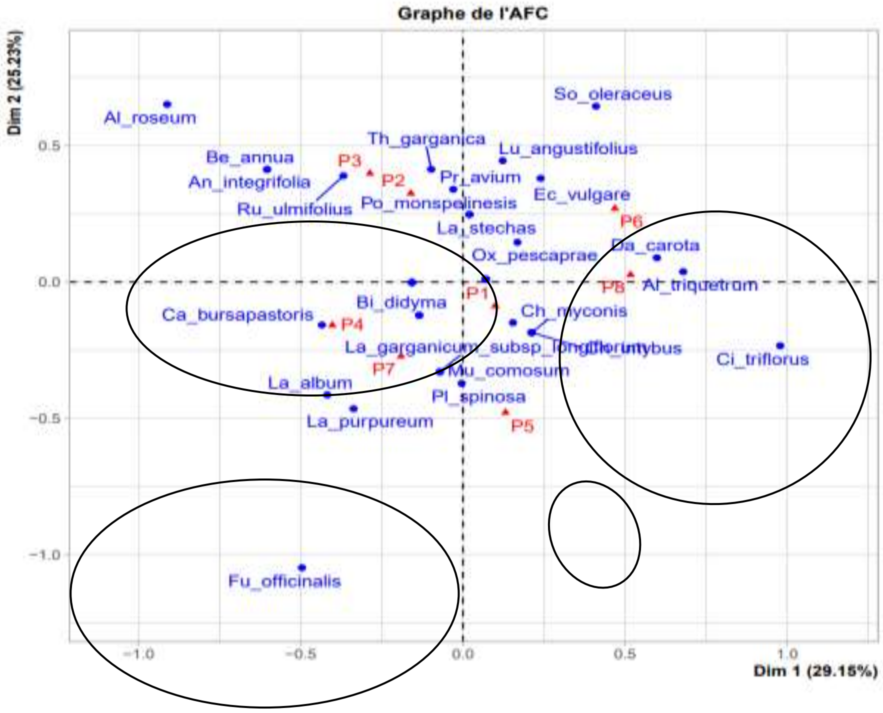

Fig (8): Correspondence Factor Analysis (CFA) used to assess distribution and affinity nuclei of the plant species and the plots studied in the $F_1 \times F_2$ factorial plan.

The physico-chemical analysis of the Ikhelidjen soil carried on post-fire shows that the analyzed soil presents a change in pH towards low alkalinity (pH=7.6), accompanied by an increase in organic matter levels (OM=45.6%) and a slight salinity expressed by the electrical conductivity (EC=538µS/cm), while its sandy loam texture remains unchanged.

Discussion

Algeria belongs to the Mediterranean regions, which is one of the world's hotspots for plant diversity. Its current flora corresponds to various heterogeneous groups linked to the palaeo-history of the region, more than 52% of its species are endemic to the Mediterranean biome [13; 14]. The inventory consists mainly of annual herbaceous plants where the Asteraceae family is best represented with 8 species. While the Brassicaceae, Lamiaceae and Liliaceae families occupy a large area in this forest; covered with diversified heterogeneous vegetation and a multi-regional floral procession with degraded formations which are undoubtedly the result of the action of fire [7].

The first nucleus with the plots 1 is dominated by some species that prefer limestone substrates, as in the case of Ikhelidjen, which is part of the limestone mountains of the Djurdjura [15]. The second one is the richest in species, regrouping together the plots 6 and 8, where *Allium triquetrum*, *Daucus carota, Echium vulgare, Lavaandula stechas* and *Lupinus angustifolius,* form naturally on the banks of a river and can be found in a variety of habitats, tolerating most soil conditions and even occasional dry spells [16, 17]. The preence of species: *Thapsia garganica, Bellis annua, Andryala integrifolia* and *Rubus ulmifolius,* are ecological indicators and grow on sandy soils at high altitudes and in dry environments [18, 19]. The last spot, of affinity between plots 4 and 7, is the second most abundant since the soil is a seed bank, which have been found to attract and kill nematodes, thus locally enriching the soil with organic matter [20]. This flora taxa is composed of many pioneer species, dominated by species with high colonization capacity such as: *Allium roseum* and *Allium triquetrum* which are Liliaceae belonging to the great cosmopolitan families of the plant kingdom, with the specificity that are wetland indicator species [9, 21, 22] as is the case in Ikhlijen area, which has significant stationary humidity due to nearby stream.

This flora regeneration concords with a previous work [23], concerning the post-fire evolution of the Kabylia forest ecosystem (Northern Algeria). The floristic diversity of Ikhelidjen area may be due to the isolation of the site because of the lack of anthropogenic activity disturbance, but fires are not recurrent or frequent enough to reduce floristic richness and diversity [24]. The presence of suitable environmental conditions, such as humid microclimate, optimal temperature and wind, could also be the origin of the renewal and rapid development of the local flora.

The results of the physico-chemical analysis of the Ikhelidjen soil revealed changes in the measured parameters and these are the consequence of fire denaturalisation, of organic acids by releasing alkaline cations (C, Na) bound to organic matter and volatilizes organic nitrogen and influences the mineral behaviour of the soil compartments, making them more erosive and more susceptible to leaching and desiccation [25]. Plant communities are in direct interaction with their soil throughout their existence (Freshet et al., 2018).

Conclusion

The recorded biodiversity of Ikhelidjen's flora was characterized by the massive regeneration of herbaceous, perennial and annual species from the Asteraceae, Poaceae and Fabaceae families. This could be due to the fertility of the soil, particularly as the vegetation retains the same dynamics and structure without any profound floristic changes. In addition, it was also noticed stable adapted plant community after the fire which temporarily eliminates all the epigeous vegetation and the appearance of a new equilibrium that is established during the healing process of the forest ecosystem. As a conclusion, the disturbed communities are recovered and reconstituted in the same way as they were before the fire. Therefore, the results confirm the hypothesis that stands are resilient after fire. This is the phenomenon of self-healing, excluding the fire as a factor in the disappearance of the plant cover, while preserving its identity and original characteristics.

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