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Dynamics of Litter decomposition: Effect of Antimicrobial features on leaf decomposition

Neslihan Karavin*, Ali Cımık, Zuhal Ural and Esra Erdem
Amasya University, Faculty of Arts and Science, Department of Biology, Amasya-Turkey
*Corresponding Author E-mail: nnecli@gmail.com

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ABSTRACT

One of the basic processes in ecosystems is the litter decomposition that performs nutrient cycling. There are several factors effective on decomposition rate. The aim of the study was to determine the variation in litter decomposition rates between pure and mixture litters and the effect of antimicrobial features of litter on decomposition rates. We compared litter decomposition in Malus domestica L. and Populus nigra L. leaves because of their antimicrobial activity. Litter bags were used to examine the decomposition rate and the bags were placed in the same location and exposed to same environmental conditions. The highest decomposition rate was obtained by P. nigra, followed by M. domestica and their mixtures, respectively. We conclude that the differences in decomposition rate between P. nigra and M. domestica may be caused by litter quality and differences in their antimicrobial activity.

Key words: *Litter, decomposition, Malus domestica, Populus nigra, antimicrobial activity*

INTRODUCTION

Ecosystems are sustained by means of different biological, chemical and physical processes. One of these basic processes is the litter decomposition in ecosystems which transforms organic substances to the simple forms and performs nutrient cycling. It is known that besides environmental factors, litter quality and diversity also has major impacts on litter decomposition[1]. Several studies focused on effects of litter diversity on decomposition rate rate[2,5-6]. Researchers examined the decomposition rate of needle litter and broadleaf litter mixture and reported that mixture litters decomposed faster compared to pure litter[2-5]. Few studies carried out on decomposition of broadleaf litter mixtures show an increase in decomposition rate and some of others didn't determined significant variation in mass loss between pure and mixture litters [6-8]
One of the features of a broadleaf leaf litter is rapid decomposition which provides faster nutrient cycling due to its high nutrient content, low lignin and polyphenol concentrations[3,9]. However, it is of interest to know if it is valid for all broadleaf litter with antimicrobial impacts. One of the basic factors that affect litter decomposition rate is the potential microbial activity of litter compounds.
Mixing the different litter types may cause both synergistic and antagonistic interactions[8,10-11]. Synergistic interactions may be explained as an increase in nutrient used by decomposers.

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The addition of different litters with high nutrient supply provides rapid decomposition to the low-quality litters. As antagonistic interactions, there are some substances in leaf litter that may inhibit fungal or bacterial colonization[11-12]. Indeed, the effect of litter diversity on decomposition and antagonistic interactions in litter mixtures are still unclear.

The objectives of the study were determining the variation in litter decomposition according to litter diversity and the effect of antimicrobial features of litter on decomposition rates. *Malus domestica* L. and *Populus nigra* L. leaves were used as litters for of their antimicrobial activity. Antimicrobial and antifungal activities of *P. nigra* and *M. domestica* were reported in the previous studies[13-14]. *M. domestica* is a common and economically important fruit tree in most countries and also study area. *P. nigra*, is an economically important fruit tree used as timber and grown usually near the orchards or as poplar grove. Poplars are commonly along the borders of arable fields. . Examining the decomposition rates of these species is important for plants grown under these trees. It is expected that results of the study provide beneficial information both for plant ecology and agriculture.

MATERIALS AND METHODS

The study was carried out in Amasya in the Central Black Sea Region of Turkey. The senescent apple and poplar leaf samples were collected in three different apple and poplar orchards as freshly fallen leaves under the trees in November. The undamaged leaf samples were selected and dried in drying-oven at 75 °C until constant weight and then milled. Litter bags were used to examine the decomposition rate. Litter bags 20×20 cm in size were made from fibreglass net with 2 mm mesh size. Three set of litter bags were prepared in order to test the effect of litter diversity on decomposition rate. In this context, ten litter bags of the first set enclosed 5g of apple leaf litter, ten litter bags of second set enclosed 5g of poplar leaf litter, and ten litter bags of third enclosed 5g of apple and poplar leaf litter In order to provide similar conditions, the litter bags were placed in the same area in sparse *Pinus* woodland. Deposited materials on the ground removed and litter bags were fastened directly to the soil by iron nails in March. In order to determine the decomposition rates, litter bags were collected in December (about ten months later). Five of the litter bags enclosed with poplar leaves were omitted because of contamination. The litter bags were air-dried in the laboratory for few days and washed with distilled water in order to remove the foreign materials and dried at 75 °C into the drying oven. Decomposed leaves were weighed and remaining dry weights were calculated.

The statistical analyses were done by using SPSS (Version 20). Differences in mean remaining dry weights were determined by Tukey post-hoc test at the 0.05 level of probability. Variation in litter decomposition rate according to kind of litter type was tested by one-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Remaining leaf litter dry weights of *M. domestica* and *P. nigra* are given in figure 1. The results indicate the highest decomposition rate was determined in *P. nigra,* followed by *M. domestica* and their mixture, respectively. The litterbags exposed to similar conditions such as same area and environmental conditions, the differences in decomposition rate between *P. nigra* and *M. domestica* may be caused by litter quality and differences in their antimicrobial activity.

Differences in remaining dry weights were indicated in Table 1. Significant differences were determined between remaining dry weights of *P. nigra* and *M. domestica,* and *P. nigra* and their mixture. Variation in remaining dry weights between *M. domestica,* and their mixture was not significant. Considering the decomposition rate of *M. domestica* and *P. nigra*, a decrease in decomposition rate was observed when litters were mixed. In contrast, a faster decomposition rate was determined by Taylor et al.[6] in mixture of *Populus tremula* L. and *Alnus crispa* (Ait.) Pursch litters. In the study by Hansen,[7] mass loss in mixtures of *Betula alleghaniensis* Britt., *Acer saccharinum* L. and *Quercus rubra* L. was examined and mass loss did not vary significantly according to litter diversity[8].

The mixing of *P. nigra* and *M. domestica* litters may be lead to high antimicrobial activity in decomposing litter. McArthur et al.[15] and Nilsson et al.[16] determined that release of antimicrobial substances such as tannins and polyphenols from litter may decrease litter decomposition[11]. These substances were reported by Harrison[12] for tannins of oak leaf litter[11]. Similar antimicrobial substances were involved both in *P. nigra* and *M. domestica*, which cause antifungal and antimicrobial activities[13-14]. It is thought that lower decay in litter mixture was a result of these substances.

In the literature it was explained that litter diversity is effective on decomposition rate and it is caused by several factors. These factors are explained by Bonanomi et al.[17] as follows: passive diffusion or microbial active transport of nutrients between different materials may decrease the decomposition rate of nutrient poor litter, and higher water retention capacity of plants could be expedites decay of other plant litters or the release of some of compounds with antimicrobial activity e.g. tannins and polyphenols from litters may be lead to decrease in litter decomposition compared to pure litter. Last explanation confirms our hypotheses and results. Substances with antimicrobial activity in *P. nigra* and *M. domestica* leaves such as tannins, flavonoids and polyphenols may have caused decrease in litter decomposition[13-14]. Additionally, *P. nigra* and *M. domestica* leaf litter mixtures may have decomposed more slowly than pure litters due to co-effect of these substances with antimicrobial activity.

As a conclusion, the results of our study indicated that pure and mixture litters of *P. nigra* and *M. domestica* were significantly different. Variances in decomposition rate between *P. nigra* and *M. domestica* is thought to be caused by litter quality and differences in antimicrobial activity. Additionally, the decrease in mass loss of mixture litters compared to the pure litters may be a result of antimicrobial activity of *P. nigra* and *M. domestica*. In natural ecosystems litter layers are composed of litters from various species and these litter mixtures produce both synergistic and antagonistic interactions. These interactions may occur based on litter quality and existence of substances with antimicrobial activity.

Fig. 1: Remaining dry weights of leaves and their differences according to kind of litter type

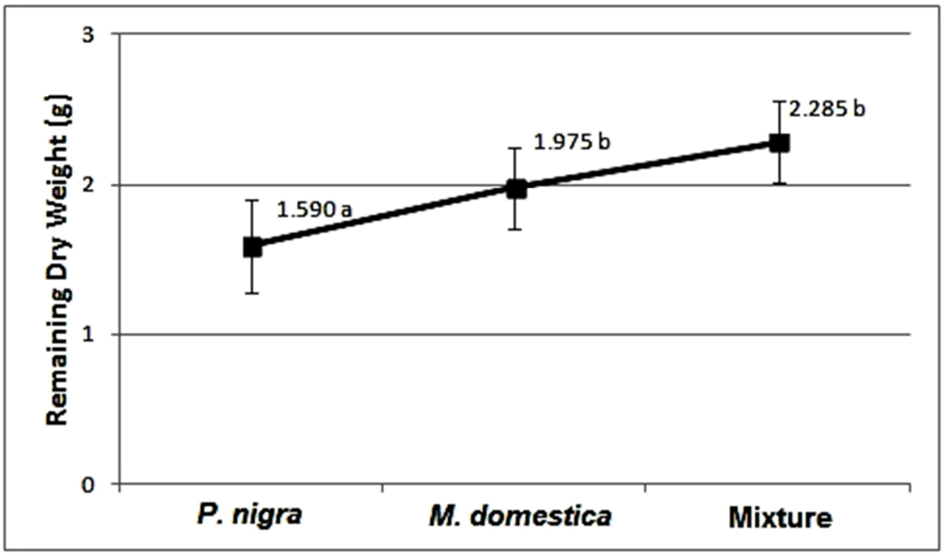

Table 1: ANOVA table of variation in litter decomposition according to traffic-based heavy metal pollution

Sum of Squares	df	Mean Square	F	*P*
.552	2	.276	4.052	.03

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