Original Scientific paper
10.7251/AGRENG2001015B
UDC 551.577.13:630

SUPPLY OF NPK ELEMENTS THROUGH PRECIPITATION AND THROUGHFALL IN A COPPICE OF GREEN OAK IN THE EAST OF ALGERIA

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ABSTRACT

Nutrient provisions through precipitation and throughfall represent major factor of the sustainability of the forest ecosystem. Nevertheless, data related to this aspect are non-existent in Algeria. Precipitation and throughfall volumes and their contributions in NPK elements were evaluated between 2012 and 2013, in a green oak coppice at Marconna in Aurès (eastern Algeria). Precipitation volumes were evaluated by the placement of 10 containers in a bare soil. To quantify the throughfall, four containers were installed under the canopy of each tree among 25 selected trees. Water samples taken from previously rinsed plastic bottles with distilled water were kept away from light and transported to the laboratory for volume estimation and chemical analysis, as quickly as possible. After rapid filtration, samples became ready for NPK analysis. Various devices and chemicals were used for the measurements of NPK elements in the laboratory. Kjeldahl's method, colorimetry and flame photometry were used for quantifying total nitrogen, phosphorus and potassium respectively. The results showed that annual rainfall amounts varied between 223,9 and 289,6 mm, whereas the annual throughfall was 127,1 mm for 2012 and 189,8 mm for 2013.Besides, the annual quantities of N, P and K returned to the soil by the rainfall ranged from 5,05 to 7,62 kg/ ha/year. However, the throughfall results showed that the coppice accumulated amounts of N, P and K elements varying between 4,08 and 5,47 kg / ha / year. On average, nitrogen was the most provided element. It represented 47,07%.

Keywords: *Nitrogen, potassium, phosphorus, rainfall, Marconna.*

INTRODUCTION

Green oak (*Quercus ilex* L.) is one of the most important forest species in the Mediterranean region (Aguillaume *et al.*, 2017). In Algeria, its area decreased from 354 000 (Leutrech-Belarouci, 1991) to 149 000 hectares (El Achi, 2010), in few years. In the Aurès, it is often in the form of simple coppice characterized with low productivity. The low density and the weak average height of the trees (2,5 m)

constitute signs of the impact of the climatic constraints and the anthropic action (Khater, 2010).

Atmospheric supply appears to be one of the major pillars of the sustainability of the low mineral fertility ecosystem (Legout, 2008). Evaluating the amount of water and nutrients provided by precipitation and throughfall are very useful for better management of forest ecosystems (Lequy, 2012). In a context of climate change and for a forest ecosystem with low mineral fertility, a reduction in annual rainfall would cause a drop in atmospheric inputs, which would very quickly be influenced the flow of elements circulating in the ecosystem (Legout, 2008). Studies on the contribution of biogenic elements through precipitation and rainfalls are numerous for forest environments in Europe (Mangenot and Toutain, 1980; Lequy, 2012). However, this type of research remains very limited in North Africa (Badri, 2003).

For Algeria, to our knowledge, no data are available on the contributions of NPK biogenic elements by precipitation and throughfall in a green oak coppice. That is why the present study aims to fill this gap and provide necessary data for the sensible management of green oak forests in semi-arid environments.

MATERIALS AND METHODS

Study site

Precipitation and throughfall measurements and their contribution in NPK elements were carried out continuously between January 2012 and December 2013 in a green oak coppice in the Aurès (East of Algeria). The latter is located at 1310 m above sea level, 12 km south of the Batna city. Its age is more than 25 years.

The density is 370 stems / ha. Their soil is of calcimagnetic type, with 10 to 18 % gradient. The average annual precipitation over the 22 years period (1989-2010) was 331,28 mm. For the same period, the average temperature was 15,6 ° C. The drought period was very long and it is often longer than five months (from May to November).

Experimental plan

Precipitation and throughfall water were collected manually using a total of 110 inverted cone-shaped plastic containers, with a lid whose conical bottom is pierced with small holes to minimize evaporation and retain plant and animal debris. The containers were fixed on metal supports well embedded in the ground.

The amounts of precipitation were evaluated by the placement of 10 randomly distributed containers in a bare soil area, about 10 m away from the canopy.

To quantify the throughfall water, four containers were installed under the canopy of each tree among the 25 selected trees. The overall collection area for all containers (100 containers) was 4,9 m². The latter is considered sufficient to adequately estimate throughfall (Rodrigo and Avila, 2001; Llorens and Domingo, 2007).

Protection against light, to avoid algal pollution, is ensured by the use of dark opaque containers. The cleaning of the containers used to recover the throughfall to be analyzed was carried out regularly after each measurement.

Water samples taken from plastic bottles previously rinsed with distilled water were kept away from light and transported to the laboratory for volume estimation and chemical analysis as quickly as possible.

After rapid filtration of the collected water with filter paper to remove floating material, precipitation and throughfall samples were ready for NPK measurements. Three methods were used in total: Kjeldahl's method for quantifying total nitrogen, colorimetry for total phosphorus and flame photometry for potassium.

It should be noticed that the quantities of precipitation and throughfall collected are expressed in mm. However, the results relating to N, P and K inputs by precipitation and throughfall are expressed in kg / ha / year.

Data analysis

The obtained results were subjected to variance analysis (ANOVA) at the error threshold of 5%. The software used is SPSS version 10.0.5 (SPSS Inc.). Moreover, Microsoft Excel 2007 was used to draw nutrient provisions curves.

RESULTS AND DISCUSSION

Nutrient provisions by precipitation

Figure 1 showed that the annual quantity of N, P and K brought by precipitation varied depending on the year, from 5,05 (2012) to 7,62 kg / ha (2013). However, ANOVA analysis did not reveal any significant difference between years (*P* ranged from 0,106 to 0,600).

These quantities of nutrients were provided by 223,9 (2012) and 289,6 mm of precipitations (2013).

Aurès region is well exposed to desert influence and wind erosion. It seems that these two phenomena would contribute significantly to the contribution of NPK elements by precipitation and throughfall.

Moreover, the low nutrient supply in 2012 compared to 2013 was due to reduced volumes of precipitation. An increase of 65,7 mm of rainfall brought a significant additional quantity of 2,57 kg / ha / year of nutrients to the forest floor in 2013.

NPK provisions through precipitation found in this study, are low comparatively to values from other studies (Allen *et al.*, 1968; Nihougrade, 1970; Badri, 2003; Legoute, 2008) which reported amounts ranging from 10 to 17,7 kg NPK / ha / year for sites that often receive more than 600 mm of rainfall per year.

The NPK contribution by precipitation, was dominated by nitrogen, which constitutes 86,75% of the total average supply.

The contribution during the two years of study for phosphorus remains very modest. It fluctuated from 0,27 to 0,39 kg / ha / year (figure 1). These results are in agreement with those of Lequy (2012) which observed in France, a total atmospheric deposition of phosphorus by precipitation between 0,2 and 0,8 kg / ha / year.

Besides, the amount of potassium brought by precipitation is also weak. It was on average 0,51 kg / ha / year for our study period (Figure 1).It was slightly superior to that found by Duchesne, (1999) (0,36 Kg /ha / year).

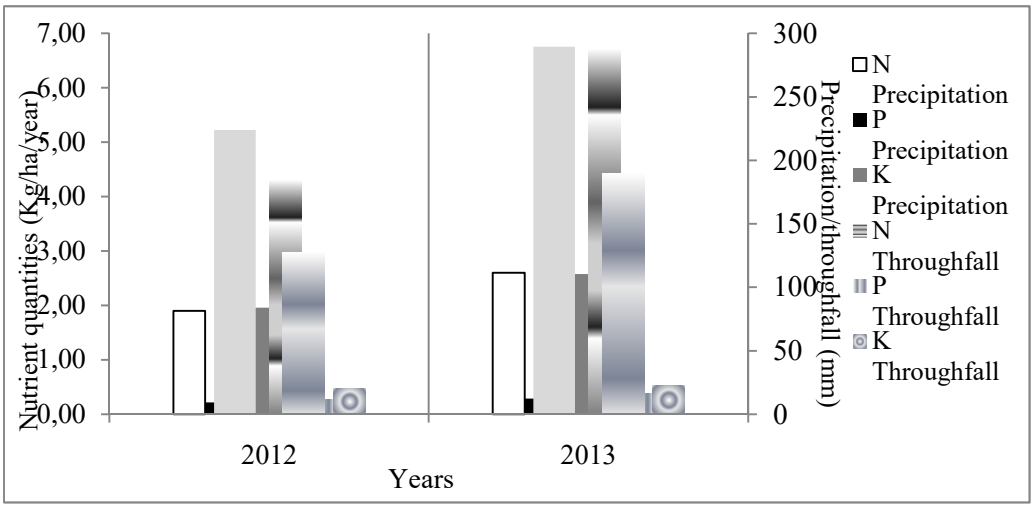

Figure1. Quantities of precipitation, throughfall, and nutrient provisions by them in Marconna green oak coppice

Throughfall

Our results showed that the soil accumulates, through throughfall, quantities of elements N, P and K which vary between 4,08 and 5,47 kg / ha / year. It should be noticed that the interannual variations remain low and not significant for the measured elements (*P* varied between 0,337 and 0,531).

The nutrient supply found in this study are relatively small compared to those reported by various authors (Carlisle *et al*., 1966; Rodrigo *et al*., 2003) who assessed this intake between 12,9 and 31,8 kg / ha / year. Nevertheless, the low intakes obtained in the present study were accompanied by small volumes of throughfall which did not exceed during the two years of study 190 mm/ year. The average throughfall rate found in Marconna coppice (66,3 %) is consistent with other researches on oak (63,8 to 77,8 %) mentioned by Llorens and Domingo (2007) for various Mediterranean countries, having a very important annual rainfall of 478 to 1275 mm. However, if we consider our throughfall in mm, it remains on average very weak with 158,45 mm. Throughfall volumes reflect the total provision of nutrients regardless of their concentrations (Matias *et al*., 2011).

In addition, Aguillaume *et al*. (2017) studied oak forests characterized by high precipitation volumes and high throughfall rates (66 - 77 %), and they found that these quantities of throughfall contributed with 15 to 23,5 kg / ha / year of N, P and K. These nutrient quantities are clearly superior to those obtained in our study.

Indeed, several researchers such as Migon *et al*. (1989); Rodrigo *et al*. (2003) and Matias *et al*. (2011) have experimentally demonstrated that biogenic inputs depend largely on precipitation and throughfall, structure and dynamics of vegetation cover and interception rates. Similarly, the investigation of Aguillaume *et al*. (2017) on

the contribution of biogenic elements by precipitation and throughfall in four green oak in Spain over three years (2011-2013) have shown that nutrient supply are highly dependent on climate, characteristics and the quality of the area.

On average, the NPK provisions by throughfall were dominated by nitrogen and potassium. Nitrogen represented 47,07 % of the NPK annual supply. Its amount fluctuated between 1,9 to 2,6 kg / ha / year (figure 1). While the potassium represented 47,54 % of the NPK annual provisions. It varied between 1,96 (2012) and 2,58 kg / ha / year(2013).

The total contributions of N element during the two years of study are lower (1,9 – 2,6 Kg / ha / year) compared to those brought by precipitation (4,3 – 6,7 Kg / ha / year).

These values are close to those of Duchesne (1999) who found 5,76 kg / ha / year of nitrogen brought by the precipitation and 4,98 kg / ha / year by the throughfall. The results of nitrogen are consistent also with several studies (Nambiare and Fife 1987; Escudro *et al*., 1992 in Duchesne 1999; Aguillaume *et al*., 2017).

Other studies under various forest canopies (Nys, 1987; Chang and Matzner, 2000) have shown that nitrogen provisions by throughfall are about twice as low as in uncovered areas.

On the other hand, the results of potassium are in agreement with those of Migon *et al*. (1989) and Legoute (2008) who reported that the supply of potassium by throughfall was greater than that by rainfall. When precipitation passes through a forest cover, there is a strong enrichment in K (Duchesne, 1999).

In this study, the green oak cover enriches the soil in K four to five times more than in P. These results converge with those of Aguillaume *et al*. (2017) who also mentioned that the effect of the green oak canopy on the potassium intake is very strong.

Regarding phosphorus, the average amount of phosphorus provided by the throughfall (0,26 kg / ha / year) in the present paper (figure 1) remains close to that reported by Duchesne (1999) (0,23 kg / ha / year).

CONCLUSION

The assessment of N, P and K supplies through precipitation and throughfall in a green oak coppice represents a first study of this kind in Algeria.

The analysis of rainfall data for 2012 and 2013 showed that the annual quantity of NPK returned to the ground by precipitation varied between 5,05 and 7,62 kg / ha / year. Throughfall contributed with quantities of NPK elements, varying between 4,08 and 5,47 kg / ha / year. The low volumes of throughfall water and the low NPK provisions induce low productivity of the Holm oak.

Throughfall water contained practically 4 to 4,5 times more potassium than precipitation water.

The fluctuations of rainfall in the Aurès may generate a shortage of nutrient supplies that can significantly influence, not only the availability of the three important elements (nitrogen, phosphorus and potassium), but also the tree resistance to drought.

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