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The development of bacteria with different trophic features as influenced by type of soil cultivation

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SUMMARY

The aim of the study was to investigate the influence of the no-plowing tillage on the development of two trophically differentiated groups of microorganisms (oligotrophic and copiotrophic bacteria) and on the quantitative relationships between these microorganisms, expressed as the O – to – C coefficient. For the verification of the hypotheses under study factorial block model with two factors - type of soil cultivation and depth of soil layer – and test days as blocks was used.

KEY WORDS: factorial block model, no-plowing tillage, oligotrophic bacteria, copiotrophic bacteria.

1. Introduction

In contemporary sustainable agriculture there has been a growing interest in simplified methods of soil cultivation (Radecki and Opic 1991). As compared with the conventional system of tillage, simplified cultivation makes possible the diminution of costs (energy) and reduction of anthropopressure on agroecosystems.

The no-plowing system considerably changes the physico-chemical properties of soil environment (Doran 1980), but our hitherto knowledge on the ecology of soil microorganisms pertains to the conventional tillage of soil.

Therefore, the aim of our study was to elucidate the influence of the no-plowing system on the development of two trophically differentiated groups of microorganisms, i.e. oligotrophic (O) and copiotrophic (C) bacteria. The quantitative relationships between these microorganisms, expressed as the O – to – C coefficient, indicate

the character of microbiological transformations of soil organic matter (Weyman-Kaczmarkowa and Pędziwilk 2000).

2. Materials and methods

Soil samples were taken from the Złotniki fields belonging to the Experimental Station of the Agricultural University of Poznań. Research was conducted for two years. The soil was sampled (five replications) five times in the first year (April to November) and six times in the second year (March to November), from the 1-10 cm and 11-20 cm soil layer of plots under winter wheat sown after faba bean, cultivated conventionally (control) and in the no-plowing system. In all times of analyses five samples were taken. Soil humidity was also estimated once per every five replications.

The numbers of colony forming units (cfu) of oligotrophic bacteria (O) and copiotrophic bacteria (C) were estimated in each sample, on diluted and full strength medium, respectively, according to the Ohta and Hattori method (1983). The ratio of O –to – C was calculated as the quotient of mean cfu O and cfu C number from five estimates in each analyzed term.

It is well known that the level of soil humidity is one of the important factors affecting the occurrence of O and C bacteria in the soil. That is why it was initially assumed that the covariance factorial model with humidity as the accompanying variable would be the most suitable for the verification of the hypotheses under study. However, it turned out that moisture variability for particular test days was much lower than between test days. So the much simpler factorial block model proved equally suitable, as it takes into account the following sources of variability that occur in the experiment:

1. type of soil cultivation – two levels: conventional and no-plowing,
2. depth of soil layer – two levels: 0 – 10 cm and 11 – 20 cm,
3. test days – 11 levels.

Test days were treated as blocks.

To make sure that the assumption of the homogeneity of the observation variance in subclasses is satisfied, a logarithmic transformation of the value of the O:C ratio was performed. The size of cfu O and cfu C was standardized by substituting the i-th value in j-th subclass by value y_{ij}^s (Walkowiak, 2000):

$$y_{ij}^s = \frac{(y_{ij} - \bar{y}_i)\,\bar{\sigma}}{\sigma_i} + \bar{y}_i,$$

where σ_i is the standard deviation in i-th subclass, and $\bar{\sigma}$ is the arithmetic mean of σ_i. Such standardization equalized the observation variance in a subclass without changing its mean.

For models thus defined, homogeneity of the observation variance in subclasses was checked by Cohran's C and Bartlet's χ^2 tests (Zieliński 1972, p. 54). Goodness of fit of the residual probability distribution in comparison with normal distribution was verified by the Kolmogorov-Smirnov test (Zieliński 1972, p. 74), whereas goodness of fit of each model compared to the data was checked graphically by means of the plot of observed to predicted values, and a plot of the residual to predicted values. The significance of the differences between the main effects and interaction effects of particular factors was tested by variance analysis. In cases of significant disparities, detailed hypotheses concerning differences between types of cultivation in particular layers of soil, were verified.

3. Results and discussion

3.1. The number of colony forming units (cfu) of oligotrophic (O) bacteria

Variance analysis showed very significant differences between the two types of soil cultivation (level of significance $p = 0.01$), as well as a significant effect of the interaction between cultivation and the depth of the soil layer. The mean numbers of cfu O in soil cultivated by the no-plowing system (NT) was significantly bigger than that for conventional tillage (CT) (Table 1). Differences between the layers turned out to be insignificant (Table 1). The significance of interaction between the type of cultivation and the depth of soil layer led to the conclusion that although in both layers the number of cfu O is higher for NT than for CT, the difference in the interaction with cultivation is significantly greater in the surface soil than in the deeper layer (Table 1, Fig. 1).

Table 1. Mean values of cfu numbers of O for each type of cultivation in each soil layer in 10^6 g^{-1} dry soil

Soil layer	Cultivation		Mean
	conventional	no-plowing	
0-10 cm	88.70	121.13	104.92
11-20 cm	95.42	106.24	100.83
Mean	92.06	113.69	

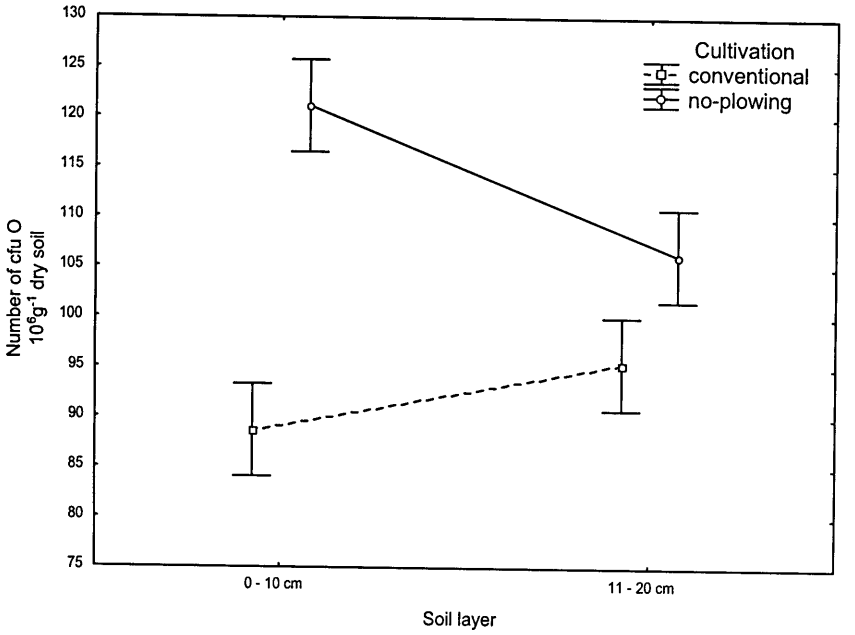

Fig. 1. The cfu number of O for types of cultivation in each soil layer

3.2. The number of colony forming units (cfu) of copiotrophic (C) bacteria

An analysis of the variance of cfu C size, carried out similarly as in the previous case, established the level of significance at $p = 0.05$ and showed that the type of cultivation and its interaction with the depth of soil layer had a significant influence on the number of cfu C. On average the number of cfu C was lower for NT than for CT (Table 2). Here also the differences between soil layers proved insignificant (Table 2). In the surface layer the difference between the mean numbers of cfu C for both types of cultivation was insignificant, whereas in the deeper layer the mean of cfu C was significantly smaller for NT than for CT (Table 2, Fig. 2).

Table 2. Mean values of cfu numbers of C for each type of cultivation in each soil layer in 10^6 g^{-1} dry soil

Soil layer	Cultivation		Mean
	conventional	no-plowing	
0-10 cm	77.10	78.32	77.71
11-20 cm	79.63	68.84	74.24
Mean	78.37	73.58	

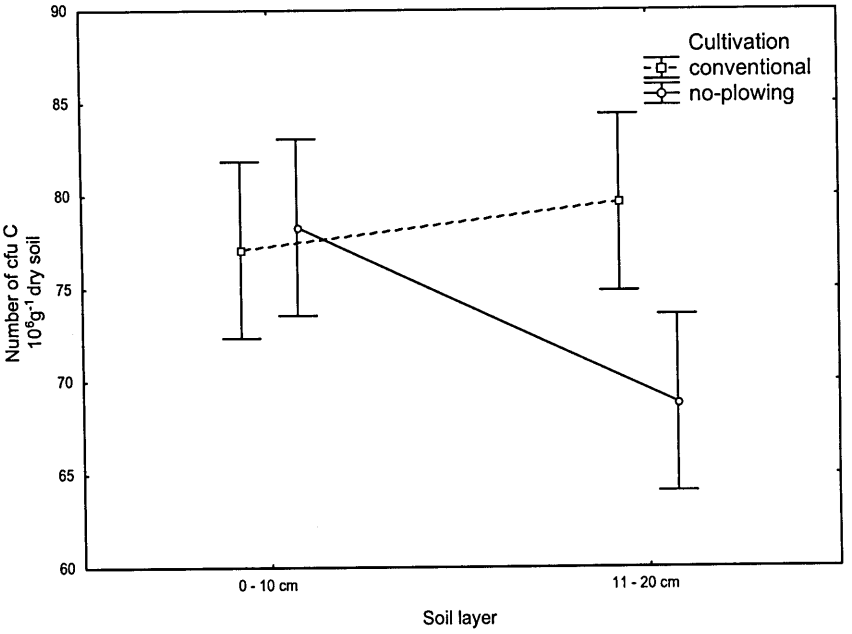

Fig. 2. The cfu number of C for types of cultivation in each soil layer

3.3. The O – to – C coefficient

From the variance analysis performed for transformed values of the O:C ratio it follows that for NT the ratio is significantly ($p = 0.05$) higher than for CT. The influence of soil depth, and of the interaction between the type of soil cultivation and depth turned out to be insignificant (Fig. 3).

4. Conclusions

Summing up, regardless of the differences of the direction and scale of changes in the O – to – C coefficient value, related to the depth of soil layer, the no-plowing system in comparison with conventional tillage induces better conditions for the domination of oligotrophs in whole communities of soil inhabiting bacteria. Such a domination is conducive to sustaining the constant level of organic matter in the soil. For this reason no-plowing seems to be worth enough to became widespread as a soil cultivation system.

Let us also note that the above conclusions could be reached either using the covariance factorial model or the simpler factorial block model. The decision which

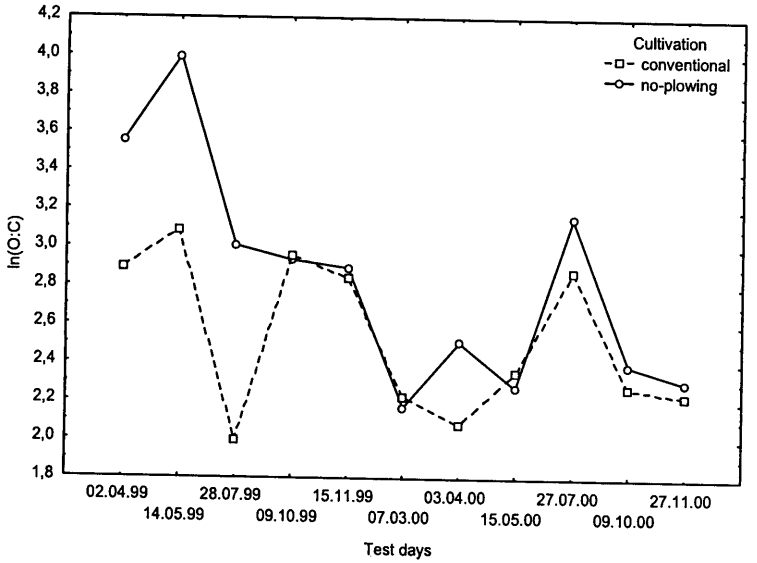

Fig. 3.Natural logarithm of O – to – C coefficient for particular test days

of the models would be more adequate was preceded by an analysis of the variability of soil humidity on particular test days. As the variability of soil humidity on test days proved to be smaller than between test days, the second model was selected. In an opposite case, the covariance factorial model is to be preferred.

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Wpływ typu uprawy gleby na rozwój bakterii o różnych cechach troficznych

STRESZCZENIE

Celem podjętej pracy było zbadanie wpływu uprawy bezorkowej na rozwój dwóch zróżnicowanych troficznie grup bakterii (oligotroficznych i kopiotroficznych) oraz na ilościowe relacje miedzy nimi, określane współczynnikiem O:C. Do weryfikacji interesujących hipotez wykorzystano model czynnikowy w układzie blokowym z dwoma czynnikami – typ uprawy gleby oraz głębokość w warstwie ornej – i terminami pomiarów jako blokami.

SŁOWA KLUCZOWE: model czynnikowy w układzie blokowym, uprawa bezorkowa, bakterie oligotroficzne, bakterie kopiotroficzne.