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Recovery of the biological activity in a vineyard soil after landscape redesign: A three-year study using the bait-lamina method

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Summary

To detect changes in the biological activity (checked as soil animals feeding activity), the bait-lamina test (VON TÖRNE 1990) was used in a vineyard and a fallow soil (old meadow) during a three-year study. Situated in the vine-growing region of Rheinhessen near Mainz, Germany, the vineyard was part of an intensive redesign of the landscape accompanied by soil restoration. In 1994 new grapevines were planted in a two-row-system: 1) uncovered, 'open' soil, 2) green-covered soil (grass and clover). The new vineyard soil was in a 'raw' soil stage (humus: <1.7 %) whereas the fallow soil (reference soil) was undisturbed (humus: approx. 5 %). At the onset of the experiment in spring 1997 the soil faunal feeding activity in the vineyard soil was close to zero while in the fallow soil the activity was 23 %. In the following tests the feeding activity increased in both, the green-covered and uncovered soil; the highest level of feeding activity was finally found in the covered soil. The results indicate that under the local climatic conditions soil faunal activity recovers within a few years after soil restoration and that the rate of biological activity depends on soil management.

K e y w o r d s : biological activity, vineyard soil, landscape redesign, bait-lamina test, minicontainer test, *Collembola*.

Introduction

In the last decades many vine-growing regions of Germany were subjected to an intensive landscape redesign. Most of the smaller vineyards were combined to form larger units; these changes were often accompanied by significant changes of the landscape. Historical soils were removed and then replaced by new soil covers which were often a mixture of unweathered subsoil and weathered topsoil. This new, 'immature' soil cover has low organic matter and its biological activity is low. The biological activity of soils can be determined by the bait-lamina test (VON TÖRNE 1990), which bases on the feeding activity of soil animals. BODE and BLUME (1997) compared various arable soils while other authors investigated the effect of special impacts on soil life, *e.g.* soil compaction, soil acidification and the application of soil amendments (HEISLER 1994; EISENBEIS *et al.* 1996; PFOTZER and SCHÜLER 1997).

With respect to the fauna of vineyard soils special groups, *e.g.* nematodes, lumbricids, mites, spiders and collembolans, have been studied. It is known from laboratory studies, that members of the meso- and macrofauna feed on bait-laminas (HELLING *et al.* 1998, EISENBEIS and HEIBER unpubl.). Our hypothesis was that in the first years after the planting of grapevines the faunal activity is very low, but over years, with increasing root growth and net-input of organic residues into soil, we expected the overall activity of soil animals to increase significantly as visualized by their feeding activity.

Material and Methods

Experiments were carried out in Rheinhessen near Mainz, Germany. The loamy soil originates from both, tertiary limestone and loess deposits. It is rich in calcareous material and has been modified by tillage to a Pararendzina-Rigosol. In 1994, after redesigning of the vineyards grapevines were planted (cv. Blauer Spätburgunder grafted to SO 4). No humus accumulation could be observed visually in soil at this stage. The soil between grapevines was either uncovered or covered with grass and clover. Close to the vineyard an intensively rooted fallow (old meadow) with topsoil rich in humus remained unaffected from redesigning. This site was used as reference. In 2001 the humus content of the plots were: 1.72 % (uncovered soil), 4.50 % (green-covered soil) and 5.51 % (fallow soil).

From 1997 to 1999 we used the bait-lamina test (VON TÖRNE 1990; Fig. 1). The bait mixture consisted of 65 % cellulose (microgranular), 15 % agar-agar, 10 % bentonite (clay and minerals), and 10 % wheat bran (finely grinded and sieved) (EISENBEIS 1998 a). In March/April and in October/November 64 bait-laminas with 1,024 holes filled with dry bait mass were inserted vertically into the soil at each of the plots for 14 d. The feeding activity was defined as the ratio of consumed (= open) and not consumed (= closed) baits (EISENBEIS 1998 a).

In spring 1999 six soil cores (diameter 15 cm, depth 10 cm) from each plot were taken to the laboratory. The soil mesofauna was extracted from two soil layers: 0-5 cm and 5-10 cm. In addition two minicontainer bars (EISENBEIS *et al.* 1999) containing 12 minicontainers filled with about 200-300 mg of dry grapevine leaf litter and sealed with 500 µm gauze discs were exposed horizontally within the upper top-

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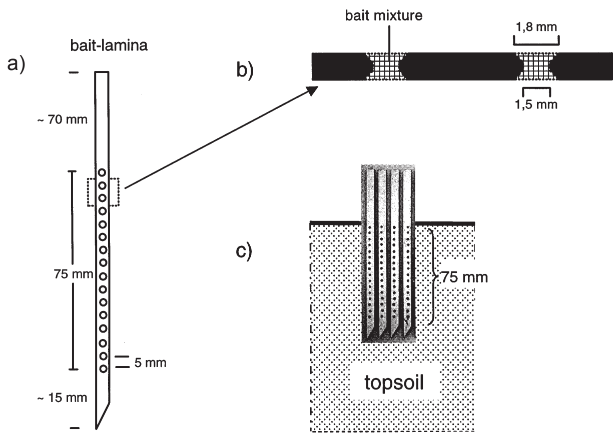

Fig. 1: Construction of a bait-lamina (**a**), conical profiles of holes filled with bait mixture (**b**), laminas in topsoil, distance about 10 cm (**c**).

soil (depth: 5 cm). After exposure the remaining ash-free mass was determined in the laboratory (Eisenbeis 1998 b).

Results

Five years after replantation the uncovered topsoil was still free of any visible humus accumulation, whereas the green-covered soil showed a small humus zone within the topsoil. In spring 1997 the feeding activity differed distinctly in uncovered (3.3 %), green-covered (1.7 %) and fallow soil (23.0 %) (Fig. 2). In autumn 1997 the uncovered soil had still approximately the same activity (3.5 %), but the activity in the green-covered soil had increased significantly to almost 9.0 %, and in the fallow soil to 29.8 %. In spring 1998 the activity increased significantly up to 12.8 % in the uncovered soil and up to 21.3 % in the green-covered soil, whereas in the fallow soil it had decreased to its original level again (23.5 %). The next assessment in autumn revealed a further increase in both vineyard soils to 30.3 % and 56.8 %, respectively. Note, that the activity in the fallow soil had more than doubled too within this period, but the activity in the fallow soil never exceeded that of the covered soil until the end of testing. In 1999 the activity pattern in the two covered soils slowly decreased again, but the difference in activity between the uncovered and the covered soils remained nearly constant. In the uncovered soil the final activity was 17.5 % (Fig. 2).

In spring 1999 an analysis of the soil fauna indicated very low numbers of *Collembola* in the uncovered soil (approximately 5,000 m^{-2}), whereas in the covered soil we found >60,000 m^{-2}. In addition, the vertical distribution of *Collembola* seemed to be different. The ratio between the upper (0-5 cm) and lower topsoil (5-10 cm) was 5.4 (green-covered soil), 4.1 (fallow) and 1.4 (uncovered soil).

The remaining grape leaf mass after exposure in soil (5 cm depth) for 6 months was as follows: uncovered soil (55.1 ± 12.5 %), green-covered soil (57.8 ± 6.4 %) and fallow soil (45.1 ± 21.3 %). The mass loss of the two minicontainer bars in the fallow soil was very different. One bar decomposed very slowly (remaining mass 63.5 ± 11.8 %), while the other decomposed very fast (remaining mass 26.8 ± 8.5 %). In contrast grape leaves in minicontainers in vineyard soils decomposed very similarly within the two bars. The highest average mass loss occurred in the fallow soil, but it was not significantly different from the vineyard plots.

Discussion

Green cover in vineyards is often used as strategy against soil erosion, but it also improves soil fertility. According to Preuschen (1983) the erosion of vineyards in northern Ba-

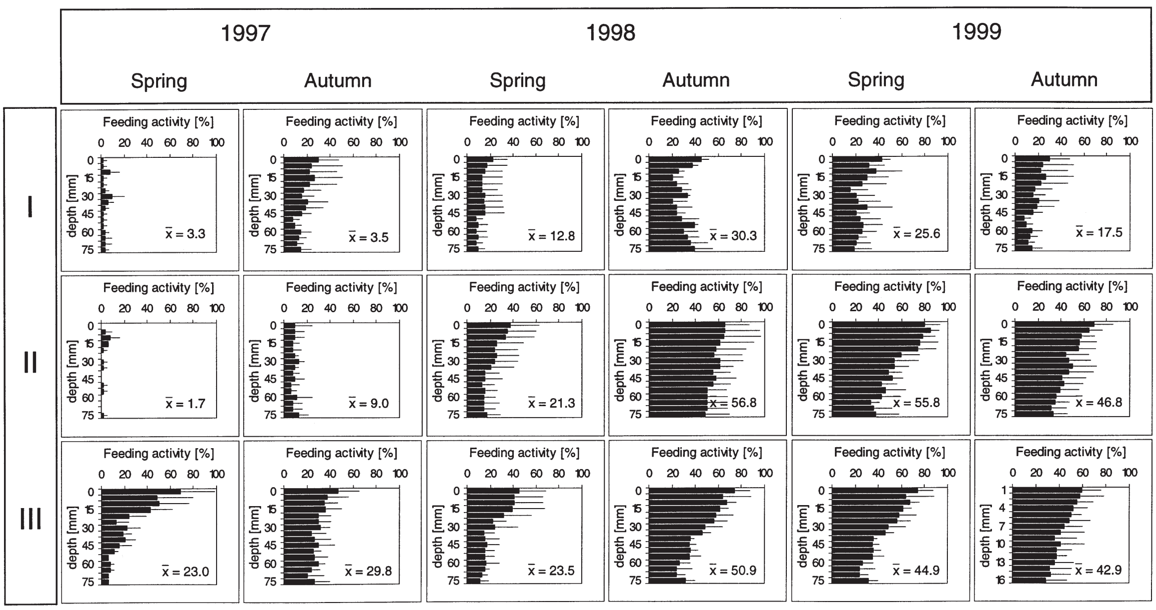

Fig. 2: Feeding activity on bait-laminas in (**I**) uncovered vineyard soil, (**II**) green-covered vineyard soil, and (**III**) fallow soil (old meadow). Each diagram represents the data of 64 bait-laminas; bars indicate standard deviation, $\bar{x}$ = mean of total activity.

varia strongly declined after three years of green cover and the growth of grapevines increased significantly.

To our knowledge the present study is the first report on a three-year monitoring of soil faunal feeding activity in a vineyard soil. At the beginning, in spring 1997, the activity was near zero at the two plots and the typical hyperbole feeding profiles could not be recorded. The vineyard activity profiles showed many unfed layers and there was no clear preference for the top layers. It is assumed, that these irregular profiles reflect soil disturbance which is associated with very low biological activity. EISENBEIS *et al.* (1996) described a similar profile structure for a strongly acidified forest soil (feeding activity near 5 %), which 5 years after lime application turned into a more hyperbole high activity profile. This type of profile was found in spring 1997 only in the old fallow soil with a total activity of 23.0 %.

In autumn 1997, the feeding profiles of the vineyard plots were still untypical, but a first small increase in activity became visible, especially in the green-covered soil. In the fallow soil the activity had also increased possibly reflecting better soil conditions (*e.g.* humidity, nutritient supply) in deeper layers of the profile. This holds for all tests in autumn compared to spring trials. Summarized, the relative difference in activity between plots was unaffected in autumn 1997.

In 1998 feeding activity changed in all soils. A distinct increase in activity was recorded in spring 1998 for both vineyard soils. The activity of the uncovered soil increased about 4 times and in the green-covered soil it nearly reached the level of the old meadow soil. A further steep increase followed in autumn 1998 with a maximum activity and with high rates also in deeper layers. We assume that abiotic and biotic conditions were optimal due to a high input of nutrients and moisture.

In 1999 we observed a consolidation of the activity pattern of soils. The activity in the uncovered and the fallow soil slightly decreased, and in the green-covered soil the high activity level remained nearly constant. The activity profile of the uncovered soil was again uniform. This is presumably due to the effect of milling twice a year to a depth of 15 cm. The green-covered soil however, was only mowed twice a year providing a significant input of organic litter.

HELLING *et al.* (1998) have shown that both *Collembola* and *Enchytraeidae* are actively involved in bait consumption. Since the uncovered soil was regularly milled the abundance of *Collembola* is permanently depressed as is reflected by the low activity in this plot. On the other hand, the large number of *Collembola* in the two green-covered plots confirms the significant contribution of this group to the feeding activity.

The data of the decomposition study only suggest a tendency towards a higher decomposition rate in the fallow soil. SCHELL-BRINGMANN and KÜHLE (1986) showed that the decomposition of grapevine leaf litter, which was placed in bags on the soil surface, was much more rapid on green-covered soil than on uncovered soil.

In conclusion, using the bait-lamina method, a fast recovery of the mesofauna activity after soil restoration has been observed. Continued soil disturbance by milling reduces the soil fauna to a low level. The *Collembola* activity appears to be correlated with the feeding activity of baits, but the minicontainer test suggests that the overall biological activity was highest in the old meadow soil.

Acknowledgement

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