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Moisture effects on decomposition rates in a Mediterranean ecosystem of Attica, Greece

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ABSTRACT: The effect of soil moisture on the decomposition process in a Mediterranean ecosystem was investigated under field conditions using an *in situ* moisture increasing treatment. Ten 1m x 3m plots were set within the study area (5 treatment plots and 5 control plots) to assure control, replication, randomization and interspersion of sampling. Four different 10month experimental cycles were designed to evaluate the effect of the seasonality on the decomposition process. Litterbags of 20 μm and 1 mm mesh size were placed in the experimental plots for every seasonal cycle. The treatment consisted in the systematic watering of the treatment plots and its amount was decided to be 7lt/m^{2}week. Each month litterbags of both mesh sizes of every experimental cycle were randomly removed from each plot. The estimated decomposition rates indicated differences between treatment and control plots, between seasonal cycles and between the two different mesh sizes. Further analysis of the results is required in order to detect the potential relationships between soil system function (decomposition) and environmental factors acting in the microhabitat.

1 INTRODUCTION

Decomposition is defined as the gradual disintegration of dead organic matter and is brought about by both physical and biological agencies (Begon et al. 1990).

Decomposition of any resource is the result of three compound processes: catabolism, i.e. chemical changes such as mineralisation giving rise to inorganic forms; comminution, by which there is a physical reduction in particle size and often selective redistribution of chemically unchanged litter; and leaching, which causes transport down the profile or removal from the system of labile resources in either changed or unchanged form (Heal et al. 1997). It finally results in reducing the soil organic residues and releasing the nutrients, which can enter the complicated food webs and become available to the plants (Coleman and Crossley 1996).

Decomposition rate is regulated by a combination of three interacting groups of factors: (a) the physicochemical environment (pH, temperature, moisture, aeration, soil texture), (b) the quality of the resource and (c) the decomposer community (Begon et al. 1990, Lavelle et al. 1993, Heal et al. 1997).

General models of decomposition confirm the predominance of climatic factors in predicting decomposition at large geographical scales (Lavelle et al. 1993). For the Mediterranean ecosystems climate is becoming crucial for the decomposition process mainly because of its peculiarity: low winter temperatures alternating with high summer ones, which coincide with usually quite low water availability (Arianoutsou and Radea 2000). The latter, in the form of soil moisture, becomes usually the limiting factor for the decomposition process. Its raise increases the soil processes rate to a threshold beyond which it has negative effects on it because it limits soil aeration (Moore 1986, Cornejo et al. 1994, Guilledge and Shimel 1998, Chen et al. 2000).

Decomposition rates in Mediterranean ecosystems are rather low as compared to other terrestrial ecosystems. This is mainly due to the water deficit prevailing during the hot summer periods and the physical and chemical composition of litter (Arianoutsou and Radea 2000). This results in accumulation of dead organic matter in the soil system of the Mediterranean ecosystems.

In consequence, the effects that soil moisture levels might have on soil processes and especially on decomposition rate are of great scientific and management interest. Three different scientific approaches have been adopted so far in tracing answers to the above issue: (i) the study of decomposition rates under totally controlled conditions in laboratory settings (Daubenmire and Prusso 1963, Clarholm et al. 1981, Moore 1986, Bloem et al. 1992, Clein and Schimel 1993, Fioretto et al. 1998, Buchmann 2000), (ii) the comparative field study of sites of different climates or different moisture conditions (Dyer et al. 1990, Steinberg et al. 1997, Berg et al. 1993, Wachendorf et al. 1997, Guilledge and Schimel 1998), where different sites present many differences and not only the moisture conditions, (iii) the convergence of the above approaches with the application, under field conditions, of the proper *in situ* treatments. The latest approach has been realized on several types of ecosystems like on tropical forests (Cornejo et al. 1994), on arctic tundra (Robinson et al. 1999) and Alaskan taiga (Schimel et al. 1999) but not on Mediterranean ecosystems that are especially sensitive to any climate change because they are situated in a transition zone between arid and humid regions of the wolrd (Scarsia-Mugnosa et al. 2000).

The aim of this study is to investigate the effect of soil moisture on the decomposition process in a Mediterranean ecosystem of Central Greece under field conditions using an *in situ* moisture increasing treatment.

2 MATERIALS AND METHODS

2.1 *Research site*

The ideal site for this kind of research should have the above characteristics: a well developed soil litter system with spatial uniformity, homogenous vegetation structure, both horizontal and vertical (for ensuring the homogeneity in the abiotic and biotic factors potential acting upon the studying processes) and finally it should be as flat as possible.

The semi-natural Mediterranean habitats I. and A. Diomides Botanical Garden at Dafni, Attica offered us a convenient study area having the above prerequisites. The vegetation of the area is dominated by East Mediterranean Pine (*Pinus brutia*) and cypress trees (*Cupressus sempervirens)*. The area has only sparse lentisc shrubs as understory with a mor-moder litter horizon and it is protected from intruders.

2.2 *Experimental design*

The decomposition rate was measured by using litterbags 10cm x 8cm filled with sheets of cellulose. Litterbags of two different mesh sizes were used: (i) mesh size of 20μm to exclude meso- and macro- fauna (Wachendorf et al. 1997) and (ii) mesh size of 1mm to permit the entrance of the majority of soil fauna and to avoid an intense leaching bias.

It is already known from previous research (Fousseki 1979) that the decomposition rate on the field depends on the season that the resource enters the soil system. Consequently, four 9-month experimental cycles were designed and each one of these cycles begun at a different season of the year with the placement of new litterbags in the study site (Fig. 1).

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According to Hurlbert (1984) an experimental design should include: (i) elements of control, (ii) replication, (iii) randomization and (iv) interspersion. To include all the above characteristics in the experimental design ten 3m x 1m plots were dispersed within our study site. Five of them were plots of control (C) and the other five where plots of treatment (T) and were randomly chosen.

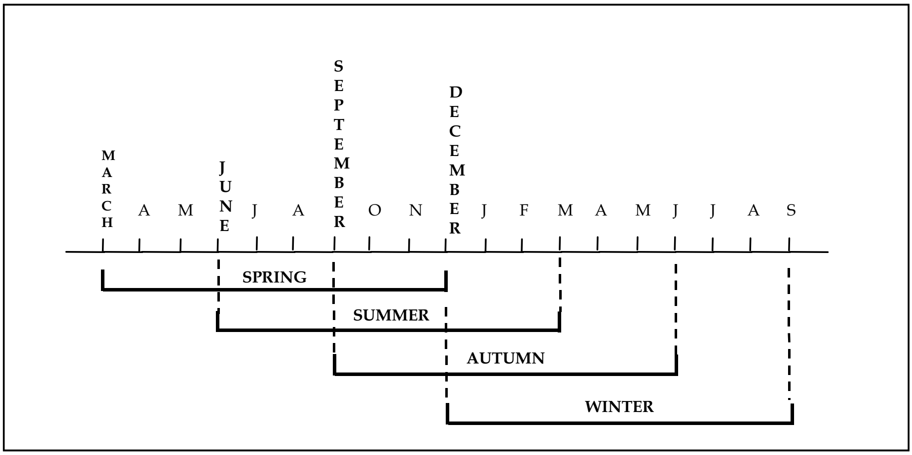

Figure 1. The four seasonal cycles of the experimental design applied

The treatment consisted in the increase of moisture by systematic watering of the treatment plots. The amount of water and the frequency of watering were decided after the evaluation of the meteorological data of the nearest meteorological station (Elefsina) over the past ten years in relation to the precipitation regime (amount and frequency). Two basic criteria were set: (i) the treatment should be within the limits of the system set by the average quantity and frequency of the annual precipitations, (ii) it should make a significant difference during the dry months of the year. It was finally decided to add 28lt/m^{2}month with a weekly rate, which equals to 7lt/m^{2}week.

Litterbags of every experimental seasonal cycle were placed in every plot. In consequence, it was necessary to create a suitable system of coordinates in each plot, which would ensure the quick location of the litterbags of every seasonal cycle and it would enable random removal when sampling (Fig. 2).

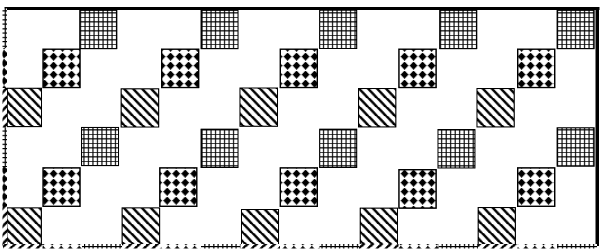

Figure 2. The design for each experimental plot. The spring litterbags were placed in the areas noted as ▧ , the summer litterbags were placed in the areas noted as ▦, the autumn litterbags were placed in the areas noted as ▦ , and the winter litterbags were placed in the areas noted as ▧, again as the spring cycle has been already finished.

2.3 *Sampling - Analyses*

One litterbag from every mesh size and every seasonal cycle was removed from each plot on a monthly basis. Soil particles were carefully removed from the litterbags. The remains of cellulose strips were removed from the litterbags, oven-dried, weighted and burned in a muffle furnace at 500^{o}C. Results are expressed as free of soil cellulose mass loss.

3 RESULTS

The estimation of the mass loss rate at the two different mesh size litterbags for the four different seasonal cycles gave some interesting results (Fig 3-6).

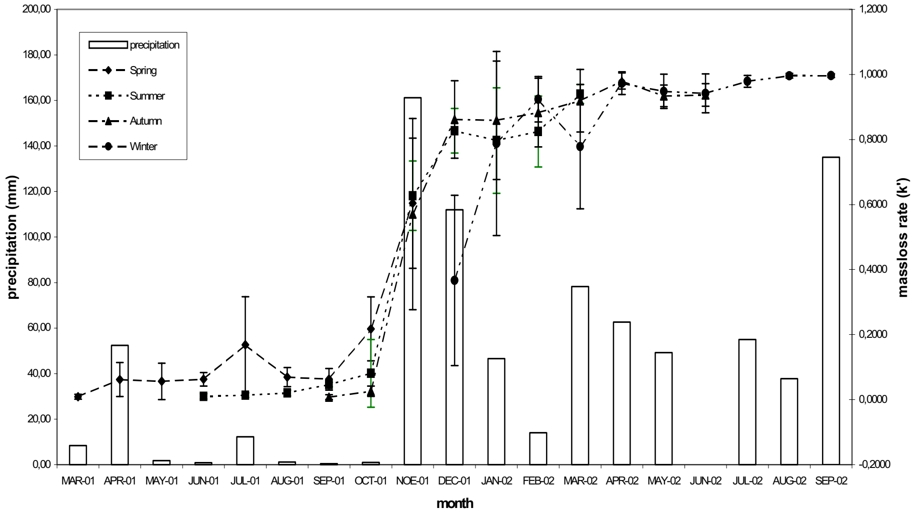

Figure 3. Cellulose decomposition rate for all the seasonal cycles in the 20μm mesh size litterbags placed in the control plots.

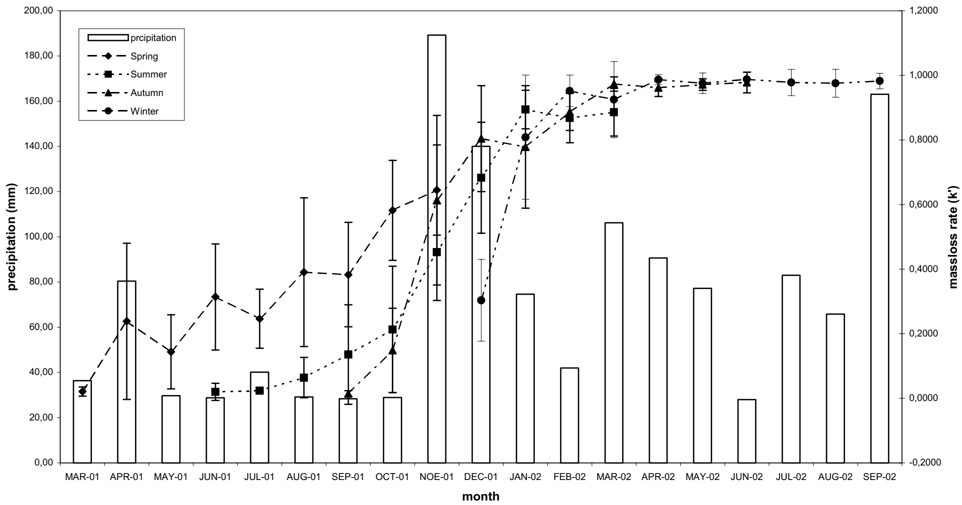

Figure 4. Cellulose decomposition rate for all seasonal cycles in the 20μm mesh size litterbags placed in the treatment plots.

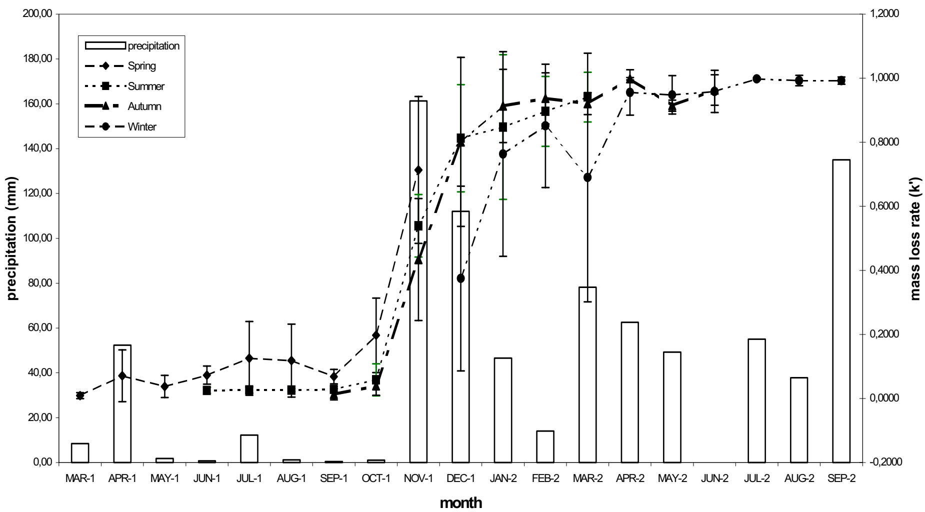

Figure 5. Cellulose decomposition rate for all seasonal cycles in the 1mm mesh size litterbags placed in the control plots.

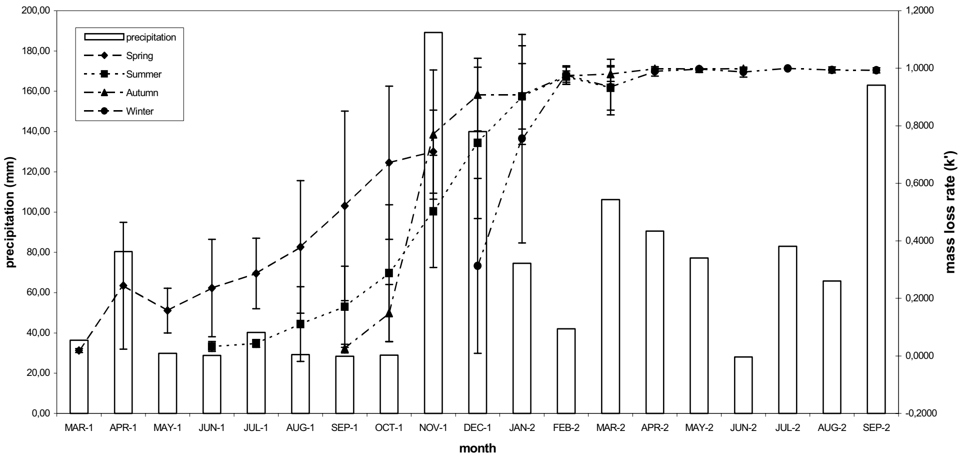

Figure 6. Cellulose decomposition rate for all seasonal cycles in the 1mm mesh size litterbags placed in the treatment plots.

The data above indicate that the mesh size has a limited effect on decomposition process during the very dry and the very wet periods in both control and treatment plots. On the contrary, during the periods characterized by medium soil moisture presence the differences in decomposition rate between small and big mesh size are greater.

Another important fact is that the four seasonal experimental cycles present different patterns of decomposition rate. The decomposition rate depends on the moisture content of the initial period (the period when the litterbags are placed into the soil). In the current study, the decomposition process is quite high from the beginning when the experimental cycle begins in a wet period. On the contrary, when the experimental cycle begins in a dry period, the decomposition process is very slow during the first months and accelerates during the following months.

Another important observation is that the treatment effect is more intense during the dry seasonal cycles, by accelerating the decomposition process while it is lower during the wet seasonal cycles, in which cases it makes almost no difference.

4 DISCUSSION

These are the preliminary results of a larger and more detailed research project. These first indications can show that soil moisture is an important factor for the decomposition process. However, this process is depended on other attributes as well: e.g. the climatic conditions and the levels of soil moisture before and after the beginning of the decomposition process. These initial results will be soon correlated with several biotic and abiotic factors to give a complete profile of the effect of this *in situ* moisture increase treatment in a Mediterranean ecosystem. From this profile we could gain some new insights on the role of soil moisture in the decomposition process.

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