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Effects of water and thermal stress on microbial respiratory activities in soils following a gradient of aridification

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In recent decades the Mediterranean climate has been marked by a significant reduction in summer precipitation especially in arid and semi-arid regions. This overall trend would be accompanied by a greater frequency of extreme events such as torrential rain, heat wave, drought that have a direct impact on the soil microorganisms. The objective of this study was to see if the aridification gradient affects microbial communities by decreasing their quantity and to see if drought cycles are expected to induce a loss of resistance and resilience of microbial functions To water stress (drying/wetting cycle).Our results showed a significant difference in basal respiration recorded between the humid, semi-arid, and arid zones, resulting in an increase and decrease in respiratory activity relative to the aridity gradient, respectively. . This shows that the response of basal respiration to water stress depends on the area of study and the climatic stress specific to each region.

Keywords: Basal respiration, arid, semi-arid, humid, soil, forest

INTRODUCTION

Soils are considered to be non-renewable in the short and medium term, and are particularly threatened by human activities and climate change.

The main threats to soils are erosion, decreased organic matter content, local and diffuse contamination, waterproofing, settlement, reduction of biodiversity, salinization and flooding and landslides of land. The soil capital is then considered as a set of stocks, which increase or depreciate, and which has a multifunctional character (Ollivier, 2008). In Algeria, the natural capital Sol represents an important part of the national wealth, but unfortunately we see in recent decades a rapid degradation of agricultural, forestry and urban soils. Especially soils in semi-arid and arid regions that is very sensitive to environmental changes. For these regions, a positive relationship is often proposed between the average rainfall and the environmental data, by scientists belonging to various disciplines. All these regions have the peculiarity of having climatic, physical or biological conditions which do not allow the development of a large plant cover (Belnap, 2003). However, the nature and abundance of species or kinds of micro-organisms appear to be dependent on local eco-biological and climatic conditions (Belnap, 2003).

Extreme disturbances and stresses result in the death of micro-organisms or induce their entry into dormancy (Suzina et al., 2004) and by consequences, disrupt the functioning of the ecosystem. However, the phenotypic and physiological plasticity of micro-organisms allows them to acclimatize or adapt rapidly to environmental stress.

The objective of this research was to identify the resistance of the western Algerian forest soils to the environmental stress of water and heat subjected to intense climatic and anthropogenic stress along a latitudinal gradient.

MATERIALS AND METHODS

Presentation of study areas:

In this study it is interesting to three areas of western Algeria.

Area of Tlemcen:

the study stations of this city are located at the level of the reserve of Moutas (Figure 1), which is located in the northern part of Algeria about 46 km as the crow flies from the sea and 26 km southwest of Tlemcen. This station is located in the humid bioclimatic floor (Gaouar, 1980).

Area of Saida:

The study stations of the wilaya of Saida are located in the forest of Djaafra Chéraga (Figure 1) which occupies a total area of about 10 177 ha, from a climatic point of view the forest of Djaafra Chéraga enjoys a semi-arid climate.

Area of Naama : The study stations of the wilaya of Naama (Figure 1) are located at the level of the Mekalis forest and the green belt. With 200 mm of annual average rainfall, this allows the study area to be classified in the lower cool, dry bioclimatic floor (Alcaraz, 1969).

Soil sampling

Five study plots of approximately 400 m^2 each have been selected in each study area; this makes a total of fifteen plots for the three zones (Tlemcen, Saida et Naama). On each plot, five soil samples were randomly taken between 0 and 15 cm deep. The 5 samples were then mixed to obtain a composite sample per plot. The samples were then sieved in the field at 2 mm and kept in coolers until the return to the laboratory. An aliquot of the composite sample was kept cool (4 ° C) pending the microbiological analyses carried out within 10 days after the sampling. Most of the chemical tests were performed on another air-dried aliquot (Guénon, 2012).

Measurement of microbial basal respiration resistance to experimental water stress

The functional resistance capacity of microbial communities was evaluated by basal respiration measurements before and after application under controlled laboratory conditions of a combination of water and thermal stress mimicking Climate change (drying at 3 increasing temperatures). For each sample, 3 fractions of ten grams (dry equivalent) of fresh soil were weighed in 3 vials of glass (117 ML). The water content of the 3-series samples was standardized to 60% of the dry mass by a sterile osmosis water supply. After a stabilization phase (incubation at 22 ° C for 24 h), a first measurement of basal respiration (RBc) was carried out according to the protocol described by Anderson and Domsch (1978). Thus the vials were closed with an airtight plug immediately after the replacement (4 minutes) of their internal atmosphere by a controlled atmosphere, then incubated 4 hours at 22 ° C. After this incubation, an aliquot of the flask's atmosphere (1 ML) was injected using a syringe in a gas chromatograph (Chrompack CHROM 3 – CP 9001). The chromatograph was equipped with a TCD detector and filled column (Porapack) circulating helium at a flux of 60 mL. H-1. Ambient CO_2 concentrations were subtracted from the CO_2 concentrations measured after incubation to obtain the amount of CO2 produced by the heterotrophic micro-organisms contained in the sample. Each sample was then dried for 7 days at 30 ° C, 40 ° C or 50 ° C. Each sample was then remoistened to 60% of their field capacity and a second measurement of basal respiration (known as RB30, RB40, or RB50 depending on stress) was carried out after 24 h of incubation at 22 ° C. The respiratory activities measured on the subsamples that underwent stress (RB30, RB40, or RB50) were expressed as a percentage of the controls (RBC). The resistance of this (RT) was calculated as follows:

RTi (%) = [RB30i/RBci)] ×100

A value close to 100% indicates high resistance. Values greater than 100% indicate an amplification of microbial activity while values below 100% show a decrease in these activities. This calculation was chosen because it is close to the definition of functional resistance as being the ability of an activity to avoid a shift after stress.

Statistical analysis

The effects of bioclimatic levels on the physico-chemical and microbiological properties of soils were studied by an ANOVA with a factor followed, with significant effect ($P < 0.05$), of multiple comparison tests of the HSD averages of Tuckey for Describe in detail the variations between the floors. All these analyses were carried out using the statistical software 6.0.

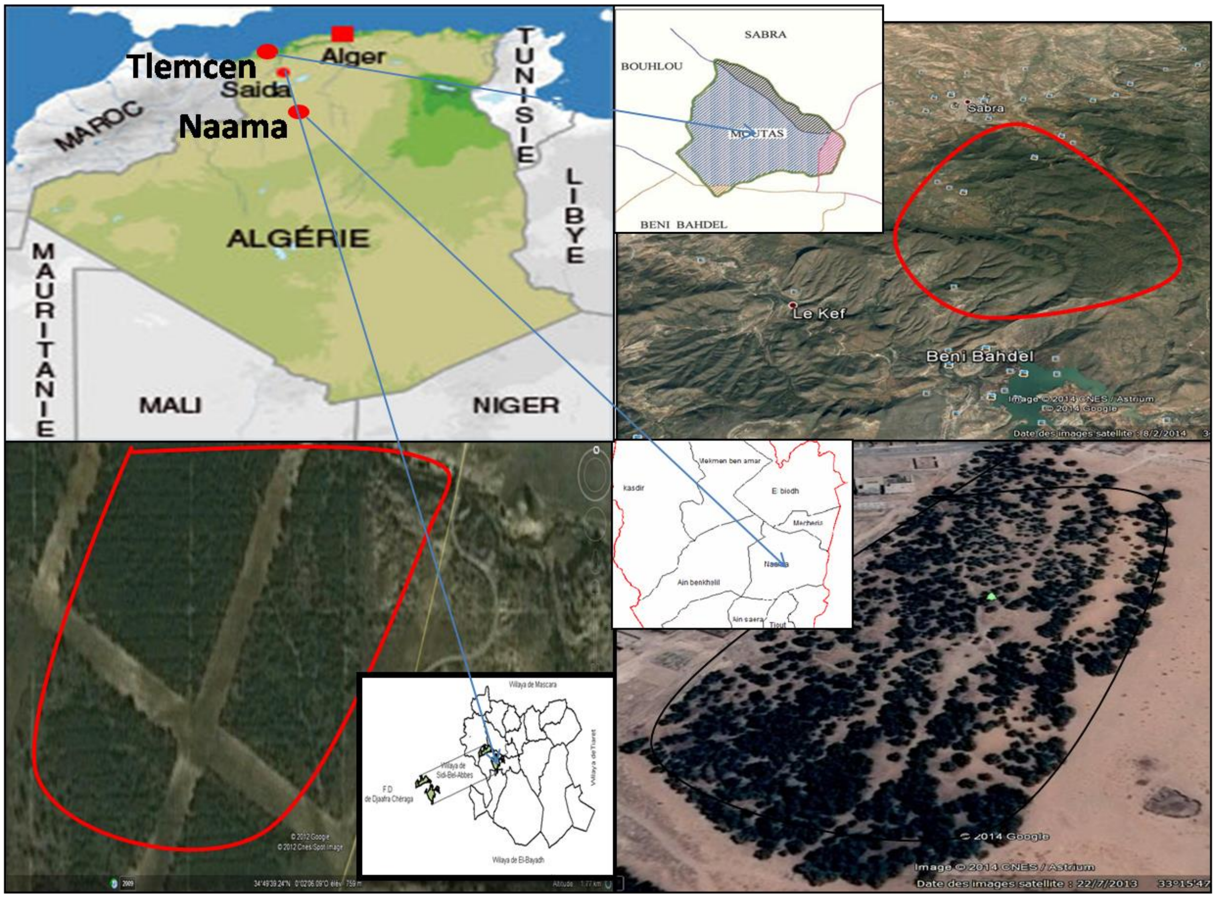

Figure 1: Presentation of study areas

RESULTS AND DISCUSSION

Effects of water and thermal stresses on microbial respiratory activities of soils.

The average effects of water and thermal stress, i.e. for all study areas, on basal respiratory activities are presented in Figure 2. There is a difference in basal respiration recorded between the bioclimatic stages and the selected temperatures (30 and 40 and 50 ° C), which translates to 30 and 40 ° C, respectively, by an increase in respiratory activity in the humid zone by Ratio to the semi-arid and arid zone that are slightly closer. On the other hand, for the temperature of 50 ° C a strong basal respiration is recorded for the three study areas and is more marked for the humid and semi-arid zone (Figure 2).

The characteristics of each bioclimatic stage are expected to be likely to lower the tolerance levels of microbial communities and their functions to water and thermal stress. All this would change the chemical and biological conditions of the soil and thus their evolution. This transformation of soils in turn impacts vegetation, soils and agriculture, especially in very sensitive and fragile semi-arid and arid soils. The stress that we have applied is made up of two phases; A phase of desiccation at different temperature and a phase of rehumidifying. For temperatures 30 and 40 ° C we measured a fairly low basal respiration in the three zones (Humid, semi-arid and arid) a few hours after wetting with respect to the temperature of 50 ° C where a strong basal respiration was recorded for the three zones and more accentuate in humid area. The amplification of respiratory activity following a desiccation/humidifying stress is a common response that has been measured by many authors (Bottner, 1985; Schimel et al, 1999; Fierer et Schimel, 2002). This process, which is named "Priming effect" in English, is largely due to the mineralization of microorganisms dead by Survivors (Guénon 2010).By the water potential of the cells quickly equilibrium with the surrounding waters.

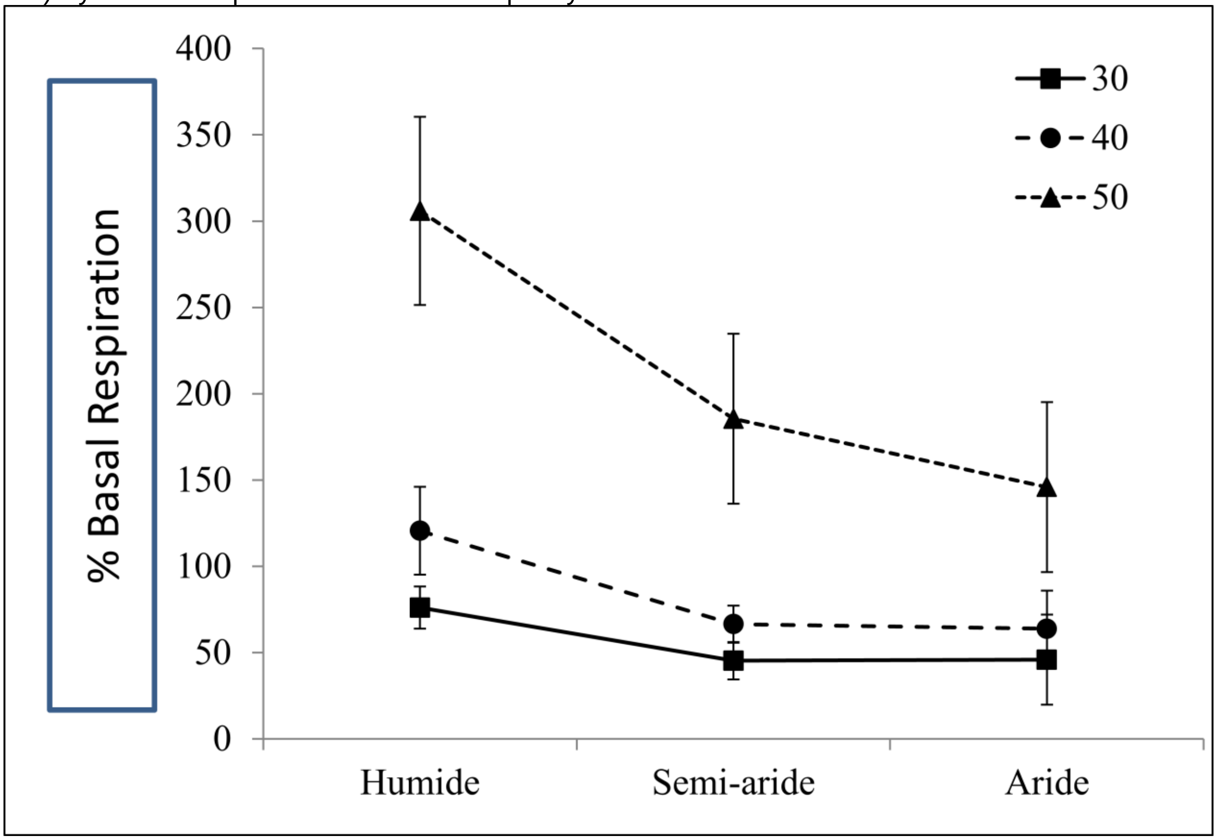

Figure 2: Respiratory responses to the application of water and thermal stress

When soils dry up and water potential declines, cells must accumulate solutes (osmolytes), at the expense of other cellular functions, to reduce their internal water potential and to avoid dehydration and death (Harris, 1981; Schimel et al, 2007).

Beyond a certain desiccation threshold, the most sensitive micro-organisms die and the most resistant survive stress by forming endospores or cysts. Rapid rehydration of the soil causes a sudden swelling of the cells that is generated by the high concentrations of osmolytes synthesized during desiccation.

Under extreme conditions, total cytoplasmic constituents can thus increase to 30 to 40% of total bacterial or fungal carbon against 3% under "normal" conditions. The same applies to nitrogen (60% vs. 6% in bacteria) (Schimel et al., 1989).

CONCLUSION

The basal respiration results of the sampled plots show the major influence of the bioclimatic stage on the respiratory activities of the various microbial communities constitutive of these soils, which range from a gradient Aridification.

The effect of the geographical area, inherent in climatic conditions, illustrates the fundamental role of climatic gradients (thermal and water), the establishment of microbial communities and their activities, and the different bio climates of which they are the reflection, both along the bioclimatic stages, but also at larger spatial scales along latitudinal gradients.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS

BAH designed, carried out the experiments and wrote the article, HA to corrected the article, ZM did the mapping; AA participated in the experiments and followed the field. BAH, HA, ZM and AA read and approved the final version.

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